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Influence of protein supplementation and implant status on alleviating fescue toxicosis

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ABSTRACT: Heat stress is a major problem in transporting stocker calves with symptoms of fescue toxicosis. Removing calves from tall fescue pastures and offering diets devoid of endophyte-infected tall fescue could reduce the severity of toxicosis and precondition calves for transport to the feedlot. In the present experiment, a pasture phase was used to condition yearling steers to grazing tall fescue and induce symptoms of fescue toxicosis, and a pen phase followed to determine effects of implanting at the start of grazing and protein supplementation (hay only vs hay plus supplement) on short-term changes in rectal temperature and serum prolactin concentration. Neither implant status nor protein supplementation affected (P > 0.10) white blood cell count or rectal temperature. White blood cell counts at the conclusion of the pasture phase averaged 8,778 cells/μL and were within a range indicating no immunological response. Changes in rectal temperature and serum prolactin concentration during the pen phase were not influenced (P > 0.10) by implanting or supplementation. Initial rectal temperatures for the pen phase were high (39.9°C) but declined linearly (P < 0.001) over the first 106 h and were below a normal temperature (39.2°C) by 82 h following removal from tall fescue pastures. Serum prolactin gradually increased (P < 0.001) to a peak by 82 h and stabilized thereafter. Results indicate that neither supplemental protein nor an estrogenic implant influenced recovery indices of fescue toxicosis, whereas removing calves from tall fescue pastures and excluding dietary tall fescue for 3 to 4 d may alleviate symptoms of fescue toxicosis.

Key Words: Animal Health, Cattle, Festuca, Poisoning, Stress

Introduction

Cattle grazing tall fescue frequently exhibit fescue toxicosis, a malady caused by consumption of toxins produced by the endophyte Neotyphodium coenophialum (Glenn et al., 1996). Symptoms of fescue toxicosis include retention of rough hair coat, increased body temperature, labored respiration, and decreased weight gain (Hoveland et al., 1983; Schmidt and Osborn, 1993). Fescue toxicosis is most severe at the onset of high ambient temperature and humidity during the late spring and summer (Hemken et al., 1981; Stuedemann and Hoveland, 1988).

Decreased BW gain of calves exhibiting fescue toxicosis has prevented the wide use of tall fescue for stocker production (Hoveland, 1993). Furthermore, transporting stockers exhibiting toxicosis can be difficult because the combined stresses of the toxicosis and transporting can result in high mortality (Smith, 1986; Atkinson, 1992). Therefore, fescue toxicosis exacerbates the stress from transport and can increase vulnerability to high mortality.

Although decreased serum prolactin concentration has not been directly related to the incidence of fescue toxicosis (Strickland et al., 1993), other hormones have been implicated as contributing factors in the etiology of toxicosis (Stuedemann et al., 1985). Reductions in serum prolactin in cattle exhibiting fescue toxicosis may be in response to changes in other hormones that are inducing toxicosis. Aiken and Piper (1999) measured prolactin of steers that were moved from endophyte-infested tall fescue to eastern gamagrass and found serum prolactin to increase from 20 ng/mL at the time steers were removed from tall fescue to approximately 100 ng/mL after 28 d of grazing eastern gamagrass.

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Removing stocker cattle from tall fescue before transport to the feedlot could improve health status and reduce stress during transport. Stressed calves have shown to have higher protein requirements (Cole and Hutchinson, 1990), which suggests that protein requirements are higher for calves exhibiting symptoms of toxicosis. Improved BW gains through implanting with anabolic agents could also affect health and stress levels. The objective of the present experiment was to determine the effects of protein supplementation and previous implanting on serum prolactin and rectal temperature of steers exhibiting symptoms of fescue toxicosis.

Materials and Methods

The experiment was conducted in 1999 near Booneville (35° 5′; 94° 0′ W) in west-central Arkansas. All procedures were approved by the committee for animal welfare at the Dale Bumpers Small Farms Research Center. Two phases were used in the experiment: 1) a pasture phase was conducted for 66 d to condition yearling steers to tall fescue and induce symptoms of fescue toxicosis and 2) an 18-d pen phase followed the pasture phase to monitor rectal temperature and serum prolactin.

