THE IMPACT OF FESCUE TOXICOSIS & T-SNIP SCORE ON POST-WEANING
BEEF CATTLE PERFORMANCE

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by

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The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

THE IMPACT OF FESCUE TOXICOSIS & T-SNIP SCORE ON POST-WEANING
BEEF CATTLE PERFORMANCE

Presented by Blake Robertson McDonald,

a candidate for the degree of Master of Science,

and hereby certify that, in their opinion, it is worthy of acceptance.

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DEDICATION

To my late grandpa, Jim McDonald, who instilled in me a passion for agriculture and a desire to never stop learning, and taught me how to enjoy a good day's work.

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TABLE OF CONTENTS

LIST OF TABLES

THE IMPACT OF FESCUE TOXICOSIS & T-SNIP SCORE ON POST-WEANING BEEF CATTLE PERFORMANCE

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ABSTRACT

It is well known that fescue toxicosis has a negative impact on cattle productivity. These studies were conducted to evaluate the effects of fescue toxicosis on post-weaning beef steers, as well as the impact of T-Snip score on performance of steers and heifers. We hypothesized that cattle that consumed an E+ diet would perform lower than cattle that did not. We also hypothesized that the cattle coming off of an E+ diet would remain at a lower weight than those that did not throughout the feeding period. T-Snip scores were also believed to be indicative of animal performance while consuming an E+ diet. A two-phase feeding trial was conducted to evaluate the aforementioned effects. 306 crossbred steers (288.8 ± 3.81 kg) were blocked by weight, T-Snip score, and color, and assigned to one of two treatments. The grow phase consisted of the first 54 days of the experiment. Throughout this period, high roughage, growing diets were fed to the steers. The treatment group was fed a diet containing toxic tall fescue seed, whereas the control diet was fed a seed-free diet. The finishing phase was day 54-slaughter. In this period, all animals were fed a common, corn-based finishing diet. For the first phase of the experiment, there were no differences between treatments for initial bodyweight (IBW), DMI, dry matter intake as a % BW (DMPW), ADG, GF, or end bodyweight (EBW). There was however differences between T-Snip star scores among treatments. In the control group, animals with 2 and 3 stars had a higher ADG ($P \leq 0.05$) (1.74 kg vs. 1.68

kg) than animals with 0, 1, & 4 stars (1.59 kg, 1.53 kg vs. 1.53 kg). In the E+ group, animals with zero stars had the lowest ADG (1.42 kg), animals with 1 or 2 stars had an increased ADG (1.65 kg vs. 1.63 kg) and animals with 3 or 4 stars had the highest ADG (1.74 kg vs. 1.76 kg) ($P \leq 0.05$). In the finishing phase, control animals had increased DMI ($P < 0.05$) (8.33 kg vs. 7.82 kg). DMIPW, ADG, and EBW tended ($P < 0.10$) to be higher for the control groups. There were no differences between T-Snip star scores among treatments during the finishing phase. HCW was higher for control animals than E+ animals ($P \leq 0.05$) (343.01 kg vs. 331.13 kg) Marbling scores were lower in E+ animals than control ($P \leq 0.05$) (4.41 vs. 4.71) Carcass value was higher for control treatment than E+ ($P \leq 0.05$) ($1486.93 vs. $1420.68). The only difference among T-Snip star scores occurred in the control group, where 0 star animals had increased backfat (BF) ($P \leq 0.05$). In another study we evaluated if performance of beef heifers grazing E+ pasture differed among T-Snip score. It was hypothesized that as T-Snip score increased (increased tolerance to E+ tall fescue) average daily gain of heifers would increase. 180 angus-based commercial heifers (343.22±17.87 kg) grazed E+ tall fescue pasture for 75 days. Each animal had a hair sample taken and submitted for a T-Snip score and tolerance rating, where animals with 0-1 star were considered susceptible, animals with 2-3 stars were average, and animals with 4-5 stars were considered the most tolerant to fescue toxicosis. As hypothesized, there were differences in ADG between tolerance ratings. ADG for susceptible animals was 0.20 kg, average animals gained 0.25 kg, and the tolerant heifers gained 0.29 kg/d ($P = 0.07$). Average daily gains were as expected for heifers grazing E+ tall fescue pastures. Heifers identified as tolerant had 45% greater average daily gain than heifers identified as intolerant. The objective of this study was to

determine if genetic testing for fescue tolerance used in cows had relevance for calves as well. This research demonstrated that genetic selection to improve fescue tolerance could improve progeny performance.

CHAPTER 1

REVIEW OF LITERATURE

Tall Fescue

Tall Fescue, *Lolium arundinaceum,* is a cool-season perennial bunchgrass that is the most common forage found in the humid transition zone of the United States (Stuedemann and Hoveland, 1988). Tall Fescue originated in Europe, and was brought to America in the late 1800's. Tall Fescue is also found in parts of South America and Africa (Buckner et al., 1979). Though Tall Fescue was introduced in the United States in the 1800's, its widespread popularity didn't come about until the mid-1940's.

