# Endophyte in Tall Fescue: Impact on Horses and Cattle

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Tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh.] is an introduced cool-season perennial grass from Europe. Originally imported for regularly flooded pastures, tall fescue is now widespread across the United States due to its adaptability of a wide range of soils and climate. Kentucky 31 tall fescue is the ecotype discovered in 1931 by E.N. Fergus, which launched its popularity as a dependable, adaptable, and palatable pasture crop. In the mid-1970s, the negative effects caused by consuming tall fescue were termed fescue toxicosis. The source of fescue toxicosis was not identified until Charles Bacon first reported evidence of an endophytic fungus in tall fescue. The endophytic fungus, later identified as *Neotyphodium coenophialum*, has a symbiotic relationship with tall fescue. Tall fescue provides nutrients for the endophyte, while *Neotyphodium coenophialum* produces toxic alkaloids that protect the plant from herbivory, diseases, and gives the plant its tolerance of many environmental stresses, including drought. The three main classes of alkaloids that potentially cause fescue toxicosis are ergot, pyrrolizidine (lolines), and pyrrolopyrazine (peramine) alkaloids (Schultz). Ergot alkaloids are made up of three families: ergopeptines, ergolines, and clavines. **Ergovaline,** an ergopeptine, is the primary alkaloid toxin affecting grazing mammals. *Neotyphodium coenophialum* does not change the appearance of the plant. Therefore, the endophyte is only detected by laboratory analysis. Endophyte-infected tall fescue spreads solely by seed. Due to the vast acreage of tall fescue, fescue toxicosis is the top toxicity problem of large animals in the United States.

## Tall Fescue and Cattle

In beef cattle, endophyte infected tall fescue consumption can cause the following disorders:

Fescue Foot – Fescue foot is a dry, gangrenous condition of the body extremities of cattle consuming “wild” endophyte fescue. Usually it causes lameness and/or the loss of the tips of the tails or ears, but may result in sloughing of hooves or feet. Animal gains also are reduced. Fescue foot is generally associated with cold weather.

Bovine Fat Necrosis – This condition of cattle is caused by the presence of masses or hard fat in the abdominal cavities that can cause digestive or

calving problems. It usually occurs only where essentially pure wild endophyte fescue pastures have been heavily fertilized with poultry litter or nitrogen fertilizer.

Fescue Toxicity – Signs of fescue toxicity can include: (1) reduced feed intake; (2) decreased weight gain; (3) lower milk production; (4) higher respiration rate; (5) elevated body temperature; (6)rough hair coat; (7)more time spent in water and/or shade; (8) less time spent grazing; (9) low blood serum prolactin concentration; (10) excessive salivation; and (11) lower reproductive performance. Some or all of these responses have been observed with beef cattle, dairy cattle, sheep, and deer consuming pasture, greenchop, hay and/or seed.

## Effects of Endophyte on Grazing, Intake, Digestibility and Gain in Cattle

Grazing Time **-** Several studies have shown that as endophyte infection level (the percentage of fescue plants in a stand that are infected) increases, animals spend less time grazing during the day and more time grazing at night. In Maryland, grazing time was reduced by about 20% as compared to steers grazing EF fescue (Table 1).

**Table 1. Percentage of time steers grazed during daylight or dark hours.**

| | Endophyte Level | |
|---|---|---|
| | Low% | High % |
| **Daylight** | **52** | **34** |
| **Dark** | **14** | **22** |

Bond, J., J.B. Powell. and B.T. Weinland. 1984. Behavior of steers grazing several varieties of tall fescue during summer conditions. Agron. 7,76:707.

In a Georgia study in which steers were switched from EI (95% infected) to EF (<1% infected) fescue, steers on EF fescue spent about 60% of the time between noon and 6:00 p.m. grazing, as compared to only about 5% by steers on EI fescue. Steers switched to EI fescue showed a reduction in grazing time within two days, and forage intake for this group was depressed within one week. Forage intake for the group switched to EF fescue remained lower for at least 10 days following the switch, but was normal after 28 days. However, grazing time for those switched to EF fescue was still reduced one month later.