Pasture Phase

Forty-five yearling steers of mixed breeding (0 to 50% Bos indicus) were randomly allotted to nine groups, and groups were randomly assigned to pastures. Nine 1-ha pastures of endophyte-infected ‘Kentucky-31’ tall fescue with Leadvale silt loam (fine-silty, siliceous, thermic Typic Fragiudult) soil were used in the pasture phase. Treatments of implanting (n = 5) and no implanting (n = 4) with Synovex-S (Fort Dodge Animal Health, Fort Dodge, IA) were assigned to pastures in a completely randomized design. On the initial day of grazing (April 16), steers were weighed unshrunk, dewormed with Ivermectin (Merck, Whitehouse, NJ), and implanted if assigned the implant treatment. Initial BW averaged 240 ± 3 kg. Pastures were grazed continuously for 66 d, and a mineral and vitamin supplement (Nutrena Feeds Division, Cargill, Kansas City, KS) was offered for ad libitum consumption that contained Ca (min. 12.0%, max. 14.0), P (min. 12.0%), Na (min. 4.6%, max. 5.9%), Mg (min. 1.25%), K (min. 1.25%), Cu (min. 21 ppm), Se (min. 18 ppm), Zn (min. 300 ppm), vitamin A (min. 440,000 IU/kg), vitamin D₃ (99,000 IU/kg), and vitamin E (33 IU/kg).

Pastures were fertilized with N on April 10 at a rate of 75 kg/ha. Forage was monitored at 2-wk intervals by taking 50 disk meter readings for each pasture. Disk meter height averaged over the season was assumed to reflect forage availability to cattle. The disk meter used in the study was similar in design to the one described by Bransby et al. (1977), except that the movable plate was 45 cm in diameter and weighed 1.9 kg.

Pastures were sampled on June 18 to measure ergovaline, an ergopeptine used as an indicator of the potential toxicity of consumed forage (Garner et al., 1993; Sleper and West, 1996). Single, whole tillers from 25 randomly chosen plants were collected and combined for each pasture and stored frozen for subsequent determination of ergovaline concentration following procedures described by Moubarak et al. (1996).

Pen Phase

On the last day of the pasture phase (June 20) steers were placed in a drylot at approximately 2000 and given ad libitum access to bermudagrass hay and water. The following day at 0600 (10 h after removal from the pastures), steers were weighed unshrunk. Hair coat conditions were rated and recorded as being either sleek, rough, or transitional (i.e., some roughness of hair over the rump and shoulder regions), and rectal temperatures were recorded.

Following sample and data collection on the 1st d, implant treatment groups were separated and individual steers within each group were randomly assigned to 11 pens of four steers per pen (implant, n = 6; no implant, n = 5). One implanted steer was randomly chosen for removal from the study to complement the number of steers needed per pen. Each outdoor pen was 4.9 × 6.4 m with a surface composed of a 5- to 10-cm layer of shale. Feeders for hay and protein supplement, water tubs, and plastic tarps for shade were placed in the pens. Two feeding treatments were randomly assigned to pens within previous implant treatments. One treatment was bermudagrass hay fed for ad libitum intake (six pens), and the other treatment was bermudagrass hay fed for ad libitum intake plus a protein supplement (five pens; soybean meal, 47.5% as fed; cottonseed meal, 47.5% as fed; and cane molasses, 5% as fed) fed at a daily rate of 2.3 kg·steer⁻¹·day⁻¹ (approximately 1% of BW). Hay remaining from the previous day was removed and replaced with an amount of hay that was approximately 10% in excess of daily consumption. Square bales of hay were sampled before the start of the experiment by collecting core samples from the centers of 10 bales. Samples were ground and analyzed for CP with a Kjeltech 1030 Auto Analyzer (Tecator, Höganäs, Sweden) and for IVDMD using the Goering and Van Soest (1970) procedure modified for using the Ankom Daisy II In Vitro Digester (Ankom Technology Corp., Fairport, NY).

Blood samples were collected at 10 (d 1), 34 (d 2), 58 (d 3), 82 (d 4), 106 (d 5), 178 (d 8), 226 (d 10), 274 (d 12), 370 (d 16), and 418 (d 18) h after termination of grazing. Approximately 10 mL of blood was collected from each steer in the caudal vein at the base of the tail. An extra 10 mL of blood was collected on the initial sample date for determining white blood cell counts. Rectal temperatures were recorded until normal temperatures were measured for each steer for two consecutive days. Sample and data collection was initiated at
Figure 1. Frequency of steer hair coat ratings at the termination of grazing tall fescue pastures (pasture phase). Implantation did not affect \((P > 0.10)\) hair coat ratings; therefore, ratings for implantation and no implantation treatment groups were pooled.

Approximately 0600 and typically took 1.5 to 2.0 h to complete. White blood cell counts were performed on initial whole blood samples using a SYSMEX F800 Hematology Analyzer (Sysmex Corp., Long Grove, IL). Blood samples were centrifuged \((3,000 \times g)\) to separate and collect serum and then frozen \((0^\circ C)\). The serum was subsequently assayed for prolactin by double antibody RIA (Henson et al., 1987), having within and between CV of 8.6 and 14.1%, respectively.

