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

**S. Ray Smith, Laura Schwer,** and **Thomas C. Keene,** Plant and Soil Sciences, University of Kentucky, N-222 Ag Science Center North, Lexington, KY 40546

Corresponding author: S. Ray Smith.  raysmith1@uky.edu

## Abstract

During 2001-2002, Kentucky's Thoroughbred industry was devastated by Mare Reproductive Loss Syndrome (MLRS). As a follow-up, a horse pasture evaluation program was initiated in Kentucky that conducted 70 evaluations covering over 11,000 total farm acres from 2005 through 2008. Our objective is to provide a brief review on tall fescue toxicity in horses and to review of the University of Kentucky Horse Pasture Evaluation Program. Botanical composition and percent cover were evaluated by visual ratings of random quadrats. Average species composition was 22% tall fescue, 28% Kentucky bluegrass (*Poa pratensis* L.), 11% orchardgrass (*Dactylis glomerata* L.), 8% white clover (*Trifolium repens* L.), 20% weeds, and 11% bare soil. The final report to evaluated farms provided information on soil type and productivity, estimation of forage availability, laboratory evaluation of tall fescue endophyte infection rate and ergovaline level, a series of fescue and general pasture management recommendations, and over 30 extension publications. The Pasture Evaluation Program has been a successful extension program at the University of Kentucky and has provided the opportunity for many complementary research projects.

## Introduction

During 2001-2002, Kentucky's Thoroughbred industry was devastated by Mare Reproductive Loss Syndrome (MLRS). Although MLRS was finally associated with the eastern tent caterpillar (*Malacosoma americanum* F.), losing one third of the foal crop ($300 million) brought a renewed concern for tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh.] toxicity in horses. Consequently, a horse pasture evaluation program was initiated in Kentucky that conducted 70 evaluations covering over 11,000 total farm acres from 2005 through 2008. Our objective is to provide a brief review on tall fescue toxicity in horses and to review the University of Kentucky Horse Pasture Evaluation Program.

## Literature Review

The most evident effects of equine fescue toxicity are apparent in pregnant mares. Monroe et al. (14) was the first to find conclusive evidence concerning pregnant mare tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh.] toxicity and reported increased gestation length (17,20), agalactia (6,14), foal and mare mortality (14,16), tough and thickened placentas (12,14), retained placentas (6,14), weak and dysmature foals, reduced serum prolactin levels (2,13,14) and reduced progesterone levels (2,5,14). Other symptoms include abortions (17), decreased conception (3,17), early embryonic mortality (3,17), and dystocia (12,17). Studies found a general lack of elevated body temperatures (7), unlike fescue toxicity in cattle, but some studies reported increased sweating in pregnant mares (17). 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) (10). However, most extension publications suggest a more conservative level of 150 ppb (11). Tables 1 and 2 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 (1).

Table 1. 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 (22) |
| 160 | No clear signs of fescue toxicosis (2) |
| 271 | No negative pregnancy outcomes (23) |
| 308 | Weight loss<br>Suppressed serum prolactin<br>No adverse effects on pregnancy through day 28 (2) |
| 325 | Signs of fescue toxicosis (2) |
| 867 | Decreased progestogen concentration<br>No effect on embryonic development<br>No pregnancies lost (4) |
| 1171 | Significantly prolonged luteal function<br>Decreased 14 day viable pregnancy rate per cycle<br>Increased early embryonic death rates (3) |

Table 2. Summary of ergovaline research on mares during late term pregnancy (last 60 to 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 (14) |
| 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 (1) |

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 et al. (19) 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 faecal ergovaline (19). Fayrer-Hosken et al. (9) 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 et al. (21) 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 (8). Bromocriptine decreased the prolactin concentrations and prevented the increase in gel-free

semen volume caused by sexual stimulation (21), 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.