Intake and Digestibility - On-farm observations and research have provided evidence that cattle prefer EF and novel endophyte fescue. In Tennessee, steers had a preference for clover in EI pastures, but there were indications that they preferred fescue to clover in EF pastures. When heifers in Missouri were offered diets containing 60% fescue seed, either EF or 75% EI, 11 of 12 heifers avoided the EI diets. Much, but not all, of the reduction in livestock average daily gain (ADG) or gain per unit area of land an EI fescue is due to reduced feed intake.

Normally, physical factors such as high fiber content of forage are associated with poor intake, but they do not explain intake differences between EI and EF fescue. Further, the toxins do not appear to have a major effect on microbial digestion in the rumens of grazing animals. Forage digestibility and crude protein levels are similar in EI and EF fescue.

## Effects on Beef Yearling Gains

Since the early reports of the association of the endophyte with fescue toxicity, many grazing and feeding trials with EI and EF fescue have been conducted. A summary of data (Table 2), illustrates that decreased gains of steers grazing EI forage are widespread, quite uniform, and not limited to certain geographic areas or management conditions.

**Table 2. Daily gains of steers as affected by low or high incidence of endophyte infection.**

| | Endophyte[1] | | Daily Gain | | | |
|---|---|---|---|---|---|---|
| Location | Low E | High E | Low E lb/day | High E lb/day | Feed | Reference |
| Alabama | 2 | >90 | 1.83 | 0.99 | Pasture | Hoveland et al., 1983 |
| Arkansas | 0 | 81 | 1.57 | 1.21 | Pasture | Goetsch et al., 1988 |
| Kentucky | <1 | 61 | 1.54 | 0.99 | Pasture | Boling, 1985 |
| Missouri | 3 | 83 | 1.37 | 0.46 | Pasture | Crawford et al.,1989 |
| Oklahoma | <1 | 76 | 1.87 | 1.37 | Pasture | McMurphy et al., 1990 |
| Tennessee | 2 | 71 | 1.48 | 1.06 | Pasture | Chestnut et al.,1991 |
| Virginia | 0 | 77 | 1.43 | 0.90 | Pasture | Tulley et al.,1989 |

[1]Number of infected tillers per 100 tillers.
[2]Not reported.

Fescue toxicity is sometimes referred to as "summer syndrome" or "summer slump" because visible signs are most pronounced during hot weather. However, poor weight gains on EI pastures can occur throughout the grazing season. In an Alabama study (Table 3), during November, December, and March there was a 50% decrease in ADG of steers grazing EI fescue, as compared to EF fescue. During the warmer months of April, May and June, the decrease was 59%.

Factors affecting animal reaction to fungus toxins include air temperature, humidity, presence of other forages, animal management, and time of year (toxin levels are higher in spring and summer than at other times during the year). Though several factors affect reaction to the toxins, steer ADG typically decreases about: 0.1 lb for each 10% increase in infection rate.

In Georgia, grazing behavior of steers on EI and EF fescue pastures was similar in March. However, higher temperatures during April and June resulted in steers on EI fescue spending less time grazing, more time standing in the shade (heat stressed animals normally stand to maximize evaporative cooling), and consuming more water than steers on EF fescue.

**Table 3. Seasonal daily gains (lb) of steers grazing infected and non-infected fescue (3 yr average).**

| Months | Endophyte ~5% | Endophyte >94% | ADG Decrease |
|---|---|---|---|
| Nov., Dec., Mar. | 1.59 | .79 | 50% |
| Apr., May, June | 1.72 | .71 | 59% |

Hoveland, C.S., S.P. Schmidt, C.C. King, Jr. and E.M. Clark. 1984 Association of fungal endophyte with seasonal gains of beef steers grazing tall fescue pasture. In: H. Riley and A.D. Skelvag (Ed.) Proc. Eur. Grassl. Fed. p. 382-386.

If forced to exert themselves physically during hot weather, animals suffering from severe fescue toxicity are at risk for heat overload that can result in death.

Increased nitrogen (N) fertilization increases the incidence of bovine fat necrosis, but investigations have revealed that N fertilization does not affect steer ADG on EI fescue (except indirectly by increasing the competitiveness of fescue, thus increasing the amount of toxic fescue in an animal's diet). However, N fertilization of EI fescue can increase gain per acre because of higher stocking rates.

