The Texas Journal of Agriculture and Natural Resource 24:88-96 (2011)

Goat Performance and Prolactin Levels as Affected by Tall Fescue Toxicosis

Brittney L. Junell[1]
Derald A. Harp[1]
Joe H. Bouton[2]
David B. Crenshaw[1]

[1]*Department of Agricultural Sciences, Texas A&M University-Commerce, Commerce 75428*

[2]*Samuel Roberts Noble Foundation, Ardmore, OK 73401*

ABSTRACT

Ergot alkaloids in tall fescue (*Festuca arundinacea* Schreb) infected with *Neotyphodium coenophialum* cause tall fescue toxicosis with symptoms including decreased prolactin and reduced performance. The development and use of tall fescue with "novel" (a.k.a. non-toxic), endophytes that do not produce ergot alkaloids eliminates tall fescue toxicosis in sheep and cattle. This study examined toxicosis in crossbred Boer goat (*Capra hircus*) performance and prolactin levels. Secondly, the commercial potential of a new tall fescue cultivar containing a non-toxic, novel endophytes (PDF584) was assessed for goat production in north central Texas. Grazing toxic tall fescue had no effect on goat gain, body condition score, rectal temperatures, or serum prolactin levels when compared to the other treatments. The goat's physiological ability to de-toxify ergot alkaloids in its liver is speculated to be the cause. PDF584 performed similarly to annual ryegrass and should have potential for use as cool season grazing forage in north central Texas.

KEY WORDS: boer goats, *Festuca arundinacea*, ergot alkaloids

INTRODUCTION

Tall fescue toxicosis is associated with decreased serum prolactin (Elsasser and Bolt 1987; Schillo et al., 1988; Bolt et al., 1982), reduced average daily gain (ADG), increased core body temperature and respiration rates, vasoconstriction, and lowered reproductive activity in grazing livestock (Read and Camp 1986; Hemken et al., 1979, 1981; Bond et al., 1984; Jackson Jr. et al., 1984; Zanzalari et al., 1989). Limited information is available concerning the effect of the ergot alkaloids on goat productivity. Also, no information is available concerning goat performance on tall fescues infected with a novel endophyte. The objectives of this study were to compare performance and serum prolactin levels for goats grazed on tall fescue, and evaluate the performance of a new tall fescue cultivar containing a non-toxic, novel endophyte (PDF584), likely to be released for use in north central Texas.

MATERIALS AND METHODS

All experimental procedures in this research were reviewed and accepted by the Agricultural Research Service Animal Care and Use Committee in accordance with the *Texas A&M University Guide for the Care and Use of Laboratory Animals*.

Six 0.2 ha paddocks were established in fall 2006, on Lufkin-Rader complex soil (Loamy, deep, nearly level, moderately well drained and somewhat poorly drained soils) in Commerce, Texas (33°24′ north latitude; 95°92′ west longitude). Two paddocks (reps) were planted with a wild-type tall fescue cultivar, Bulldog 51, containing a toxic endophyte, two paddocks (reps) were planted with PDF584 tall fescue, an experimental non-toxic cultivar inoculated with a novel endophyte (AR584), and two paddocks (reps) were planted using annual ryegrass. Therefore, treatments were the toxic tall fescue, non-toxic novel tall fescue, and annual ryegrass paddocks in a completely randomized experimental design. Bulldog 51 and PDF584 were supplied as seed by the Samuel Roberts Noble Foundation, Ardmore, Oklahoma. Annual ryegrass was purchased at Northeast Texas Farmers Co-op, Greenville, TX. Paddocks were planted by no-till drill with fescues seeded at 6.8 kg/ha and ryegrass seeded at 18.1 kg/ha. Paddocks were uniformly fertilized with 90.7 kg/ha of 9-23-30 on November 2, 2006 and again on November 5, 2007 with 68 kg/ha of urea. Paddocks were separated with a 7-wire electric fence system maintained with a 6000 to 9000 volt charger in each paddock. Weather data were collected for the duration of the trial using a Davis Instruments Vantage Pro weather station (Davis Instruments, Hayward, Calif.).