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 (20). 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 (20). 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 (1,20). Novel endophyte varieties such as MaxQ (Pennington Seed, Madison, GA) have been researched and patented and are available for purchase (5,20). 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 (20). Ergovaline concentrations are the highest within the seedheads of the endophyte-infected tall fescue (18,20) (Fig. 1). Therefore, strategic mowing of the infected pastures to prevent seed development can reduce the risk of a spike in toxicity levels (20).
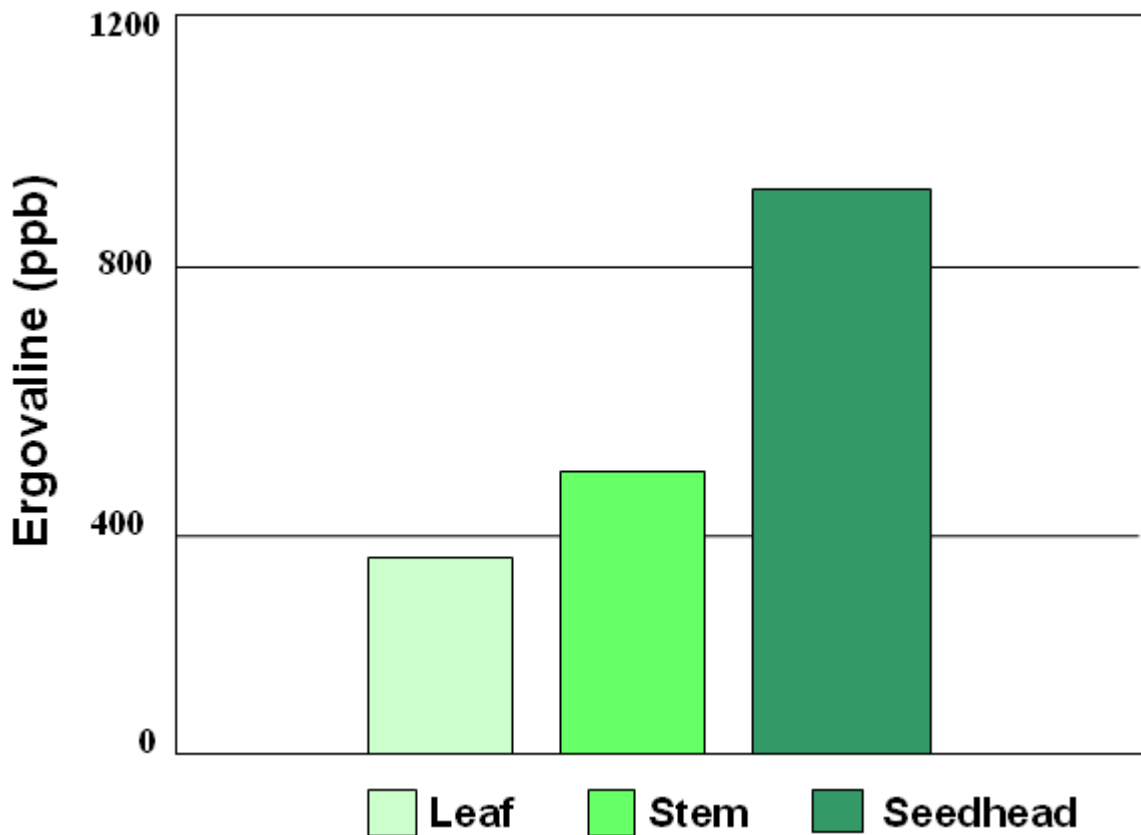


Fig. 1. Ergovaline levels for different portions of tall fescue (18).

