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Assessing risk of plant-associated toxicosis using sentinel farms and historical records

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Abstract

Assessing toxicity of grassland/rangeland plants and their impact on livestock production and morbidity is an issue around the world. Tall fescue (*Schedonorus arundinaceus* Schreb.) is a naturalized grass species occurring on over 14 million ha in the USA with the majority infected with a fungal endophyte that produces ergopeptine alkaloids (primarily ergovaline). The objective of this paper is to show how an innovative pasture evaluation system at the University of Kentucky has been used to incorporate plant toxicity information and species composition measurements to assess risk to livestock. Over the last 20 years over 500 horse farms have been intensively evaluated to determine total botanical composition and the ergovaline content of tall fescue present in pastures. Using various strategies, these measurements have been used to develop risk categories, which have then been communicated to the farms to enable stocking decisions. This project will establish sentinel farms that will provide additional information on seasonal variability for ergovaline levels and the potential impact on livestock. This assessment strategy can be used to assess risk to livestock in many ecological regions around the world.

Introduction

Traditional methods to alleviate risk of plant-associated poisonings in livestock on rangelands and grasslands have been to monitor species composition and livestock health and then to avoid/reduce exposure or remove toxic plants by mechanical or chemical methods (van Raamsdonk et al. 2015). There are situations where the plants of concern are endemic and/or compromise a major component of a grassland system. For example, the tall fescue cultivar Kentucky 31 (KY-31) was widely planted in the eastern USA after being released in 1943 because of superior persistence, long growing season, and biomass production. It is now considered a naturalized species and occurs on 14 million ha in the USA. In the 1980's, it was discovered that the persistence of KY-31 was primary due to the mutualistic relationship with a fungal endophyte (*Acremonium coenophialum*). Unfortunately, this endophyte produces toxic ergopeptine alkaloids which cause a range of symptoms which vary depending on livestock species. Pregnant broodmares in the last 30-60 days of gestation are most sensitive (Bacon, 1995). Ergovaline and other ergopeptine alkaloids consistently cause decreased or absent colostrum and milk production in late-gestational mares and failure of passive transfer in their foals. Other effects in mares include prolonged pregnancy, dystocia, premature placental separation, and other reproductive abnormalities. Dysmaturity, overmaturity, postmaturity, and septicemia can occur in foals. In cattle, low weight gain, reduced pregnancy rates, decreased milk production, and temperature-dependent effects of vasoconstriction (e.g., heat stress during warm temperatures or sloughing of

hooves, ears, and tail switches during extreme cold). Non-toxic endophyte-free and novel endophyte tall fescue cultivars have been developed, but it is not feasible to replace all 14 million ha due to the terrain of many farms, reduced persistence, and the cost of reestablishment. When properly managed, toxic tall fescue can be a useful or at least a tolerated species in grasslands.

The effects of toxic tall fescue on pregnant mares can be significant, but risk is difficult to evaluate. While testing for endophyte presence and ergovaline concentration are easily conducted, a true risk assessment must include an estimation of the amount of tall fescue in the diet. Ergovaline concentrations also vary seasonally and based on pasture management. The University of Kentucky (UK) Horse Pasture Evaluation Program combines ergovaline and endophyte testing with species composition data to objectively assess the risk to horses grazing individual pastures, assist farms in “triage” of pastures, and help determine when mitigation and management strategies can be utilized or when complete renovation is recommended. Additionally, several farms have committed to becoming sentinel farms and conduct monthly sampling of pastures to inform the entire livestock industry in the region when ergovaline levels are increasing or decreasing in general.

Methods

To evaluate livestock risk on pastures, “Ergovaline in Total Diet” is calculated using the percentage of tall fescue in the pasture compared to other available forages, and the concentration of ergovaline within tall fescue plants.

Species composition is determined using an occupancy method (Payne et al., 2023; Vogel and Masters, 2001) with 75cm x 75cm wire grids that contain 25 smaller squares, 15cm x 15cm. Each smaller square is evaluated individually for botanical composition and the most dominant species or category is recorded. Species and categories include tall fescue, Kentucky bluegrass (*Poa pratensis* L.), orchardgrass (*Dactylis glomerata* L.), white clover (*Trifolium repens* L.), broadleaf weeds, nimblewill (*Mulenbergia schreberi* J.F Gmel.), warm-season annual grasses, bare soil and “other forages”. Grids are randomly placed at 10 to 20 locations depending on pasture size with a normal range of 0.25 ha to 16 ha. By evaluating all plant species and not just the amount of tall fescue present, the amount of tall fescue in the grazing diet can be calculated, and other management recommendations such as seeding and broadleaf weed control can be tailored to the needs of the pasture.

