

# Animal Response to Toxic and Non-Toxic Tall Fescue

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Tall fescue (*Festuca arundinacea* Schreb.) is currently grown on about 35 million acres in the United States. It has been utilized extensively for grazing cattle, especially in the south central and southeastern regions. Performance of cattle grazing tall fescue has been quite variable, especially during the warm summer season. Reduced performance during this time is often referred to as the summer syndrome, summer slump or summer fescue toxicosis. This syndrome is characterized by reduced gains, elevated body temperature, increased respiration rate, excess salivation, long rough hair coat, decreased milk production and standing in the shade and wet places.

Attempts to identify antiquality components associated with poor performance of ruminants grazing tall fescue have been in progress for many years. The diazaphenanthrene alkaloid perloine was first isolated from perennial ryegrass (*Lolium perenne* L.) in New Zealand (Grimmett and Melville, 1943). Tall fescue was also observed to contain this alkaloid (Grimmett and Waters, 1943). Gentry (1968) reported that perloine concentrations peaked in late July or early August in Kentucky, the time that symptoms of summer fescue toxicosis is often observed.

These findings prompted the studies of Bush et al. (1970, 1972) which showed that perloine inhibited *in vitro* digestion of cellulose and volatile fatty acid production. Decreased growth of the ruminal cellulolytic bacteria *Bacteriodes succinogenes*, *Butyrivibrio fibrisolvens*, *Ruminococcus albus* and *R. flavefaciens* in pure culture were also observed. Perloine monohydrochloride was isolated for an *in vivo* study (Yates et al., 1975). Lambs fed a diet containing 0.5% added perloine had decreased digestibilities of crude protein and cellulose and elevated body temperatures compared with controls (Boling et al., 1975). Earlier work by Buckner et al. (1973) showed that perloine concentration in tall fescue was highly heritable and selections were made containing low concentrations of this alkaloid. During this process, a selection designated as G1-307 tall fescue was observed to be extremely toxic to cattle. This selection was subsequently found to be highly infected with the tall fescue endophyte.

## Endophytic Fungus of Tall Fescue

Bacon et al. (1977) reported that toxic tall fescue contained the endophytic fungus *Epichloe typhina*, which is

currently called *Acremonium coenophialum* (Morgan-Jones and Gams, 1982). The fungus is found within the infected tall fescue plant and is transmitted to subsequent generations via the seed. The endophyte has been shown to be present in high amounts in seed of infected tall fescue plants (Johnson et al., 1983). Siegel et al. (1984) observed that the endophyte was highest in the leaf sheath (dry weight basis), followed by seed, crown, stem, leaf blade and root. The endophyte concentrations in leaf blades and roots were extremely low compared with leaf sheaths and seeds.

The tall fescue endophyte can be determined microscopically or by the enzyme-linked immunosorbent assay (ELISA) developed by Johnson et al. (1982). Siegel et al. (1984) reported that over 97% of the fields tested in a two-year survey in Kentucky were infested with the endophyte. Daniels et al. (1985) in an Arkansas survey observed that 80% of the plants examined microscopically contained the endophyte.

There are no visible symptoms of infestation of tall fescue plants by the endophytic fungus (Hinton and Bacon, 1985). The general measurement of forage composition and yield seem to be unaffected. Isolation of the pyrrolizidine alkaloids N-acetyl loline and N-formyl loline from tall fescue was reported by Robbins et al. (1972), which was prior to recognition of the endophyte in tall fescue. Subsequently, the positive relationship between *Acremonium coenophialum* infestations and concentrations of N-acetyl and N-formyl loline alkaloids in tall fescue was established by Bush et al. (1982). Ergopeptine alkaloids (Yates et al., 1985), peptide and clavine ergot alkaloids (Lyons et al., 1986), and steroid metabolites (Davis et al., 1985) have also been isolated from toxic tall fescue. An excellent review of ergot toxicity from endophyte infected grasses was recently published by Bacon et al. (1986).