Experimental Design I. Crossbred Boer goats (n = 30; 23.6±9.8 kg BW) were stocked on a naturalized pasture composed predominantly of Coastal Bermuda grass and received a daily offering of 14% all-purpose pellet. Prior to grazing, goats were treated for internal parasites with Prohibit™ (AgriLabs) at a rate of [0.63 g/kg BW]. On January 7, 2008, goats were randomly allotted to 1 of 3 treatments by BW to six pasture blocks for a grazing period of 160 d in length in a put-and-take grazing system. Hutches were provided in each paddock. Water and a trace mineral salt-mixture block (United Salt, Houston, TX) were provided ad libitum, and goats were monitored daily. Shrunk weights were taken at the start and finish of the grazing period and at 3-week intervals. Initial weigh date was January 7, 2008 and continued every 21-d until June 12, 2008. For a period of 10 to 12 hours before weigh dates, goats were not fed or allowed access to water. Goats were processed randomly at 9:00 AM and shrunk weights were measured using a manual scale (Paul Scales, Duncan, Ok.). Rectal temperature and respiration rates were taken each time goats were weighed. Rectal temperatures were measured via a handheld digital thermometer (Johnson and Johnson, New Brunswick, NJ) with the probe placed approximately 3 to 4 cm into the rectum. Respiration rates were calculated on sec/10 breaths. BCS were measured (Villaquiran et al., 2000) at 21-d intervals by two trained animal science technicians and averaged. Famacha© scores were observed by a trained animal science technician on 21-d intervals and Cydectin© was administered orally to animals scoring 4 or higher. Once measurements were complete, animals were given access to water and Coastal Bermuda grass hay in pre-assigned holding pens until re-allotted to assigned paddocks.

Blood samples for prolactin analysis were collected at trial initiation on January 7 and January 31, 2008. Blood was placed into 10-ml Vacutainer© tubes and allowed to coagulate at room temperature for 30 min. Tubes were then centrifuged (3,000 x *g*, 24°C, 25 min). Serum was decanted and frozen at -80°C until prolactin analysis was performed. Serum prolactin was analyzed at the University of Tennessee, as described by (Bernard et al., 1993) with anintra- and interassay CV of 10 and 15%, respectively.

Forage sampling was initiated before goats started grazing paddocks and continued throughout the grazing period. The samples from each paddock were then composited and a representative sample was obtained. Duplicate samples were dried at 60°C in a forced-air oven and ground coarsely to 1.5 to 2 cm lengths using a mechanical grinder. Samples were ground through a 1 mm screen using a Wiley Mill grinder and transported to the Samuel Roberts Noble Foundation for analysis. Nutrient components were reported as a percentage of acid detergent fiber (ADF), neutral detergent fiber (NDF), dry matter (DM), Ca, K, Mg, P, protein and total digestible nutrients (TDN) using NIRS (FOSS Analytical model 6500 using ISIscan™ software), located at the Samuel Roberts Noble Foundation in Ardmore, OK. Forage availability within the paddocks was determined by a plate meter method (Bransby et al., 1977) on 21-day intervals. Twenty-five randomly selected tillers were collected from each fescue paddock on 21-day intervals. Samples were placed in dampened brown paper towels and placed in Ziploc© bags. Bags were kept on ice and transported to the Samuel Roberts Noble Foundation within 24 hours of collection for analysis of endophyte (Immunoblot) and alkaloid (ELISA) presence.