### Pasture Evaluation Program Procedures

The University of Kentucky's Horse Pasture Evaluation Program conducted 70 farm evaluations from 2005 through 2008. Soil types of each farm were determined using USDA-NRCS's online Web Soil Survey (Fig. 2). Species

botanical composition and ground cover was determined visually by trained observers using 0.6-m² quadrats randomly tossed in each pasture following a W-shaped pattern. Species categories included tall fescue, Kentucky bluegrass (*Poa pratensis* L.), orchardgrass (*Dactylis glomerata* L.), white clover (*Trifolium repens* L.), weeds, and bare soil. If a field contained over 2 percent additional forage species, the percent cover of each species was recorded. Weed species were listed in order of abundance, but the percent composition of weeds was not recorded. A digital picture was taken within each quadrat using a Ricoh Caplio Pro G3 camera (West Caldwell, NJ) with global positioning system (GPS) capabilities to produce aerial maps of the sampling locations and for later referencing. The number of grid estimations was determined by the size of the pasture: < 5 acres, 10 samples; 5 to 10 acres, 15 samples; > 10 acres, 20 samples.
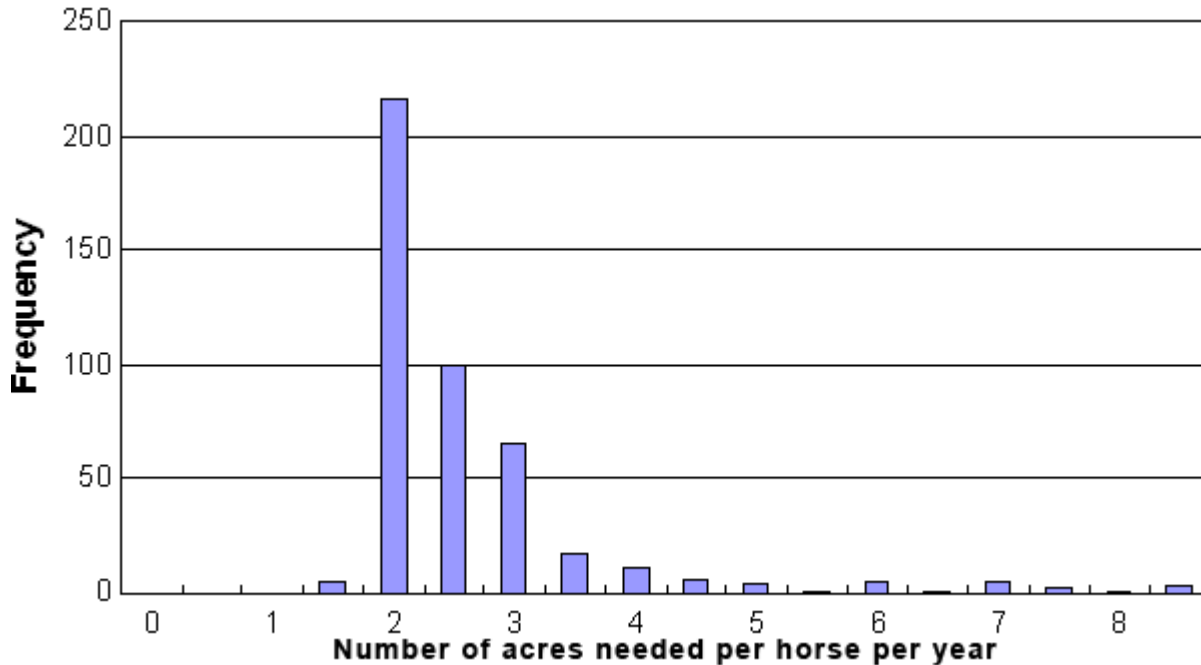


Fig. 2. Distributions of soil carrying capacities for all soil types within the 70 horse farm evaluations calculated using soil ratings from USDA-NRCS's online Web Soil Survey.