Grab samples of tall fescue material are also collected from 10-20 locations within the pasture at average grazing height, ranging from 7 to 10 cm from the soil. These samples are submitted to the University of Kentucky Veterinary Diagnostic Laboratory for analysis. Details on sampling, handling during transport and storage and analysis can be found in Lea et al. (2014). The total concentration of ergovaline plus its epimer ergovalinine is reported on a dry matter basis in parts per billion (ppb) within the tall fescue sample.

Previous research suggests that horses graze different forage species in similar proportions to how they are present in the pasture (Morrison et al., 2008). Therefore, the species composition data collected and the ergovaline analysis can be combined to calculate ergovaline in total diet using the formula below:

$$\left(\frac{\% \text{ TF}}{\% \text{ TF} + \% \text{ BG} + \% \text{ OG} + \% \text{ WC} + \% \text{ OF}} \right) \times \text{Ergovaline (ppb)} = \text{Ergovaline in Total Diet (ppb)}$$

Figure 3. Formula for calculating ergovaline in total diet.

(TF=Tall Fescue; BG = Kentucky Bluegrass; OG = Orchardgrass; WC = White Clover; OF = Other Forages)

Results

Assessment of Pastures by calculating Ergovaline in Total Diet

Using the calculation of Ergovaline in Total Diet instead of simply ergovaline concentration or tall fescue percentage provides farm managers with additional stratification of pastures when evaluating the farm as a whole. Table 1 contains an example abbreviated datasheet containing several pasture species compositions and ergovaline concentrations.

Table 1. Abbreviated datasheet from a Lexington, KY, USA, area horse farm.

Pasture	Acres	% Tall Fescue	% Desirable Forages	% Undesirable Components	Ergovaline (ppb)	Ergovaline in Total Diet (ppb)
Pasture 6	29.7	7	88	5	309	23
Pasture 7	31.1	68	31	1	119	81
Paddock 3	0.7	67	19	14	384	302
Paddock 10	0.5	17	38	45	564	172
Paddock 12	1.8	63	29	8	741	500

Pasture 7 and paddock 3 and 12 all contained similar percentages of tall fescue (63-68%), however, the ergovaline concentration ranges widely (119 – 741 ppb). Therefore, ergovaline in total diet was quite low in pasture 7, high in paddock 12, and moderate in paddock 3. Pasture 6 and paddock 10 contained less tall fescue and only moderate ergovaline levels, but very different amounts of desirable forages. Pasture 6 contained a high percentage of other desirable forages, therefore ergovaline in total diet was very low (23 ppb). Paddock 10 contained a high percentage of undesirable components, limiting ergovaline dilution in the diet and resulting in a higher ergovaline in total diet (302 ppb).

Data such as this allows horse farm managers to select pastures that can be grazed without additional management (pastures 6 and 7), pastures that need improved management to reduce tall fescue (paddock 10), and pastures that likely need total renovation (paddock 12),

Use of Sentinel Farms to Monitor Seasonal Ergovaline Concentrations

Ergovaline is known to vary throughout the year and typically produces a spike in the spring in conjunction with seed production and a secondary, smaller spike in the fall coinciding with fall growth (Figure 2). However, in recent years the monitoring of sentinel farms has shown that the fall spike can plateau and remain high for months. Climatic conditions in years where ergovaline levels have plateaued in the fall have had warm, dry falls followed by consistent precipitation and mild early winter conditions.

