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Using Mycosorb® to address physiologic changes induced by endophyte-infected tall fescue

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Introduction

Tall fescue (*Festuca arundinacea*) is the most widely grown perennial, cool-season forage grass in the United States and the most abundant forage grass in the southeastern US. Tall fescue is adapted to a wide array of environments but dominates the transition zone between the northern and southern regions of the eastern US. Hoveland (1993) indicated that of 21 states surveyed, tall fescue was used primarily for hay and pasture, with 8.5 million cattle and 688,000 horses grazing these pastures. From an agronomic perspective, tall fescue is desirable because of its ease of establishment, range of adaptation, extended grazing season, pest resistance, and tolerance to poor management (Paterson *et al*., 1995). However, it can be infected with an endophytic fungus known as *Neotyphodium coenophialum* (Morgan-Jones and Gams, 1982). The infection with endophytic fungi stimulates production of an array of bioprotective alkaloids. These include the diazaphenanthrene, pyrrolizidine, and ergot groups (Bush and Burrus, 1988). Endophyte infection, and the resulting alkaloids, has been reported to enhance competitive ability, increase drought tolerance, improve nutrient acquisition, and deter herbivory (Clay *et al*., 2005).

The ergopeptide alkaloids cause fescue toxicosis, a syndrome that costs US livestock producers more than $600 million annually (Hoveland, 1993). Ergopeptide alkaloids, such as ergovaline, ergotamine, and ergovalinine, are non-ribosomally synthesized by the endophytic host and contain lysergic acid and three amino acids that vary among, and define, the molecules of the ergopeptide family (Panaccione *et al*., 2001). Of the ergopeptides, ergovaline is present in highest concentration in fescue and has been associated with its toxic effects. Ergovaline contains D-lysergic acid, L-alanine, L-valine, and L-proline, and differs from the most common ergopeptine, ergotamine, by containing L-valine in place of L-phenylalanine (Brunner *et al*., 1979).

Effects of endophyte on animals and management strategies

In ruminants, as documented particularly in cattle, consumption of endophyte-infected tall fescue can result in hyperthermia and reductions in feed intake, weight gain, serum prolactin concentration, milk production, and reproductive performance (Paterson *et*

al., 1995). In horses, problems associated with consumption of endophyte-infected tall fescue are mostly observed with broodmares. These include prolonged gestation, dystocia, agalactia, thickened placentas, and poor foal viability (Heiman *et al*., 1981; Taylor *et al*., 1985; Monroe *et al*., 1988; Putnam *et al*., 1991). In addition, decreased concentrations of thyroxin, prolactin, progesterone, and estradiol (Heiman *et al*., 1981; Thompson *et al*., 1987; Monroe *et al*., 1988) have been reported. Consequently, researchers have been investigating strategies to alleviate, or minimize, the negative consequences associated with consumption of endophyte-infected tall fescue by livestock. These include dilution through supplementation (Hannah *et al*., 1990; Forcherio *et al*., 1993) or inter-seeding pastures with nonendophyte-infected forage varieties (Hill *et al*., 1979; McMurphy *et al*., 1990). However, these methods have had limited success in counteracting fescue toxicosis.

In recent years there have been a number of products introduced that claim to reduce the negative effects of endophyte-infected tall fescue. One product that has shown promising results is Mycosorb® (Alltech Inc., known as MTB-100™ in some countries). Most of the research completed to date has evaluated the ability of Mycosorb® to improve performance and lower body temperature of beef cattle grazing endophyte-infected tall fescue. In a 2003 review, Akay *et al*. (2003a) noted that supplementation with Mycosorb® increased dry matter intake and reduced rectal temperature in steers consuming endophyte-infected tall fescue seed compared with steers not receiving Mycosorb®. Furthermore, beef cows grazing endophyte-infected tall fescue from late spring to early fall in 2001 and 2002 had greater weight gains when supplemented with 20 g/d of Mycosorb® than cows not given Mycosorb®. In a recent 3-year study, cow/calf pairs were provided increasing levels of Mycosorb® (0, 10, 20, or 40 g/hd/d) from early May to late October each year while grazing endophyte-infected tall fescue pasture (Aaron *et al*., 2006). Cow and calf weight gain and cow body condition score (BCS) increased linearly with increasing dietary Mycosorb®. Therefore, the data suggest supplementation of cattle with Mycosorb® can improve cow and calf performance and reduce ill effects associated with intake of endophyte-infected tall fescue.