Experimental Design II. Forage digestibility *in situ* was determined using three crossbred Boer goats (70.3 ± 4 kg of BW), fitted with rumen collection cannulas provided by the Texas A&M *Agri*Life Research and Extension Center, Stephenville, TX. Goats were housed in a partially open barn with provided shade and ad libitum access to Coastal Bermuda hay and water. For 2 wks. before the beginning of the experimental trial the goats were adapted to the forage. Goats were randomly assigned 1 of 3 treatments consisting of wild-type toxic tall fescue, non-toxic novelty tall fescue and annual ryegrass. Environmental temperatures were consistent with temperatures in north central Texas for July 2008 (The Weather Channel Interactive, Inc.; average temperature: high 34.4°C, low 21.1°C), with barn temperatures approximately equal to environmental temperatures. Forage samples consisted of Bulldog 51 tall fescue, PDF584 novelty tall fescue and annual ryegrass (three replications per treatment). Each treatment was randomly allocated to a specific goat with time intervals of 0, 6, 12, 18, 24, 48, and 96 h to obtain a sufficient degradation curve. Zero bags were used to estimate immediate loss of soluble nutrients and forage sample dust in the rumen while 96 h bags were used to estimate indigestible fiber (IDF) (Van Soest 1994). Dacron bags were weighed before filling with treatment material and after filling. Bags were then heat sealed at two locations on bag. An approximate 2 g sample size was placed in 10 cm x 5 cm bags (50 cm^3) and weighed to the nearest 0.01 g (Nocek 1988). A maximum of nine bags were inserted into the goat rumen at one time attached to a chain using zip ties©. Once bags were removed they were quickly rinsed in ice water to remove loose ruminal particles and arrest microbial fermentation, detached from the chain and placed into a Ziploc© bag and frozen until analysis. All bags were rinsed simultaneously to avoid differences that may be caused by rinsing. Bags were placed into a tub and manually rinsed with distilled water, stirred and squeezed, and the water drained. The process was repeated several times until water was clear. Bags were placed into a washing machine and washed twice on a 2 min rinse cycle (Cherney et al., 1990) then dried in a forced air oven at 60°C and weighed to the nearest 0.01 g.

The experimental design was completely randomized in which animal units were treated as replications and blocked over days. All statistical analyses were conducted using PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Repeated measures (physiological and blood parameters) were analyzed as a split-plot in time. Non-repeated measures (nutrient digestibility) were analyzed as a completely randomized design using one-way ANOVA. The model included main effects and their interactions.

Endophyte Presence, Alkaloid Production, and Forage Availability. In terms of endophyte presence and toxin production, the tall fescue paddocks represented the wild-type toxic and non-toxic novelty treatments as expected. Viable endophyte infection ranged from 87.5% to 95.8% in non-toxic novelty paddocks and 62.5% to 91.7% in wild-type toxic tall fescue paddocks during the study period. Ergot alkaloids were identified in 93.75% of the wild-type toxic paddocks, while the alkaloid was not present in the non-toxic novelty paddocks. As expected, the alkaloid was identified in 93.75% of the toxic endophyte-infected Bulldog 51, while the alkaloid was not present in the non-ergot alkaloid producing PDF584.

Based on plate meter readings, the annual ryegrass treatment had lower ($P < 0.0001$) forage availability across sampling dates than both the wild-type toxic and non-toxic novelty tall fescue treatments. No differences were shown between the two tall fescues treatments. Environmental conditions were favorable for forage growth during winter and spring months, but minimal decline of forage from paddocks was observed. Soil type and paddock location could be a possible cause of forage decline. There was 66% forage availability for novel PDF584 tall fescue and 37% wild-type toxic tall fescue forage availability across sampling dates.

Forage Digestibility. Forage quality of all winter paddocks were within the normal NIRS database limits. Crude protein (CP) concentrations ranged from 8.5 to 13.1% across sampling dates, ADF ranged from 43.3 to 47.7%, and NDF ranged from 62.9 to 69.0%. Annual ryegrass had higher levels of in-vitro total dry matter digestibility (IVTDMD), DM, CP, NDF and ADF compared to both two tall fescue treatments. No differences were found between the two tall fescue treatments for all the same parameters except DM where the wild-type toxic was slightly higher than the non-toxic novelty tall fescue.

In situ digestibility was not different between forage treatments (Figure 1). Treatments of wild-type toxic tall fescue, non-toxic novelty tall fescue and annual ryegrass began at the zero time point with digestibility averages of 22.7, 25.0 and 24.4%, respectively. IDF values were 81.2, 80.6 and 77.7% for the 96 hr time slot.

Physiological Effects. Suppressed serum prolactin concentrations are a widely accepted indicator of fescue toxicosis (Hoveland et al., 1983). Treatment values of serum prolactin concentrations in this current study were within normal limits published by Malven and McMurtry (1973) and did not differ among wild-type toxic and non-toxic novelty treatments or within paddocks to published findings for sheep (Parish et al. 2003a, 2003b) (Figure 2).