Fescue toxicity of each pasture was described by the endophyte infection level (percent) and ergovaline concentration (ppb) determined by collecting and analyzing tall fescue tillers and grab samples, respectively (16). Fescue tillers were collected by cutting one tiller with a sharp knife at the soil surface from two separate plants either within or near each quadrat. A minimum of 20 tillers was collected from each pasture. Tillers for each pasture were stored in plastic bags on ice in a covered, portable cooler to avoid ergot alkaloid break down. The tiller samples were submitted to the Seed Testing Laboratory, University of Kentucky College of Agriculture Division of Regulatory Services for determination of percent endophyte infection using the Pytoscreen ELISA ergot alkaloid immunoblot test kits purchased from Agrinostics Ltd. (Athens, GA). The tall fescue grab samples were collected by removing the top portion of two separate tall fescue plants by hand (above 7 cm) near each quadrat sample location to imitate grazing. They were collectively stored in a paper bag on ice in a covered, portable cooler to prevent ergot alkaloids from degrading during the collection, handling, and transportation. The samples were oven-dried at 55°C for 24 hours in a forced air oven, then ground through a 1 mm screen in a Thomas Wiley mill (Thomas Scientific, Swedesboro, NJ) for analysis of ergovaline concentration using reverse-phase high performance liquid chromatography. Normally tall fescue samples for ergot alkaloid analysis are freeze dried, but our procedure of oven drying at a set temperature for a set period of time was developed by L. Bush (*personal communication*). Using this

procedure Bush found that 30% of the ergot alkaloids will volatize during drying, therefore the liquid chromatography results were adjusted accordingly (*personal communication*).

### Program Synopsis and Outcomes

Each participant in the program received a summary binder, which included individual field data, overall farm data, soil information, general and specific recommendations, and over 30 publications for additional assistance. The individual field data included the species composition, specific weeds found, digital photographs of each quadrat, and an overall aerial photo of the field with quadrat locations shown based on GPS coordinates. An action log was included for each field to assist the participant in recording actions taken for pasture improvement. An overall farm data summary was also provided, which included the individual fields and farm average percentages for species composition, ergovaline concentration, and endophyte infection level. The overall study results were provided to allow the participant to compare their current pasture status with the average findings of the surrounding area (Table 3). In addition, the average ergovaline consumption was calculated based on an available forage calculation of each farm (Table 4). The amount of available forage was defined as perennial grasses and clover in the pasture that were readily consumed by horses. We assumed that the species most readily consumed were tall fescue, Kentucky bluegrass, orchardgrass, and white clover. The consumption of weeds was not accounted for using this method. The expected amount of tall fescue consumed was based on the percentage of tall fescue compared to the total available forage on a ground cover basis. Therefore, the ergovaline concentration of the available forage (ppb) showed the relative amount of ergovaline intake by the horses grazing on a respective pasture (Table 4). Research by Morrison et al. (15) suggested that tall fescue is consumed in proportion to the relative amount that exists in a given pasture. Therefore, the amount of ergovaline in the diet can be calculated based on the concentration of ergovaline in the fescue plants of the field, then multiplied by the amount of fescue in the available forage.

The USDA-NRCS's online Web Soil Survey was used to ascertain the soil characteristics of each participating farm. Each farm was located using the interactive aerial map and designated as the area of interest. The soil type with slope and ratings were acquired using the soil data explorer for the vegetative productivity of non-irrigated grass-legume pasture crops. The animal unit month (AUM) for horses was calculated using the NRCS pasture production ratings for each soil type (rating divided by 1.2 since body weight for an average horse is more than the standard 1000 lb AU). The soil carrying capacity (acres required per horse) was calculated using the AUM values for each soil type (12 divided by AUM). The total number of acres and farm percentage of each soil type was specified. Fig. 2 illustrates the frequencies of the different soil carrying capacities within central Kentucky. The majority of soils evaluated can support one horse for one year on 2 to 3 acres.