## Animal Responses to Tall Fescue

Steen et al. (1979) compared the performance of yearling beef steers grazing Kentucky 31, G1-306, G1-307 and Kenhy tall fescue from March 24 to September 3 (Table 1). Steers grazing G1-307 had lower gains than those grazing the other selections and exhibited signs of summer fescue toxicity. Respiration rates were increased, a modest elevation in body temperature observed and calves had a long rough hair coat. Those grazing G1-307 also spent more time under pasture

TABLE 1. Gain, Respiration Rate and Body Temperature of Steers Grazing Kentucky-31, GI-306, GI-307 and Kenhy Tall Fescue<sup>1</sup>.

	Variety			
	Ky-31	GI-306	GI-307	Kenhy
Mean daily gain, kg <sup>2</sup>	0.42 <sup>a</sup>	0.38 <sup>a</sup>	0.29 <sup>b</sup>	0.40 <sup>a</sup>
Respiration rate, counts/min.	66.0 <sup>c</sup>	63.4 <sup>c</sup>	81.5 <sup>d</sup>	64.8 <sup>c</sup>
Rectal temp., C	38.67	38.74	39.13	38.78

<sup>1</sup>Means on the same line bearing different superscripts differ significantly <sup>a,b</sup>( $P < .05$ ), <sup>c,d</sup>( $P < .01$ ).

<sup>2</sup>Grazing period was March 24-September 3.

Source: Steen et al. (1979).

shades and seemed to be extremely sensitive to heat stress.

Kentucky 31, GI-306 and GI-307 fields were established from these same seed lots for evaluation using lactating dairy cows. Hemken et al. (1979) evaluated these forages in a 2-year study. Holstein cows were fed 7.3 kg daily of a concentrate mix plus either Kentucky 31, GI-306 or GI-307 forages harvested as green chop and fed fresh to cows in tie stalls during July and August. Cows consuming GI-307 had reduced forage intake, reduced milk production, body weight loss and increased respiration rates compared to those fed Kentucky 31 and GI-306 forages. Cows fed GI-307 had a significant elevation in body temperature during the second year of the study. These data prompted further investigations concerning the severe toxicity of GI-307 forage.

Since steer grazing and lactating dairy cow trials were conducted during the summer months, Hemken et al. (1981) conducted a study with calves in environmental rooms to determine the possible relationship of toxic symptoms to environmental temperature. Calves were fed fresh green chop GI-306 and GI-307 forages at 10-13 C, 21-23 C and 34-35 C (Table 2). Calves fed GI-307 at the high temperature (34-35 C) had reduced forage intake, increased respiration rate, elevated body temperature and loss in body weight when compared to those consuming GI-306 forage. These same measurements were not significantly different between

TABLE 2. Performance of Calves Fed Tall Fescue Forages in Temperature Controlled Rooms<sup>1</sup>.

Tall fescue	Room temp.	Weight Change (21-day)	Dry matter intake <sup>2</sup>	Rectal temp. <sup>2</sup>	Resp. rate <sup>2</sup>
GI-306	10-13	+22.0	78.6	39.1	20.7
GI-307	10-13	+22.3	80.0	38.7	20.3
GI-306	21-23	+20.2	79.5	39.1	27.8
GI-307	21-23	+15.0	78.2	39.1	29.7
GI-306	34-35	+11.7	70.0	40.2	91.9
GI-307	34-35	- 9.3	33.2	41.1	110.0

<sup>1</sup>Effects of temperature forage, and forage x temperature were significant ( $P < .05$ ) for all variables measured except for effect of forage on dry-matter intake.

<sup>2</sup>Average for second and third weeks of trial.