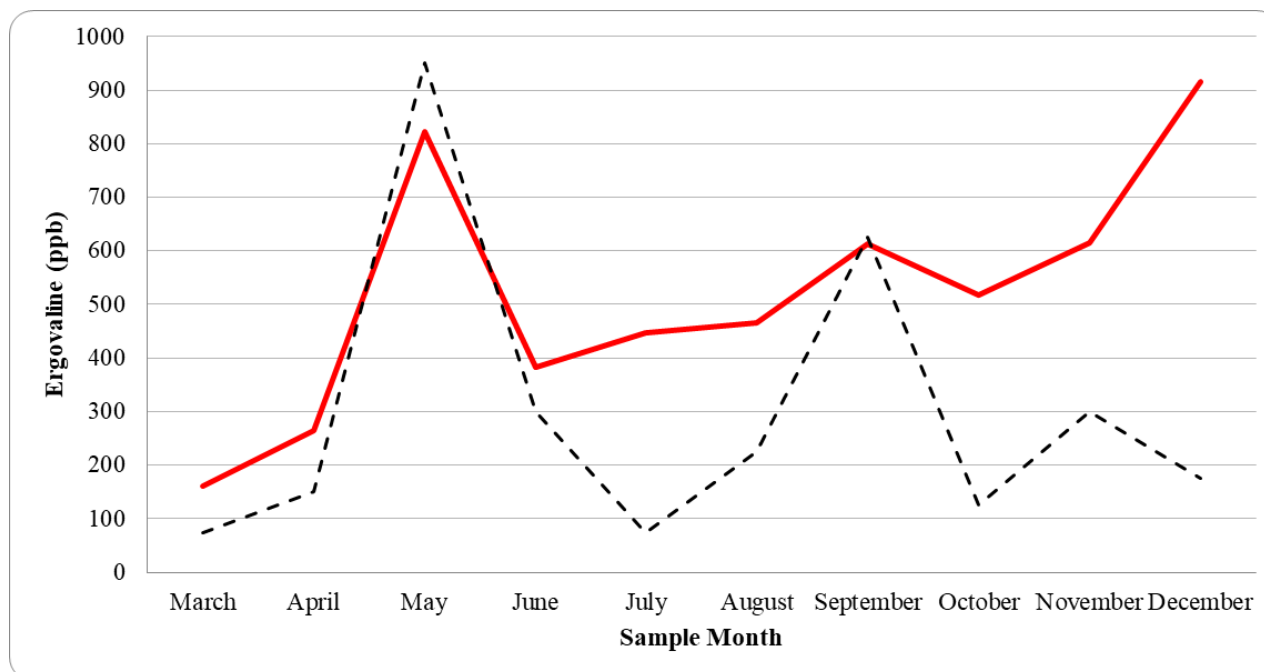


Figure 2. Seasonal variation of ergovaline concentration.

Figure 2 presents data from a single pasture in 2007 (dotted black line), showing the “normal” ergovaline concentrations across the year including a significant spring spike and a smaller fall spike. The red line represents data from many farms that were part of the UK Horse Pasture Evaluation Program in 2023. With an exceptionally dry fall and mild early winter, ergovaline concentrations remained high and even increased from October through the end of the year. Mares due to foal in January would be at their most susceptible stage during November/December (last 30-60 days of gestation) and the risk of complications such as prolonged gestation and dystocia, low or no milk production and thickened, retained placenta, would be greatly increased (Boosinger et al., 1995).

Discussion

Other research focusing on toxic plants in grasslands and rangelands have also shown the benefits of evaluation of the whole system when considering the impact of toxic plants. Pfister et al. (2002) stressed the importance of recognizing the factors that contribute to livestock poisoning, such as environmental conditions, changes in plant composition and animal behaviour. Holechek (2002) found that “poor” range management was not always correlated with livestock losses to poisonous plants and that management of such plants is more complex than just improved overall management. Finally, Krueger and Sharp (1978) found that precipitation and temperature can also influence plant growth, which in turn affects the distribution and palatability of toxic plants. Livestock managers need to adapt their management strategies based on a range of factors including weather, species composition, and animal behaviour. The UK Horse Pasture Evaluation Program has demonstrated a method of forage evaluation and sentinel farm monitoring that helps to inform horse farm managers of the relative risk posed by each pasture using the following categories: very low, low, significant, high, and very high. This allows them to make more informed decisions and can serve as a model for other evaluation methods in grasslands and rangelands.

In conclusion, reducing risk by monitoring species composition and toxin concentration has proven effective with tall fescue and this or similar methods have potential application for managing non-lethal toxic plants on rangelands and grasslands worldwide.

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