Table 3. Species compositions based on percent cover estimates from 70 horse farm evaluations 2005-2008.

| Species | Average | Standard Deviation | Distribution | |
|---|---|---|---|---|
| | | | Minimum | Maximum |
| Tall Fescue (%) | 22 | 12 | 2 | 51 |
| Kentucky Bluegrass (%) | 28 | 11 | 1 | 56 |
| Orchardgrass (%) | 11 | 6 | 1 | 26 |
| White Clover (%) | 8 | 8 | 0 | 34 |
| Weeds (%) | 19 | 10 | 2 | 50 |
| Bare Soil (%) | 11 | 8 | 0 | 40 |
| Ergovaline (ppb) | 289 | 160 | 71 | 790 |
| Endophyte Infection (%) | 73 | 15 | 32 | 95 |

Table 4. Amount of available forage and potential fescue toxicity from 70 horse farm evaluations 2005-2008.

| | | Standard Deviation | Min | Max |
|---|---|---|---|---|
| **Available forage other than tall fescue** (%)[x] | 69 | 11 | 42 | 88 |
| **Tall fescue in available forage** (%)[y] | 32 | 17 | 3 | 85 |
| **Ergovaline concentration of available forage** (ppb)[z] | 99 | 69 | 9 | 318 |

[x] Sum of tall fescue, bluegrass, orchardgrass, and white clover percent pasture composition.

[y] (Average % tall fescue / Average amount available forage) * 100.

[z] Ergovaline (ppb) * Average % tall fescue.

Recommendations for each pasture were provided based on the current vegetative status and management needs for each farm. Farm management recommendations were provided concerning tall fescue, weed control, soil fertility, grazing management, renovation, re-establishment, and forage choices for horse pastures based on the farms data. Considerable time was spent explaining the value of tall fescue for soil stability and production in pastures for non-pregnant horses. The most prominent weeds were noted (Fig. 3) with suggested herbicides to control these particular species. Herbicide spraying recommendations varied depending on the fields percent weed cover with an emphasis on non-herbicide management strategies to control weeds such as soil fertility, using adapted forage species, grazing management, and clipping. Seeding recommendations were determined by the bare soil percentage: < 10%, no seeding was necessary; 11 to 25%, seeding was an option; and > 25%, seeding was recommended. These levels were based on consultation with pasture management experts (Smith, *personal communication*).
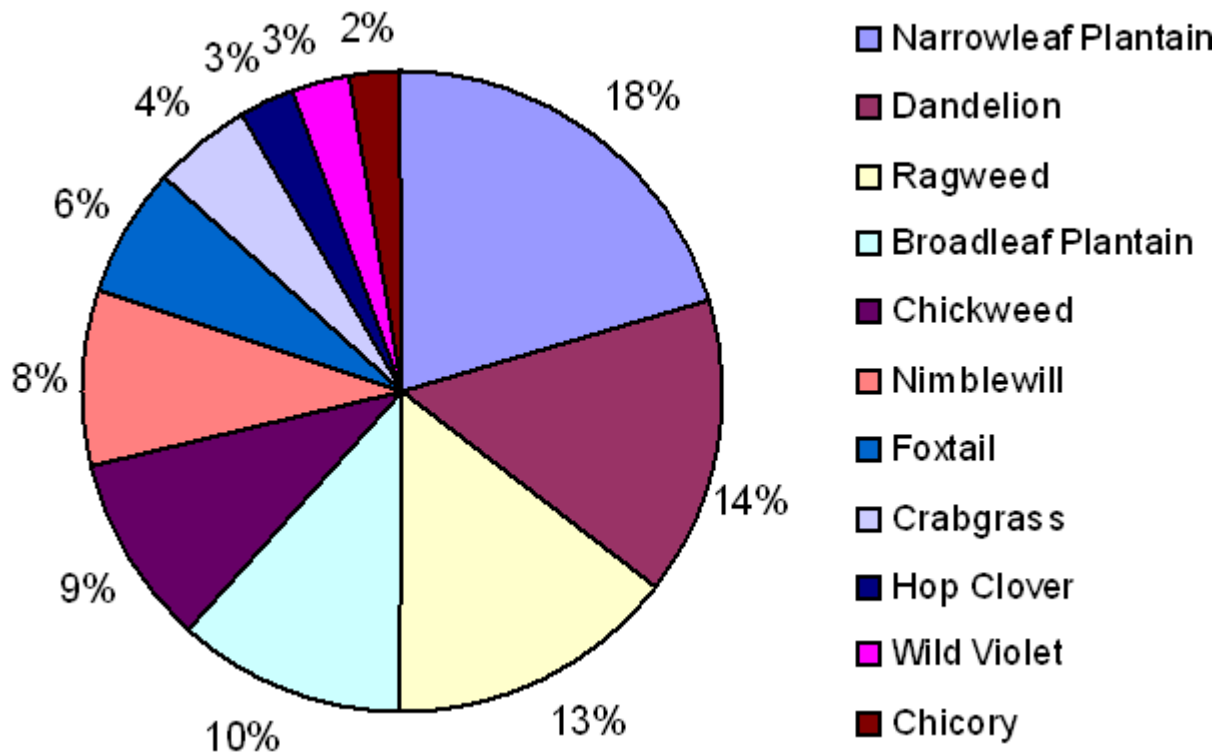
Fig. 3. Eleven most prominent weeds among the 70 horse farm evaluations from March-November 2005-2008.