Little data are available concerning the ability of Mycosorb® to ameliorate the depression in serum hormone concentration (primarily prolactin and progesterone) often observed with consumption of endophyte-infected tall fescue. Akay *et al*. (2004) used 50 pregnant mares in early gestation to determine the influence of 20 g/hd/d Mycosorb® on serum hormone concentrations. The mares were maintained on pastures with greater than 80% endophyte infection from May 29 to August 21. Serum progesterone was increased with Mycosorb® supplementation. Based on this information, we conducted two trials to comprehensively evaluate the ability of Mycosorb® to mitigate the negative physiologic changes associated with fescue toxicosis in beef cattle.

Trial 1. Alkaloid excretion and prolactin stores in beef steers fed increasing levels of Mycosorb®

This trial was conducted to evaluate the ability of increasing levels of Mycosorb® to counteract the depression in serum prolactin observed with intake of high-alkaloid tall fescue and to determine whether Mycosorb® supplementation alters ergot alkaloid excretion.

METHODS

Sixteen ruminally cannulated Angus × Hereford steers were blocked by weight and, within block, randomly assigned to treatments and housed in individual pens within an enclosed barn with continuous lighting. Mycosorb® was provided to yield the following treatments 0, 20, 40 or 60 g/hd/d Mycosorb®. All steers consumed chopped (4-8 cm), high-alkaloid (579 ppb ergovaline; DM basis) tall fescue straw, which was provided at 120% of the previous 5-day average intake. Also, soybean meal was provided (0.068% BW; CP basis) daily to all treatments to meet 100% of the estimated degradable intake protein requirement assuming a microbial efficiency of 11% (NRC, 1996). The experimental period was 29 days, with 19 days of diet adaptation and 10 days of sampling. Urine and fecal samples were collected on days 22 to 27, composited individually by steer, and stored (-20 ºC) for later analysis of ergot alkaloids. Also, steers were subjected to a thyrotropin-releasing hormone (TRH) challenge to measure pituitary prolactin stores on day 29.

RESULTS

Dry matter intake, rectal temperature, and intake and excretion of ergot alkaloids (Table 1) were not influenced (P>0.25) by increasing Mycosorb®. This finding contrasts with a report by Akay *et al*. (2003a) in which dry matter intake and alkaloid excretion by steers fed endophyte-infected fescue seed were reported to increase with Mycosorb® supplementation. The authors proposed that the alkaloids were adsorbed to the Mycosorb® and were, thereby, less bioavailable and minimized the effects of fescue toxicosis. There were a number of differences between the studies that could explain the contrasting results. We measured ergovaline and lysergic acid, whereas Akay *et al*. (2003a) measured ergovaline and ergovalinine. In addition, we measured alkaloid excretion in µg/kg BW, whereas Akay *et al*. (2003a) reported fecal concentration differences in µg/g DM. The ambient temperature in our study was approximately 2 ºC, whereas Akay *et al*. (2003a) reported 30 ºC. Hemken *et al*. (1981) suggested intake by cattle consuming endophyte-free or endophyte-infected tall fescue did not differ in an environment less than or equal to 23 ºC. This finding could explain why we found no difference in forage intake or rectal temperature.

Table 1. Effect of increasing Mycosorb® on daily excretion of ergovaline and lysergic acid in steers consuming high-alkaloid tall fescue straw.

	Mycosorb® (g/hd/day)					P[b]	
Item	0	20	40	60	SEM[a]	L	Q
Diet, µg/kg BW							
Ergovaline	10.81	10.22	10.17	9.88	0.54	0.26	0.78
Lysergic acid	1.29	1.27	1.23	1.21	0.07	0.35	0.98
Ergovaline + Lysergic acid	12.10	11.49	11.40	11.09	0.60	0.27	0.81
Urine + feces, µg/kg BW							
Ergovaline	5.98	5.88	5.47	5.46	0.381	0.28	0.91
Lysergic acid	2.62	2.52	2.80	2.39	0.158	0.57	0.35
Ergovaline + Lysergic acid	8.60	8.40	8.27	7.85	0.500	0.32	0.83

[a]n= 4

[b]Probability of linear (L) and quadratic (Q) effects of increasing Mycosorb®

In response to the TRH challenge, pituitary prolactin stores increased linearly (P = 0.05) as the quantity of Mycosorb® increased (Figure 1). This linear increase is comparable to the increase in serum progesterone reported by Akay *et al*. (2004) in mares grazing endophyte-infected tall fescue and supplemented with Mycosorb®, suggesting that Mycosorb® is able to counteract the hormonal depression observed with intake of endophyte-infected tall fescue.