Source: Hemken et al. (1981).

forage treatments at 10-13 C and 21-23 C, which resulted in a significant ( $P < .01$ ) temperature x forage interaction. These data clearly demonstrated that the symptoms of toxicity were amplified at elevated environmental temperatures, and were consistent with the symptoms observed in grazing steers and lactating dairy cows consuming GI-307 during the summer months. It was subsequently determined that GI-307 was highly infected with the endophyte *Acremonium coenophialum* and was also high in N-acetyl and N-formyl loline alkaloids.

In order to study the relationship of endophyte infection to animal performance, GI-307 parental plants were grown in soil containing the systemic fungicide benomyl. Seed from these plants were used to establish fields for hay production. Jackson et al. (1984) fed hay from orchardgrass and the forages established from the seed of GI-307 benomyl-treated and untreated plants. Hay harvested from fields established from seed of benomyl-treated and untreated GI-307 plants had N-formyl plus N-acetyl loline concentrations of 115 and 875  $\mu\text{g/g}$  and *Acremonium coenophialum* infection estimates of 44 and 95%, respectively. The response of calves consuming these hays in environmental rooms at 31-32 C is presented in Table 3. Calves consuming hay from the benomyl-treated GI-307 had higher intake, lower body

TABLE 3. Response of Calves Fed Orchardgrass and GI-307 Tall Fescue Hay Established From Seed of Benomyl-Treated and Untreated Plants<sup>1</sup>.

	Orchard grass	GI-307	
		Untreated	Treated
Feed intake, gm/kg BW <sup>.75</sup>	77.8 <sup>a</sup>	51.1 <sup>b</sup>	73.1 <sup>a</sup>
Rectal temp., C	39.7 <sup>a</sup>	41.0 <sup>ab</sup>	40.2 <sup>b</sup>
Respiration rate, counts/min.	72.6 <sup>c</sup>	103.9 <sup>d</sup>	75.2 <sup>c</sup>
Body weight change, kg	1.5 <sup>a</sup>	-18.2 <sup>b</sup>	-2.3 <sup>a</sup>

<sup>1</sup>Data are means of measurements taken during the last 6 days of a 15-day trial.

Means on the same line bearing different superscripts differ significantly <sup>a,b</sup>( $P < .05$ ), <sup>c,d</sup>( $P < .01$ ).

Source: Jackson et al. (1984a).

temperature, lower respiration rate and less body weight loss than those consuming hay from untreated GI-307. Responses of calves in the benomyl treated GI-307 and orchardgrass treatments were similar. These data clearly demonstrated that a reduction of the endophyte resulted in improved animal response.

The results of several studies in which steers and(or) heifers grazed endophyte-infected or low-endophyte tall fescues are presented in Table 4. Boling et al. (1985) compared the performance of yearling beef steers grazing endophyte-infected Kentucky 31 (61% infection), low-endophyte Kentucky 31 (<1% infection), Johnstone (6.7% infection), and low-endophyte Kenhy (<1% infection) tall fescues. Johnstone is a low-diazaphenanthrene alkaloid, low-endophyte selection developed by Buckner et al. (1983). The Johnstone PVR (pre-varietal release) seed used in this study contained 6.7% endophyte infection, but Johnstone

TABLE 4. Gains of Steers and Heifers Grazing Endophyte Infected or Low Endophyte Tall Fescue (kg/day).

Cattle	Grazing season	Forage					Reference
		Endophyte Infected Kentucky-31	Low Endophyte Kentucky-31	Johnstone (PVR)	Low Endophyte Kenhy	GI-307 Tall fescue	
Steers	Spring/summer	0.45	0.70	0.89	0.84	—	Boling et al. (1985)
Heifers (Trial 1)	"	0.23	0.42	0.39	0.34	0.22	Bolt and Bond (1985)
	(Trial 2)	0.20	0.26	0.30	0.21	0.10	Bolt and Bond (1985)
Steers	"	0.61	0.77	—	—	—	Stuedemann et al. (1984)
Steers	Fall	0.77	1.07	—	—	—	Boling et al. (1984)