### Conclusion

In conclusion, the University of Kentucky Horse Pasture Evaluation Program has been a successful extension and outreach project for horse farms in Central Kentucky. It has also provided the opportunity for many complementary research projects including microhistological analysis and Near Infra-red Reflectance Spectroscopy (NIRS) estimates of diet composition, vegetative cover using Digital Image Analysis (DIA), and spatial statistical analysis of pasture composition.

### Literature Cited

1. Aldrich-Markham, S., Pirelli, G., and Craig, A. M. 2003. Endophyte toxins in grass seed fields and straw. Coop. Ext. Pub. EM 8598, Oregon State Univ., Salem, OR.
2. Arns, M. J., Pruitt, J. A., and Sharp, C. 1997. Influence of endophyte-infected tall fescue seed consumption on the establishment and maintenance of pregnancy in mares. Pro. Anim. Sci. 13:118-123.
3. Brendemuehl, J. P., Boosinger, T. R., Pugh D. G., and Shelby, R. A. 1994. Influence of endophyte-infected tall fescue on cyclicity, pregnancy rate and early embryonic loss in the mare. Theriogenology 42:489-500.
4. Brendemuehl, J. P., Carson, R. L., Wenzel, J. G. W., Boosinger, T. R., and Shelby, R. A. 1996. Effects of grazing endophyte-infected tall fescue on eCG and progestogen concentrations from gestation days 21 to 300 in the mare. Theriogenology 46:85-95.
5. Burns, J. C., Fisher, D. S., and Rottinghaus, G. E. 2006. Grazing influences on mass, nutritive value, and persistence of stockpiled Jesup tall fescue without and with novel and wild-type fungal endophytes. Crop Sci. 46:1898-1912.
6. Copetti, M. V., Santurio, J. M., Boeck, A. A. P., Silva, R. B., Bergermaier, L. A., Lubeck, I., Leal, A. B. M., Leal, A. T., Alves, S. H., and Ferreiro, L. 2001. Agalactia in mares fed with grain contaminated with *Claviceps purpurea*. Mycopathologia 154:199-200.
7. Cross, D. L., Redmond, L. M., and Strickland, J. R. 1995. Equine fescue toxicosis: Signs and solutions. J. Anim. Sci. 73:899-908.
8. Cross, D. L. 1997. Fescue toxicosis in horses. Pages 289-299 in: Neotyphodium/Grass Interaction. Bacon and Hill, Plenum Press, New York.

9. Fayrer-Hosken, R., Heusner, G., Hill, N., and Caudle, A. 2008. Review on effects of fescue grass ergot alkaloids in the horse and preliminary study on effect of fescue grass ergot alkaloid in the stallion. J. Equine Vet. Sci. 28:666-671.