In 1931, W.M. Suiter, a farmer in Menifee County, Kentucky noticed a particular grass that was thriving on a steep hillside. Dr. E. N. Fergus, an Agronomy Professor from the University of Kentucky was summoned to the farm to investigate. Dr. Fergus took seed samples from the grass, conducted rigorous testing on the seed, and in 1943, the 'Kentucky 31' variety of Tall Fescue was released (Fergus and Buckner, 1972).

Tall Fescue is said to cover over 35,000,000 acres of land in the area deemed "The Fescue Belt" (Fribourg et al., 1991). As previously mentioned, the Fescue Belt lies in the transition zone of the eastern United States, and stretches from Virginia and the Carolinas, west to eastern Kansas and Oklahoma, the area encompasses southern Indiana and Ohio down through Alabama, Mississippi, and Georgia (Burns and Chamblee, 1979).

A large proportion of the Nation's beef cows reside in the fescue belt, and it is claimed that over 8.5 million head of cattle utilize Tall Fescue as their primary source of

forage (Stuedemann and Hoveland, 1988). Tall Fescue exemplifies a number of

agronomic strengths which allowed it to become a popular choice for pasture, erosion

control, lawns, and seed production. The grass is easily adapted, has long growing

seasons, and displays persistence in the presence of many stressors including, drought,

over-grazing, trampling, flooding, and pests. Tall Fescue is easily established in many

soils that are not suitable for crop production (Stuedemann and Hoveland, 1988).

Endophyte

Many of the aforementioned agronomic characteristics, particularly in the KY31 variety of Tall Fescue, are due to a symbiotic relationship between the plant and the endophyte, an endophytic fungus, *Neotyphodium coenophialum*. The fungus is generally referred to as the "endophyte" because it grows within (endo) the plant (phyte) (Bacon et al., 1977). The fungus is found between the cell walls of all parts of the plant, but is concentrated in the seedhead (Bacon, 1995).

Due to the advantages provided by the endophyte, varieties of Tall fescue containing the fungus have been able to out-persist varieties that are free of the endophyte in the presence of stress (Hoveland et al., 1983). Unfortunately Tall Fescue has gained a reputation for poor animal performance. This is somewhat concerning; as analyses have indicated that Tall Fescue should provide nutrients that result in good animal performance if managed well (Bush and Buckner, 1973). The poor performance is attributed to the same endophyte that provides the plant agronomic advantages.

Ergot Alkaloids

The endophyte produces a strain of compounds known as ergot alkaloids, which are toxic to animals (Bacon et al., 1977). These alkaloids include lysergic acid amides, and ergopeptines (Bacon et al., 1977). It is believed that many ergot alkaloids contribute to fescue toxicosis. The compounds are derived from D-Lysergic acid and are in a tetracyclic ergoline ring (Tudzynski et al., 2001). The structures of these compounds are very similar to dopamine, noradrenaline, and serotonin, thus ergopeptines are compatible and able to bind to neurotransmitters in the animal (Berde, 1979). Ergotamine, ergosine, ergonovine, and particularly ergovaline are the compounds that are most studied in Tall Fescue research (Yates and Powell, 1988).

Ergot alkaloids are concentrated in the seed head of the plant, though they are present in the stem and leaf as well (Rottinghaus et al., 1991). In general, ergot alkaloid content is high in mid-late spring, decreases in the summer, and peak in the fall (Rottinghaus et al., 1991). However, if fescue is maintained in the vegetative state, either by clipping, pasture rotation, or chemical suppression of the seed head, ergot alkaloid content is low in the spring, rises during the summer, and dramatically increases to the peak concentration in the fall months (Rogers et al., 2011).

Animal Disorders

When animals graze endophyte infected Tall Fescue (E+), they suffer from a disorder known as Tall Fescue Toxicosis. The syndrome is attributed to the aforementioned compounds found in KY-31 Tall Fescue. The symptoms of Fescue Toxicosis include: reduced bodyweight gains, increased body temperature, increased respiration rates, rough hair coat, reduced reproductive performance, excessive salivation, and lower serum prolactin levels (Strickland et al., 1993). The ergot alkaloid compounds have been known to cause vasoconstriction in cattle consuming E+ Tall Fescue, a serious contributor to Fescue Toxicosis (Oliver et al., 1993). Fescue Toxicosis is estimated to cost livestock producers in the United States up to $1 billion on an annual basis (Roberts and Andrae, 2004). This loss is attributed to reproductive losses and lower performance from animals grazing E+ Tall Fescue (Hoveland, 1993). In addition to Fescue Toxicosis, Fescue Foot and Fat necrosis can also be caused by the consumption of E+ Tall Fescue (Strickland et al., 1993).