## Effects on Beef Cows and Calves

Most fescue pasture in the United States is used in commercial beef cow-calf operations. In several studies (Table 4), cows grazing EI fescue lost weight and had lower pregnancy rates, and their nursing calves had slower gains and reduced weaning weights, compared to those grazing EF pastures.

**Table 4. Effect of endophyte-infected fescue on the performance of cows and nursing cows.**

| Cows | | | | Calves | | | | |
|---|---|---|---|---|---|---|---|---|
| Daily gain | | Pregnancy rate | | Daily gain | | 205-day wean wt | | |
| Low E | High E | Low E | High E | Low E | High E | Low E | High E | Reference |
| lb/ day | | % | % | lb/day | | lb | lb | |
| 1.01 | -0.51 | --[1] | -- | 2.56 | 1.87 | 520 | 434 | Schmidt et al.1983 |
| 0.46 | -0.11 | 95 | 55 | 1.72 | 1.37 | 474 | 410 | Gay et al.1988 |
| 0.44 | -0.15 | 87 | 58 | 1.63 | 1.30 | 489 | 419 | Essig et al.1989 |
| 0.09 | -0.24 | 89[2] | 74 | 1.61 | 1.28 | -- | -- | Tucker et al. 1986b |
| 0.79 | -0.46 | 78 | 49 | 2.25 | 1.90 | 529 | 461 | McDonald, 1989 |

[1]Not determined or not reported Low E fescue was 21% INF vs. 77% for High E.
[2]Low E fescue was 21% INF vs. 77% for High E.

A decline in body condition can affect reproduction, and cows that are thin before and at calving may have a long interval between calving and first estrus. Therefore, cows entering the breeding season in a poor or negative gaining condition because of El fescue probably will have a prolonged post-partum interval regardless of later endophyte effects. In Kentucky and

Missouri, supplementary feed (in the form of either clover or grain) for cattle on EI fescue improved pregnancy rates, but not up to economically acceptable levels. Thus, it appears that factors other than nutrition are involved in the reduced pregnancy rates associated with EI fescue.

## Effects on Beef Heifers

In an Alabama study, weaned beef heifers were assigned to pastures having low, medium, or high levels of infection (Table 5), and received hay of similar infection levels during winter.

**Table 5. Effect of endophyte-infected fescue on gains, pregnancy rates and milk yield of heifers.**

| Endophyte Level % | Initial weight lb | Daily gains | | Post-calving | | |
|---|---|---|---|---|---|---|
| | | Grazing lb/day | Winter lb/day | Pregnant % | Pregnant % | Milk produced lb/12 hr |
| 0-5 | 562 | 1.65 | 0.18 | 0.96 | 0.93 | 8.16 |
| 25-60 | 560 | 1.26 | 0.35 | 0.82 | 0.45 | 7.05 |
| 80-99 | 591 | 0.75 | 1.19 | 0.55 | 0.33 | 3.97 |

Danielson, D.A., S.P. Schmidt, C.C. King, L.A. Smith and W.B. Webster. 1986. Fescue toxicity and reproduction in beef heifers. J. Anim. Sci. 63 (Suppl.1): 296 (Abstr.).

Schmidt, S.P., D.A. Danielson, J.A. Holliman, H.W. Grimes and W.B. Webster. 1986. Fescue fungus suppresses growth and reproduction in replacement beef heifers. Alabama Agric. Exp. Stn. Highlights Agric. Res. 33(4):15

Heifer ADG decreased as infection level increased. All heifers were observed in estrus prior to their first breeding, but pregnancy rates decreased as infection level increased. Following first calf births, pregnancy rates were further reduced in heifers grazing pastures with medium and high infections levels, but not in those grazing low-endophyte pastures.

Initiation of the estrous cycle in heifers grazing EI fescue is not delayed, and cessation of the estrous cycle in animals already cycling does not occur. Research in Alabama indicates that conception in cattle is not affected by the endophyte. Reduced calving percentages of cattle on EI fescue appears to be due to early embryonic death.