10. Hovermale, J. T., and Craig, A. M. 2001. Correlation of ergovaline and lolitrem B levels in endophyte-infected perennial ryegrass (*Lolium perenne*). J. Vet. Diagn. Invest. 13:323-327.

11. Kallenbach, R. L., Bishop-Hurley, G. J., Massie, M. D., Rottinghaus, G. E., and West, C. P. 2003. Herbage mass, nutritive value, and ergovaline concentration of stockpiled tall fescue. Crop Sci. 43:1001-1005.

12. Loch, W., Worthy, K., and Ireland, F. 1990. The effect of phenothiazine on plasma prolactin levels in non-pregnant mares. Equine Vet. J. 22:30-32.

13. McCann, J. S., Caudle, A. B., Thompson, F. N., Stuedemann, J. A., Heusner, G. L., and Thompson, Jr., D. L. 1992. Influence of endophyte-infected tall fescue on serum prolactin and progesterone in gravid mares. J. Anim. Sci. 70:217-223.

14. Monroe, J. L., Cross, D. L., Hudson, L. W., Hendricks, D. M., Kennedy, S. W., and Bridges, W. C. 1988. Effect of selenium and endophyte-contaminated fescue on performance and reproduction in mares. Equine Vet. Sci. 8:148-153.

15. Morrison, J. I., Smith, S. R., Aiken, G. E., and Lawrence, L. M. 2009. Composition of horse diets on cool-season grass pastures using microhistological analysis. Online. Forage and Grazinglands doi:10.1094/FG-2009-0325-01-RS.

16. Porter, J. K., and Thompson, Jr., F. N. 1992. Effects of fescue toxicosis on reproduction in livestock. J. Anim. Sci. 70:1594-1603.

17. Putnam, M. R., Bransby, D. I., Schumacher, J., Boosinger, T. R., Bush, L., Shelby, R. A., Vaughan, J. T., Ball, D., and Brendemuehl, J. P. 1991. Effects of the fungal endophyte *Acremonium coenophialum* in fescue on pregnant mares and foal viability. Am. J. of Vet. Res. 52:2071-2074.

18. Rottinghaus, G. E., Garner, G. B., Cornell, C. N., and Ellis, J. L. 1991. HPLC method for quantitating ergovaline in endophyte-infested tall fescue: Seasonal variation of ergovaline levels in stems with leaf sheaths, leaf blades, and seed heads. J. Agric. Food Chem. 39:112-115.

19. Schultz, C. L., Lodge-Ivey, S. L., Bush, L. P., Craig, A. M., and Strickland, J. R. 2006. Effects of initial and extended exposure to an endophyte-infected tall fescue seed diet on faecal and urine excretion of ergovaline and lysergic acid in mature geldings. N. Z. Vet. J. 54:178-184.

20. Stuedemann, J. A., and Seman, D. H. 2005. Integrating genetics, environment, and management to minimize animal toxicosis. Pages 305-324 in: Neotyphodium in Cool-season Grasses. C. A. Roberts, C. P. West, and D. E. Spiers, eds. Blackwell Publ., Ames, IA.

21. Thomson, C. H., Thompson, Jr., D. L., Kincaid, L. A., and Nadal, M. R. 1996. Prolactin involvement with the increase in seminal volume after sexual stimulation in stallions. J. Anim. Sci. 74:2468-2472.

22. Youngblood, R. C., Filipov, N. M., Rude, B. J., Christiansen, D. L., Hopper, R. M., Gerard, P. D., Hills, N. S., Fitzgerald, B. P., and Ryan, P. L. 2004. Effects of short-term early gestational exposure to endophyte-infected tall fescue diets on plasma 3,4-dihydroxyphenyl acetic acid and fetal development in mares. J. Anim. Sci. 82:1-11.