Daily maximum and minimum ambient temperatures were collected from a weather station that was located approximately 1.5 km from the experimental site. Average daily humidities and ambient temperatures were obtained from the NCDC (2000) for measures collected at 2-h intervals from a weather station that was located approximately 48 km from the experimental site. Temperature-humidity indices were calculated from average daily humidities and ambient temperatures using an equation cited by Hahn and Mader (1997).

Statistical Analysis

Effects of implanting on average daily gain (ADG) and leukocyte data were evaluated for the pasture phase using GLM procedures of SAS (SAS Inst. Inc., Cary, NC). An effect of implantation on hair coat rating at the conclusion of the pasture phase was evaluated using CATMOD procedures of SAS. Responses in the pen phase were analyzed as repeated measures using PROC MIXED (Littel et al., 1996) to evaluate effects of protein supplementation, previous implanting, hours following removal from tall fescue, and all interactions. Linear, quadratic, and cubic regression terms for hours were analyzed as covariates, and all interactions of the regression terms with protein supplementation and previous implanting were evaluated as a test for the heterogeneity of slopes (Littell et al., 1992). Data were analyzed as a completely randomized design for both phases using pasture and pen as the experimental units for the respective pasture and pen phases. Residual error was used as the error term for testing treatment effects for both phases.

Results and Discussion

Pasture Phase

Pasture disk meter heights averaged 14.6 cm and ranged from 13.5 to 16.2 cm, which indicated that grazing intensities were low. Consequently, mature forage and seedheads accumulated in all pastures, which are conditions associated with inducing severe toxicosis (Sleper and West, 1996). Furthermore, ergovaline measured at the conclusion of the pasture phase \((2.35 \pm 0.4 \mu g/g \text{ DM})\) was high relative to reports from other studies. Welty et al. (1994) measured ergovaline concentrations in 25 genotypes of ‘Kentucky-31’ infected tall fescue for two consecutive years and reported stems to average 0.292 and 0.13 \(\mu g/g \text{ DM}\) and seed to average 41.
Figure 3. Trends in minimum and maximum ambient temperatures (3a) and temperature-humidity indices (3b) 5 d prior to and during the experimental period. Minimum and maximum ambient temperatures were recorded approximately 1.5 km from the experimental site. Daily averages of ambient temperature and humidity used to calculate temperature-humidity indices were recorded approximately 48 km from the experimental site.

2.5 and 2.3 μg/g DM for yr 1 and 2, respectively. In another study, Hill et al. (1994) was able to elicit toxicosis symptoms in steers grazing tall fescue for 60 d with ergovaline concentrations as low as 0.65 μg/g DM. Hair coat condition ratings taken at the conclusion of the pasture phase further showed that over 90% of the steers had either rough or transitional hair coat ratings (Figure 1). Furthermore, frequency distributions for hair coat condition ratings were similar (P > 0.10) between implant treatment groups.

Implantation with anabolic agents tended (P = 0.16) to improve ADG; however, ADG was highly variable (CV = 34.1%) among pastures. Steer ADG averaged 0.46 ± 0.08 kg for the implant treatment group and 0.32 ± 0.03 kg for the unimplanted group. Paisley et al. (1999) reported an increase in steer ADG with implantation on dormant, native grass prairie despite having BW gains below 0.45 kg/d. Average daily gain in the present experiment was similar to the gain (0.37 kg/d) reported by Aiken et al. (1998) for steers grazing tall fescue in the middle and late spring with no supplementation.

White blood cell counts measured at the conclusion of the pasture phase were similar (P > 0.10) between implant (9,160 ± 675 cells/μL) and no implant (8,300 ± 286 cells/μL) treatment groups. Counts also were within the normal range for cattle (4,000 to 12,000 cells/μL; Whitney, 1999). Therefore, an immune response was not elicited by steers and suggests there were no secondary infections associated with fescue toxicosis. This agrees with a previous study reporting that cattle grazing endophyte-infested tall fescue had normal immune function (Gay et al., 1990).

Pen Phase

The bermudagrass hay had CP of 10.1% and IVDMD of 49.7%. Although CP was adequate, digestibility was
limited for achieving moderate BW gains (NRC, 1996). Based on NRC (1996) values, the protein supplement was estimated to contain 46% CP and 79% TDN. Crude protein and energy concentrations in the offered amount of feed combined with consumed amounts of hay likely would produce moderate BW gains by healthy steers (NRC, 1996).