## Brahman vs. British Breeds of Cattle

Brahman cattle are known for their heat tolerance and may be better adapted to resist or tolerate the hyperthermia (high body temperature) observed during hot weather. In breed comparisons, Angus and Brahman- Angus cross steers have exhibited decreased gains when grazing El fescue, but the magnitude of the decrease is less for the Brahman-cross steers. Brahman-cross animals frequently gain better due to greater heterosis, so reduced endophyte effects, if any, are difficult to detect.

## Feedlot Gains of steers that Previously Grazed Fescue

Because of their unthrifty appearance, steers that have grazed fescue often bring reduced prices, making it important to determine whether there are carryover effects on feedlot performance. Studies in Georgia, Arkansas, Oklahoma, and Tennessee indicate that when steers grazed on EI fescue arrived at a feedlot during cooler weather, they gained faster than steers that had grazed EF fescue, especially during the first 28 days.

Steers arriving during hot weather did not show increased *gains,* but their gains were not reduced as a result of previous exposure to EI fescue. However, in a Georgia experiment, steers grazing endophyte-free fescue continued to show the same gain advantage over EI fescue in the feedlot as they did a pasture.

## Effects on Milk Production

Consumption of EI fescue reduced milk production by as much as 45% in beef cows and 50% in beef heifers in Alabama, and by 60% in dairy cows in Kentucky. Milk production of lactating dairy cows can be sharply reduced even when fescue has low infection levels. Milk production by dairy cows consuming EF fescue was similar to those grazing alfalfa-orchardgrass in Kentucky and annual ryegrass in Alabama. Differences in milk production caused by consumption of toxic fescue appear to be primarily due to differences in forage intake.

## Effects on Thermoregulation

Cattle consuming EI fescue typically exhibit hyperthermia (abnormally high body temperature) during warm weather as shown by increased rectal temperature. Studies in Kentucky have shown that EI fescue has the most detrimental effect on cattle when the ambient temperature exceeds 88$^{o}$F.

In Alabama, steers were fed non-infected or infected hay and seed in controlled environments at 70°F (cool) and 90°F (hot). Feed intake was reduced 36% by steers fed the EI diets in the cool environment, abut rectal temperatures and respiration rates were not affected. In the hot environment, feed intake was reduced 60% in steers fed the EI diet, and rectal temperatures and respiration rates increased.

In the cool environment, steers fed the EI diet had reduced temperatures at the body extremities (ear tips, tail tips, hooves). This hypothermia (reduced temperatures) in animals consuming EI fescue is most likely a result of vasoconstriction (constriction of the blood vessels) caused by the fungus toxins, and the reduced blood flow results in the fescue foot syndrome.

In a study in Georgia, body temperature of steers grazing EI fescue was higher in summer and colder in winter than those of animals grazing either EF or novel endophyte fescue.

Thus, it is clear that the toxins in EI fescue result in abnormal function of the thermoregulatory center in many animals. In warmer weather animals have difficulty eliminating heat from their bodies (evidenced by standing in shade or water, panting, etc.). Cold temperature results in natural restriction of blood flow in body extremities to minimize heat loss, but additional restriction caused by the fungus toxins reduced blood flow too much and may cause gangrene. Furthermore, when animal's body temperature is such that it makes it uncomfortable (hot or cold), it spends less time grazing and forage intake is reduced.

## Tall Fescue and Horses

The most evident effects of equine fescue toxicity are apparent in pregnant mares. Monroe was the first to find conclusive evidence concerning pregnant mare tall fescue toxicity and reported increased gestation length, agalactia, foal and mare mortality, tough and thickened placentas, retained placentas, weak and dysmature foals, reduced serum prolactin levels and reduced progesterone levels. Other symptoms include abortions, decreased conception, early embryonic mortality, and dystocia. Studies found a general lack of elevated body temperatures, unlike fescue toxicity in cattle, but some studies reported increased sweating in pregnant mares. Since horses possess more sweat glands than cattle, evaporative cooling from sweating more freely regulates body temperature. Research has shown that toxicity symptoms appear in pregnant mares at ergovaline levels greater than 300 parts per billion (ppb). However, most extension publications suggest a more conservative level of 150 ppb. Tables 6 and 7 summarize historical research studies on fescue toxicity symptoms at various ergovaline concentrations. During the last trimester of pregnancy, scientists generally recommend mares be removed from endophyte-infected pastures to avoid serious complications.