certified seed marketed contains less than 5% endophyte infection (Buckner et al., 1985a). Calves grazing the low endophyte selections had higher gains than those grazing endophyte-infected KY-31, with the highest gains observed in calves grazing Johnstone and low-endophyte Kenhy. Calves grazing endophyte infected KY-31 had suppressed serum prolactin and elevated body temperatures compared with calves grazing the low-endophyte selections. Previous studies by Hurley et al. (1981) and Bolt et al. (1982) showed depressed serum prolactin concentrations in cattle and sheep, respectively, consuming toxic tall fescue. Steers grazing the endophyte-infected KY-31 exhibited the additional characteristic signs of summer fescue toxicity (long rough hair coat, excess salivation, respiratory distress, standing in shade and wet places when accessible).

Bolt and Bond (1985) compared the performance of heifers grazing the same forage selections in addition to GI-307. Endophyte infected KY-31 and toxic GI-307 resulted in

Bolt and Bond (1985) compared the performance of heifers grazing the same forage selections in addition to GI-307. Endophyte infected KY-31 and toxic GI-307 resulted in reduced gains compared with the three low-endophyte selections. A marked depression in serum prolactin concentrations was observed due to endophyte infection. Stuedemann et al. (1984) also observed improved performance of steers grazing low-endophyte KY-31 compared with those grazing endophyte-infected KY-31.

Boling et al. (1984) conducted a study with yearling steers during the late fall to determine whether the decreased performance observed in the summer was apparent when environmental temperatures were decreased. Endophyte-infected KY-31 and low-endophyte KY-31 pastures were allowed to accumulate growth from August 9 until November 11. Calves grazing endophyte-infected KY-31 had reduced gains and elevated body temperatures during this period of cold environmental temperatures. However, gains of both groups were greater than those of cattle grazing these same respective pastures during the summer grazing period. The toxin(s) of endophyte-infected toxic tall fescue are also present in seed and have been shown to contain biological activity in hay stored for three years (Jackson et al., 1984).

Gay et al. (1984) grazed beef cows and calves on endophyte-infected KY-31 and the improved tall fescue selection low-endophyte Kenhy. The 205-day adjusted weaning weights of calves averaged 180 kg for those grazing endophyte-infected KY-31 while those on low-endophyte Kenhy tall fescue averaged 216 kilograms. Conception rates were 67 and 86% for cows grazing the two forages, respectively. Morrow et al. (1984) observed reduced performance of nursing beef calves as the level of endophyte in the forage increased. As cited by Buckner et al. (1985a, 1985b), removal of the fescue endophyte from a variety and low-endophyte varietal selection resulted in increased dry matter intake and milk production in dairy cows.

The toxin(s) of tall fescue associated with endophyte infection remain elusive, even though specific compounds are observed when the endophyte is present in the plant as previously discussed. Extraction of toxic tall fescue resulted in fractions which suppress serum prolactin and brain catecholamine levels in rats (Porter et al., 1985). Further extraction studies are needed to isolate toxin(s) associated with endophyte infection of tall fescue, and verify their biological activity in cattle. Such findings would open potential avenues for development of procedures or methods to alter biological effects of characterized toxin(s).

### Summary

The data to date suggest that replacement of endophyte-infected tall fescue with low or endophyte free selections results in increased gain of grazing yearling cattle, weaning weight of nursing calves, milk production and conception rates of cows. Planting such selections and replacement of old stands with low endophyte selections where feasible should yield improved performance in many cattle systems. However, methods need to be developed for replacement of existing infected sods with endophyte free tall fescue, especially those stands on excessive slopes. Management strategies for grazing low-endophyte fescues are also vitally needed. The utilization of endophyte free tall fescue selected for increased nutritive value, yield, persistence, disease resistance and low diazaphenanthrene alkaloids seems to offer a great potential for improved productivity of cattle consuming tall fescue.

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