Initial rectal temperature following removal from tall fescue was similar \((P > 0.10)\) between implant treatments. Initial rectal temperature averaged 39.9°C (Figure 2), which is slightly below the 40.0°C threshold temperature above which sickness or stress is indicated (Smith, 1986). Hot or cold ambient temperatures affect rectal temperature (Cole, 1993), and rectal temperature was taken at times of the day that were shortly after daily minimum temperatures typically occurred (Figure 3). Although rectal temperature was not measured when steers were initially removed from the pastures, it is likely that rectal temperature was above 40°C at this time.

Neither implanting nor protein supplementation influenced \((P > 0.10)\) changes in rectal temperature over the 109 h that rectal temperature was monitored (Figure 2). Rectal temperature of all steers declined linearly \((P < 0.01)\) over the 5-d period. Temperature taken at 82 h following removal from the pastures was below the rectal temperature that is indicative of a healthy animal (39.2°C; Smith, 1986). This agrees with results of Lusby et al. (1990), in which rectal temperature of steers grazing endophyte-infected tall fescue declined to normal after 6 d of removal from tall fescue pastures to bermudagrass-ryegrass pastures. Maximum and minimum ambient temperatures and temperature-humidity indices in the present study generally increased before the beginning of the pen phase but stabilized and did not fluctuate through most of this phase (Figure 3). Reductions in rectal temperature were therefore not influenced by a decrease in ambient temperature and humidity. Results indicate that as little as 3 d are needed to decrease rectal temperature to a normal range for steers exhibiting fescue toxicosis.

Initial serum prolactin averaged 25 ng/mL and was not affected \((P > .10)\) by implanting (Figure 4). These concentrations were similar to those shown by Aiken et al. (1998) and Aiken and Piper (1999) for steers grazing ‘Kentucky-31’ tall fescue in June. Serum prolactin concentration in the present study showed curvilinear increases (linear, \(P < 0.01\); quadratic, \(P < 0.05\); cubic, \(P > 0.10\)) over time, with the regression coefficients being similar between protein supplementation \((P > 0.10)\) and implantation \((P > 0.10)\) treatment groups. Serum prolactin tended to stabilize at approximately 75 ng/mL by 58 h. Although neither protein supplementation nor implantation affected rectal temperature or serum prolactin, both would likely affect BW gain during recovery.

It cannot be conclusively determined that serum prolactin of these steers actually stabilized at acceptable, normal concentrations under the prevailing environ-

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**Figure 4.** Relationship between serum prolactin concentration and hours following removal of steers from tall fescue pastures. Neither protein supplementation nor implantation affected \((P > 0.10)\) serum prolactin over time. The relationship was therefore determined using observations that were pooled over protein supplementation and implantation treatments.

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mental conditions. Serum prolactin of steers exhibiting fescue toxicosis that were transferred to eastern gamagrass (Tripsacum dactyloides L.) were observed by Aiken and Piper (1999) to increase to over 100 ng/mL within a 28-d period, whereas steers remaining on tall fescue and fed daily a 1:1 composted broiler litter and corn mixture never had prolactin concentrations greater than 80 ng/mL for the entire summer. In another study, steers grazing uninfected ‘Kentucky-31’ tall fescue in late June were reported to have serum prolactin concentrations of 114 ng/mL (Aiken et al., 1998). Results of the present study indicate that serum prolactin of steers exhibiting fescue toxicosis can increase in a short period of time, but alleviation of toxicosis may not be complete.

Compensatory BW gains have been obtained in the feedlot for steers backgrounded on endophyte-infected tall fescue (Lusby et al., 1990). Although complete alleviation of fescue toxicosis cannot be concluded from results of the present study, results show that endophyte-induced heat stress can be reduced in 3 to 4 d if calves are placed on a diet that is devoid of endophyte-infected tall fescue. This may allow cattle producers to precondition calves before transport to reduce mortality and possibly to enhance feedlot adjustment and performance.

**Implications**

Changes in rectal temperature and serum prolactin concentration rapidly occurred once steers were placed on diets devoid of endophyte-infected tall fescue. Rectal temperature declined to normal in 3 to 4 d following removal from tall fescue pastures, whether or not steers
received supplemental protein or an estrogenic implant. Serum prolactin concentration gradually increased once steers were removed from tall fescue and stabilized after 3 d, regardless of protein supplementation or implantation. Results indicate that stocker calves exhibiting symptoms of toxicosis can be removed from tall fescue pasture and fed only hay for 3 or 4 d to alleviate symptoms of fescue toxicosis.

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