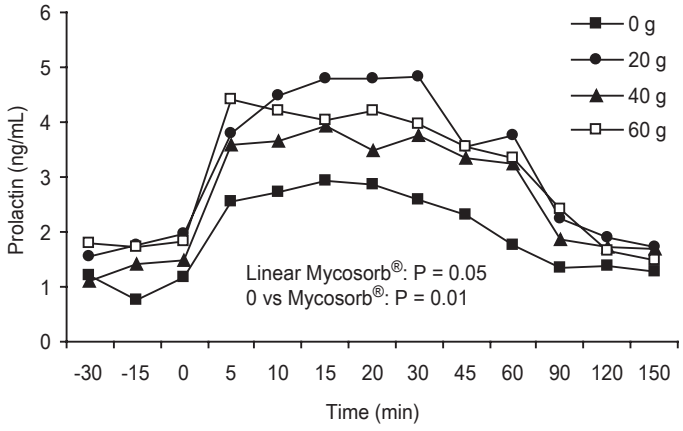

Figure 1. Pituitary prolactin stores in response to a thyrotropin-releasing hormone challenge. Steers were supplemented with 0, 20, 40, or 60 g/hd/d Mycosorb® and consuming 579 ppb ergovaline tall fescue straw. Area under the curve for the 0, 20, 40, and 60 g/day treatments was 210, 343, 284, and 330 ng, respectively.

Trial 2. Serum prolactin and milk production in late gestation beef cows supplemented with increasing levels of Mycosorb®

This trial was conducted to determine whether Mycosorb® supplementation of late-gestation beef cows consuming high-alkaloid tall fescue straw during winter could alleviate fescue foot, depressed serum prolactin, and reduced milk production.

METHODS

Sixty pregnant (approximately 200 d gestation) Angus × Hereford cows were stratified by BCS and assigned randomly to one of 20 pens and one of five treatments (3 cows/pen; 4 pens/treatment) in a randomized complete block design. All cows had unrestricted access to treatments, fresh water, and a loose, trace mineralized salt. A high-alkaloid tall fescue straw and a low-alkaloid tall fescue straw (449 and 147 ppb, respectively) were used in formulating the following treatments: low-alkaloid straw (LOW); high-alkaloid straw (HIGH); high-alkaloid straw and 20 g/hd/d Mycosorb® (20M); high-alkaloid straw and 40 g/hd/d Mycosorb® (40M); and high-alkaloid straw and

60 g/hd/d Mycosorb® (60M). Soybean meal was provided (0.2% BW; CP basis) daily to all treatments to meet 100% of the estimated degradable intake protein requirement assuming a microbial efficiency of 11% (NRC, 1996). An evaluation of all cows was conducted daily at 0630. Appraisal included assigning a locomotion score from 1 to 5. A locomotion score of 3 or higher was considered indicative of fescue foot and necessitated removal from the trial. One cow from the 40M treatment was removed after 55 days due to a lameness score of 4.

Cow body weight (BW) and BCS was measured at study initiation, day 28, and every 14 days thereafter until calving. All weights were obtained after an overnight shrink (16 hrs). Also, cow weight, BCS, and calf weight were obtained within 24 hrs of parturition. Blood samples were collected on day 1 and within 24 hrs after parturition; serum was harvested and stored (-20 °C) for prolactin analysis. Approximately 60 days post-partum, milk production was estimated by weigh-suckle-weigh.

RESULTS

Contrary to Akay *et al.* (2003a) who reported an increase in BW of cows supplemented with Mycosorb® at 20 g/hd/d compared with those not supplemented while grazing endophyte-infected tall fescue (May to October); we noted no differences (P>0.20) in pre- or post-calving change in BW or BCS as Mycosorb® increased. These differing results may be a function of heat stress in the Akay *et al.* study compared with the winter and spring temperatures associated with the current trial. Nevertheless, pre-calving BW change increased (P = 0.02) in LOW cows compared with HIGH cows.

Peters *et al.* (1992) reported daily milk production was 25% lower in animals consuming endophyte-infected compared with endophyte-free tall fescue. Also, reduced prolactin concentrations have been reported in numerous studies with animals consuming high-endophyte diets compared with those consuming low- or no-endophyte diets (Schillo *et al*., 1988; Stamm *et al*., 1994; Samford-Grigsby *et al*., 1997). In our study, milk production increased linearly (P = 0.04) as Mycosorb® increased (Figure 2). This increase is similar to the observed increase in serum prolactin concentration. A suppression of the peri-parturient surge of prolactin has been reported in cattle administered ergot alkaloids and is associated with decreased metabolic activity of the mammary cells (Tucker, 1985). We noted post-calving serum prolactin concentration increased linearly (P = 0.02) with increasing Mycosorb® (Figure 3). Also, post-calving serum prolactin decreased (P = 0.002) for HIGH compared with LOW. Mycosorb® supplementation increased serum prolactin and milk production in beef cows provided high-alkaloid tall fescue straw. As in Trial 1, indices of fescue toxicosis were mitigated with Mycosorb®.