Normal values for rectal temperatures in healthy goats in a comfortable 23° C environment are 37° to 39°C (Walker and Dziemian 1950). No treatment effects were observed for rectal temperature across or within treatments throughout duration of the study.

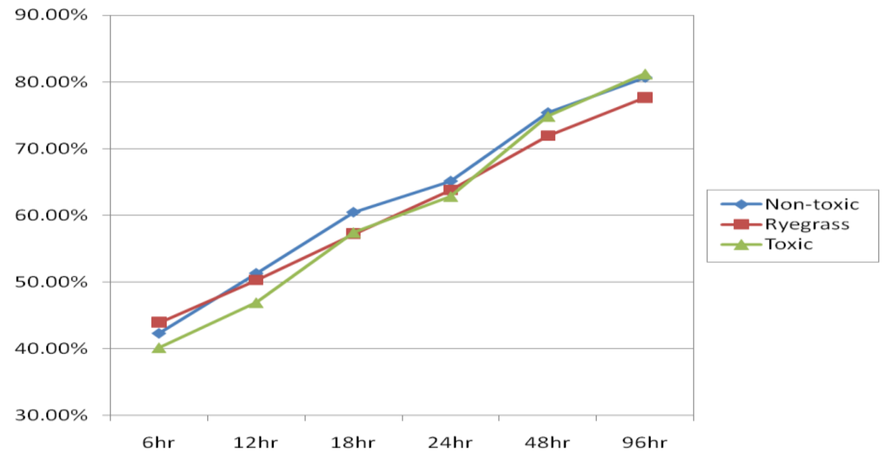

Figure 1. Cannulated Goat *In Situ* Digestibility Results from Annual Ryegrass, Wild-Type Toxic, and Non-Toxic Novelty Tall Fescue Samples.

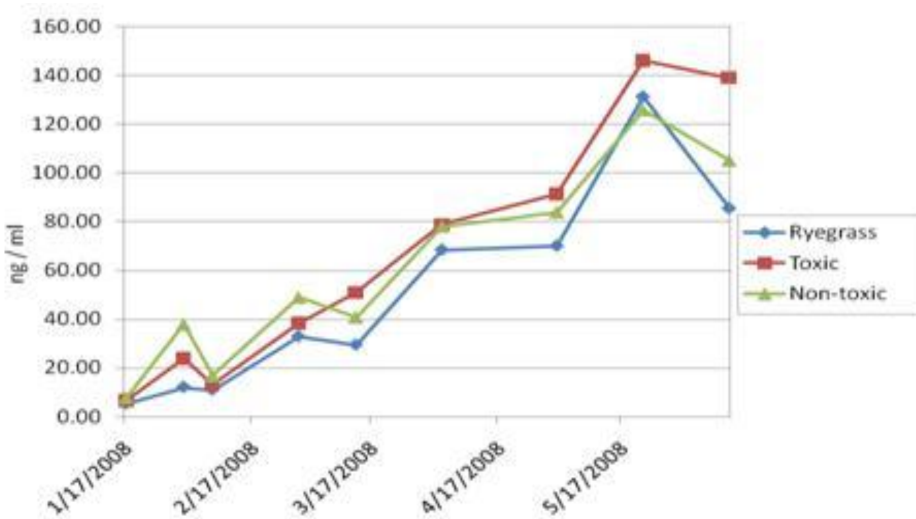

Figure 2. Serum Prolactin Levels in Boer Goats Grazing Annual Ryegrass, Wild-Type Toxic and Non-Toxic Novelty Tall Fescue.

Goats began grazing treatment paddocks with an average BW of 24.0, 23.9, and 23.5 kg for wild-type toxic tall fescue, non-toxic novelty tall fescue and annual ryegrass treatments, respectively. Final BW for the goats within paddocks were 31.75, 35.43 and 35.92 kg. Total weight gain did not differ among or within treatments in this current study.