| **Table 6. Summary of ergovaline research on mares during conception and the first trimester of pregnancy (first 110 days).** | |
|---|---|
| Concentration of Ergovaline (ppb) | Symptom |
| 45 | No negative pregnancy outcomes |
| 160 | No clear signs of fescue toxicosis |
| 271 | No negative pregnancy outcomes |
| 308 | Weight loss<br>Suppressed serum prolactin<br>No adverse effects on pregnancy through day 28 |
| 325 | Signs of fescue toxicosis |
| 867 | Decreased progestogen concentration<br>No effect on embryonic development<br>No pregnancies lost |
| 1171 | Significantly prolonged luteal function<br>Decreased 14 day viable pregnancy rate per cycle<br>Increased early embryonic death rates |

| **Table 7. Summary of ergovaline research on mares during late term pregnancy (last 60-90 days).** | |
|---|---|
| Concentration of Ergovaline (ppb) | Symptom |
| 390 | Dystocia with foal survivability greatly reduced<br>Prolonged gestation<br>No evidence of udder development nor lactation prior to and during parturition |
| 300-500 | Failure to come into heat<br>Early-term abortions<br>Prolonged gestation<br>Retained placentas<br>Difficult births<br>Poor udder development with little or no lactation<br>Poor foal survival |

Unlike pregnant mares, little is known concerning the effects of fescue toxicity on stallions and geldings. Areas of interest for male horses include ergovaline retention and elimination, fertility, body temperature, growth and development, and nutrient digestibility. Schultz reported no effects of ergovaline on body weight, rectal temperature, serum enzymes and prolactin, nutrient digestibility, or alkaloid retention. However, geldings exposed to tall fescue for 20 days compared to 4 days did excrete more fecal ergovaline. Fayrer-Hosken reported ergot alkaloids decreased ejaculate volume, but with no effects on sperm motility, number morphology, and sperm morphology. Spermatozoa counts may counteract the reduction of ejaculate volume, but further research is

needed to determine this hypothesis. Thomson researched the effects of bromocriptine on prolactin concentrations and gel-free semen volumes. Bromocriptine is a synthetic alkaloid similar to ergot alkaloids found in endophyte-infected tall fescue. Bromocriptine decreased the prolactin concentrations and prevented the increase in gel-free semen volume caused by sexual stimulation, but did not affect volume of gelatinous material, sperm concentration, motility, pH of gel-free semen, number of spermatozoa per ejaculate and prolactin concentration in gel-free semen.

## Minimizing Fescue Toxicity with Cattle and Horses

Producers can adopt pasture management practices to reduce fescue toxicity complications including removing endophyte-infected tall fescue, planting endophyte-free or novel endophyte-infected tall fescue seed, diluting endophyte-infected tall fescue pastures, strategic mowing, and stockpiling infected tall fescue. Endophyte-free tall fescue pastures can persist in cooler temperature locations, like in the Pacific Northwest states, but without proper management endophyte-free pastures will not persist in the southeastern United States. As a result, researchers have developed novel endophytes, non-ergot alkaloid-producing endophytes, to incorporate into endophyte-free tall fescue. The novel endophytes provide stress tolerance, including insect and disease resistance and drought tolerance, without producing harmful ergot alkaloids. Novel endophyte varieties have been researched and patented and are available for purchase. Herbicides are also commercially available to remove fescue in pastures. For instance, imazapic is a herbicide that kills tall fescue, but does not harm Kentucky bluegrass and orchardgrass. Another option is to dilute concentrations of toxic fescue in pastures by overseeding other grasses and legumes. Ergovaline concentrations are the highest within the seedheads of the endophyte-infected tall fescue. Therefore, strategic mowing of the infected pastures to prevent seed development can reduce the risk of a spike in toxicity levels.

**For more detailed information on these topics and for a complete set of references refer to the publications listed below:**

Tall Fescue Endophyte Concepts

Tall Fescue Toxicity for Horses: Literature Review and Kentucky's Successful Pasture Evaluation Program

These publications and others can be found on the University of Kentucky Forage website: http://www.uky.edu/Ag/Forage/ by clicking on “Forage Publications” in the middle of the screen.