Summary

Mycosorb® supplementation to beef cattle consuming endophyte-infected tall fescue increased dry matter intake (Akay *et al*., 2003a,b) increased weight gain (Aaron *et al*., 2006), lowered rectal temperature (Akay *et al*., 2003a), alleviated prolactin depression, increased pituitary prolactin stores, and increased milk production. In addition, it has increased serum progesterone in pregnant mares grazing endophyte-infected tall fescue (Akay *et al*., 2004).

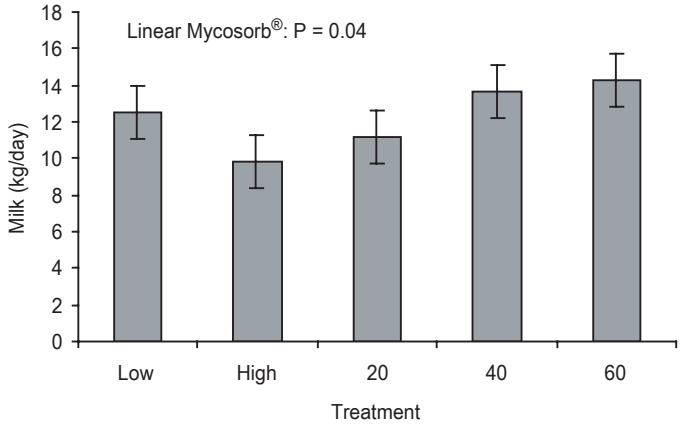

Figure 2. Milk production (approximately 60 days post-partum) in beef cows. Treatments during the last third of gestation were: Low = no Mycosorb® + low-alkaloid tall fescue straw (147 ppb ergovaline); High, 20, 40, and 60 = 0, 20, 40, or 60 g/hd/d Mycosorb® + high-alkaloid tall fescue straw (449 ppb ergovaline).

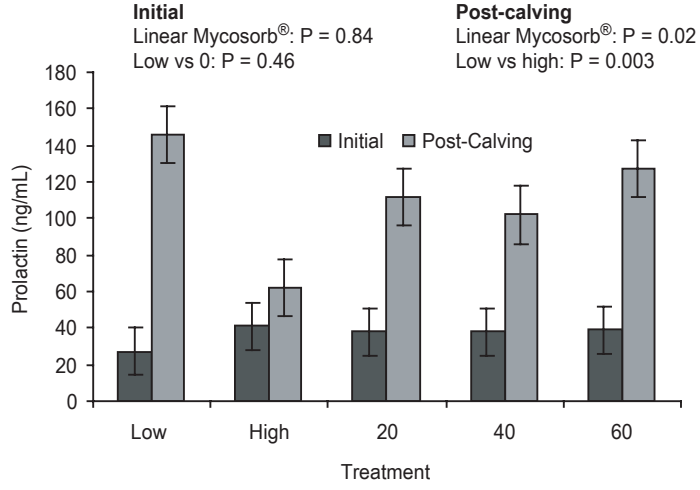

Figure 3. Cow serum prolactin concentration at trial initiation and within 24 hours post-calving. Treatments during the last third of gestation were: Low = no Mycosorb® + low-alkaloid tall fescue straw (147 ppb ergovaline); High, 20, 40, and 60 = 0, 20, 40, or 60 g/hd/d Mycosorb® + high-alkaloid tall fescue straw (449 ppb ergovaline).

Consequently, Mycosorb® appears to moderate most of the negative consequences observed with intake of high-alkaloid tall fescue. In a review of the aforementioned research, it appears that 20 g/hd/d of Mycosorb® is normally sufficient to ameliorate the consequences of fescue toxicosis in cattle and horses. It is not clear what the Mycosorb® mode of action is; however, it has been proposed that it binds the toxin(s) causing fescue toxicosis

(Akay *et al*., 2003a). Nevertheless, in our study, excretion of ergovaline and lysergic acid was not influenced by increasing Mycosorb®. It is possible that metabolism and/or excretion of an alkaloid(s) not measured could have been influenced by Mycosorb® supplementation and caused the positive effects we observed. Further research is warranted concerning the mechanism by which Mycosorb® reduces the effects of fescue toxicosis.

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