Vasoconstriction

Peripheral vasoconstriction commonly occurs in animals that are consuming E+ Tall Fescue, which impedes the animal's ability to dissipate body heat in high ambient temperatures, and can cause necrosis, sometimes severe, to extremities in low ambient temperatures (Paterson et al., 1995). In a 1969 study, ergotamine tartrate was injected into steers intramuscularly at 35-92 µg/kg BW. A decrease in skin temperature of the

tail, yet an increase in rectal temperature indicated that reduced blood flow to the skin was causing hyperthermia (Carr and Jacobson, 1969). The hormones epinephrine and norepinephrine are responsible for the control of blood flow, yet it has been shown that the levels of epinephrine and norepinephrine do not change after the consumption of E+ Tall Fescue in crossbred wethers, thus it was concluded that there must be an additional compound or compounds having an effect (Henson et al., 1987; Paterson et al., 1995). Many of the ergot alkaloids have shown that they have vasoconstrictive effects when consumed by animals, but a 2007 study concluded that ergotamine, and particularly ergovaline are significant contributors to vasoconstriction in bovine, and thus significant contributors to fescue toxicosis (Klotz et al., 2007).

Hormone Imbalance

Prolactin is a hormone that is secreted from the anterior pituitary gland, and it is involved in lactation, reproduction, and homeostasis in mammals (Freeman et al., 2000). It is well known that prolactin levels are lower than normal in animals that are grazing E+ Tall Fescue (Schillo et al., 1988). Prolactin concentration increases simultaneously with day length, which are longest in summer months (Leining et al., 1979). Summer temperatures are the highest temperatures throughout the year, and the increased prolactin levels signal for the animal to shed its winter coat to combat heat stress (Leining et al., 1979). Because of the decrease in prolactin levels in animals that consume E+ Tall Fescue, many of them are not able to shed their winter coat, contributing to heat stress (LEINING et al., 1979). The structures of ergot alkaloids are ergoline rings, similar to

6

various amides including dopamine, epinephrine, norepinephrine, and serotonin (Berde, 1979; Tudzynski et al., 2001). Due to the similar structures, ergot alkaloids are enabled to bind to the receptors of the aforementioned biogenic amides (Porter and Thompson, 1992). Dopamine is a prolactin inhibitor, thus when ergot alkaloids bind to dopaminergic receptors, prolactin levels decrease.

Fescue Foot

Fescue foot is the most severe disorder caused by consuming E+ Tall Fescue. This condition causes extreme lameness and may result in peripheral necrosis of the affected limb, generally a rear foot, most commonly the left (Cunningham, 1949). Hyperemia of the coronary band occurs between the dewclaw and hooves, and is generally accompanied by some swelling (Hemken et al., 1984). In extreme cases, the hooves may slough off, with severe cases, the entire limb may fall off between the dewclaw and hoof (Hemken et al., 1984). In addition to problems associated with the foot, the tail can be affected as well. The tail will become a purple-black color, and the animal will lose the switch (Hemken et al., 1984). Fescue foot was originally attributed to poisoning from ergot, though most incidences occur in the winter time, fescue foot can happen year round, whereas ergot related issues would only happen from January-March (Cunningham, 1949). Cunningham (1949) reported that fescue foot had been reported in animals that had been consuming E+ Tall Fescue for as little as 10-15 days, and most commonly, the incidence of fescue foot occurred in animals that did not graze Tall Fescue year round, i.e., animals turned onto winter E+ Tall Fescue Pasture.

Fat Necrosis

Bovine fat necrosis can occur in cattle that are grazing E+ Tall Fescue, especially if high levels of nitrogen are applied for fertilization purposes. This was discovered when cattle grazing fescue pastures that had been heavily fertilized with poultry litter were found to have necrotic fat throughout the abdominal cavity (Williams et al., 1969). It was later found that fat necrosis was directly related to E+ Tall Fescue pastures that had high levels of Nitrogen fertilizer applied to them (Bush et al., 1979). Bovine fat necrosis can cause digestive upset and dystocia problems due to hard, fatty masses in the adipose tissue in the abdominal cavity (Bush et al., 1979). Necrotic fat lesions are predominantly found along the intestinal tract, from the abomasum to the rectum (Bush et al., 1979).

Fescue Toxicosis

Though Fescue Foot and Fat necrosis are serious symptoms of Fescue Toxicosis, and are extremely detrimental to the health of animals consuming E+ Tall Fescue, they do not have near the negative economic effect that Fescue Toxicosis, or what some refer to as Summer Slump have. It has been proven in countless studies that animal average daily gain (ADG), milk production, and intake are significantly lower for animals that are consuming a diet consisting of high endophyte levels (Stuedemann and Hoveland, 1988). For each 10% increase in ergot alkaloid infestation, ADG has shown to decrease by nearly one tenth of a pound (Crawford et al., 1989). Generally, animal performance is lower for animals that consume E+ Tall Fescue year round, but the difference is

magnified in summer months due to heat stress on the animal. Ergovaline levels peak in

May, yet the symptoms of Fescue Toxicosis are most prevalent in the late summer

months (Hemken et al., 1981).