Respiration rates were not influenced by treatment. Values collected do not vary from normal respiration rates for goats in a 23°C environment of 24 to 40 per minute (Walker and Dziemian 1950).

BCS for the goats remained constant throughout the duration of the grazing period. No differences were noted between or within treatments. All goats kept a clean coat and appearance. Environmental conditions could have contributed to lower scores, but overall scores were well within the normal range of 3 for good body condition (Spahr 2008). Optimal scores for goats are a 1 or 2 according to the Famacha© Anemia Guide. Famacha© scores were not influenced by treatment.

DISCUSSION

Grazing wild-type toxic tall fescue had no effect on goat serum prolactin levels, ADG, respiration rates, core body temperatures, BCS or Famacha© scores. Lack of ergot alkaloid influence on daily rectal temperature match data collected by De Lorme et al. (2007), Matthews et al. (2005), Stamm et al. (1994), and Fiorito et al. (1991) who also found no difference in rectal temperature of cattle or sheep on toxic or non-toxic tall fescue treatments. Both fescue treatments were confirmed through repeated immunoblot testing to harbor the endophyte, and unlike the forage in the wild-type toxic paddocks, the non-toxic novelty tall fescue forage did not produce toxic ergot alkaloids through continuous ELISA testing associated with fescue toxicosis. The non-toxic novelty tall fescue paddocks had optimal forage availability, quality, and digestibility in comparison to wild-type toxic tall fescue and annual ryegrass. Annual ryegrass had greater ($P < 0.0001$) forage quality and digestibility than both tall fescue treatments with lower ($P < 0.02$) ADF and ($P < 0.0001$) NDF values. Annual ryegrass CP levels of 13.10% were also greater ($P < 0.0001$) than both fescue treatments of 8.48 and 9.58%, respectively. However, the CP levels attained in fescue forages should be optimal for pasture grazing and at no time during the grazing period did annual ryegrass give better live weight gain than the new tall fescue containing the novel endophyte.

It is evident that ruminants grazing non-toxic novelty tall fescue do not exhibit signs of fescue toxicosis in comparison to ruminants placed on toxic tall fescue pastures (Bouton et al., 2002; Parish et al., 2003a and b). While new novel endophyte infected tall fescue varieties have resolved the reduction in animal performance, replacement of toxic endophyte infected fescue pastures can be timely and costly. Within this current study goats were visually observed consuming both wild-type toxic and non-toxic novelty tall fescue forage varieties and both treatments remained grazed close to the ground throughout the duration of the study. Clearly, goats within the study did not show signs of fescue toxicosis as reported for other animal species (Hemken et al., 1979; Paterson et al., 1995; Oliver 1997; Burke et al., 2001). The ability of goats to better handle toxins introduced into the body as compared to other ruminants may be attributed to their liver. Once toxins are in the bloodstream, they flow to the liver for rapid degradation and alteration (De Lorme et al., 2007). A goat's liver is known to detoxify harmful agents at a greater rate than other species. For example, Ivermectin© oral dewormer is applied six times higher to goats than cattle (Kaplan 2004). Ergot alkaloids have been shown in previous research to disappear rapidly from both sheep (Jaussaud et al., 1998) and goat (Durix et al., 1999) blood after an intravenous injection of ergovaline. Ergovaline levels dropped below quantification threshold (3.5 mg/ml) within 1 hr after injection. Since research on ergot alkaloid degradation by the liver in livestock has not been performed, it is impossible to determine the extent that the liver alters and detoxifies the toxins. For producers looking for a way to effectively graze tall fescue pastures in north central Texas without hindering animal production or replacing pasture forage, goats may be an animal of choice.

Cool season pasture for commercial goat production in north central Texas is currently limited to annual forage species such as annual ryegrass and cereals. The use of perennial cool season forage such as non-toxic novelty tall fescue could be an economic advantage for producers in the region due to its perennial nature. Results from this study indicate newly developed non-toxic novel endophyte-infected tall fescue cultivars such as PDF584 produce positive goat performance similar to annual ryegrass. Therefore, if producers can achieve an acceptable level of persistence (probably 4-5 years) for this new cultivar, there should be an economic advantage for it as cool season pasture for rapidly growing goats.

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