Combatting Fescue Toxicosis

Unless E+ Tall Fescue is completely eradicated, there will always be symptoms of Fescue Toxicosis in cattle grazing in the southeastern United States. However, there are several ways to combat and mitigate the symptoms to increase animal performance and minimize economic losses that are attributed to E+ Tall Fescue. There are several strategies that can be implemented to minimize fescue toxicosis, including: replacement of toxic fescue, grazing management, N fertilization management, supplemental feeding, and seedhead control (Roberts and Andrae, 2004).

Non-Toxic Tall Fescue Varieties

Eradicating E+ Tall fescue and replacing it with either a non-toxic tall fescue or other forage can be very costly to producers. There are cultivars of Tall Fescue that do not have any endophytic fungus (E-), and animal performance is significantly higher when they graze these varieties (Pedersen and Sleper, 1988). Hoveland (1993) showed that pregnancy rates in heifers were 96 and 55% for animals grazing E- and E+ Tall Fescue, respectively. Hoveland, (1993) also reported that beef steer average daily gain increased from 30 to over 100% between E+ and E- tall fescue. It was believed that the problems associated with Fescue Toxicosis had been solved with the release of endophyte free varieties. Although the presence of the endophyte has a negative impact on the animal, it has a positive relationship with the hardiness of the plant. Unfortunately, there were significant disadvantages from an agronomic perspective when the endophyte was

not present, and the hardiness and longevity of the plants were compromised, thus stocking rates were lower, and in some instances, the entire stand of endophyte free fescue was lost (Read and Camp, 1986).

As previously reported, with each 10% increase in ergovaline infestation, animal ADG decreases by one-tenth of a pound (Crawford et al., 1989). Thus, if plants that produce no, or low levels of ergovaline, animal performance would be higher than animals grazing conventional KY31 E+ pasture. There are Tall Fescue varieties that contain an endophyte, but do not produce high levels of ergot alkaloids. Thus, the plant benefits from the endophyte from an agronomic standpoint, but animal performance is significantly higher than animals grazing E+ pasture. These varieties are known as Non-Toxic endophytes or Novel endophytes (E0). Grazing trials have shown that plant persistence is similar to E+ pasture, and much greater than E-, with similar animal performance to E- pasture and much greater animal performance than E+ pasture (Bouton et al., 2002; Parish et al., 2003). In addition to higher gains when compared to cattle grazing E+ forage, cattle that were consuming E0 pasture also had higher serum prolactin levels (Parish et al., 2003).

Replacement of E+ forage with and E- or E0 variety is a valid option for producers to combat Tall Fescue Toxicosis. When considering replacement of E+ forage, producers should evaluate their situation to make sure it is justifiable to plant a new variety, as the process can be quite expensive. Endophyte infection levels of 25-35% are considered moderate, with levels exceeding 50% referred to as high, it is thought that with even moderate levels, replacement is justified, and certainly for high infestation levels (Thompson et al., 1993; Roberts and Andrae, 2004). Considerations for timeline

of land ownership/usage and class of livestock need to be taken for economic reasons. The grazing management style also needs to be evaluated, as the E0 and E- varieties are often higher maintenance than the E+ cultivars.

It has been mentioned that E+ forages are quite persistent, thus the eradication of E+ tall fescue can be difficult (Roberts and Andrae, 2004). It is common practice to utilize a process known as Spray-Smother-Spray to kill the stand of E+ forage (Roberts and Andrae, 2004). This process involves spraying the E+ fescue with a nonselective herbicide such as glyphosate, immediately seeding an annual "smother" crop that can be grazed or harvested, spraying the annual crop with the same herbicide and then no-till drilling the new E0 or E- variety (Hill et al., 2010). The "smother" crop is utilized to aggressively grow and form a canopy to prevent the viable seed and escape tillers of the E+ forage from reestablishing. Generally, this practice works well with the first "spray" taking place in the spring, with a summer annual seeded, and a fall planting of the new variety of tall fescue. Though the process can work for spring plantings, it is a challenge for the new variety to become established in the presence of summer stressors (Roberts and Andrae, 2004).

Managing E+ Pasture/Hay

There are many ways that producers can alter their management practices to reduce the impact of tall fescue toxicosis.

Stockpiling, long intervals between pasturing, or low stocking densities can cause significant ergot alkaloid accumulation, thus magnifying the effects of fescue toxicosis (Belesky and Hill, 1997). Ergot alkaloid concentrations are drastically higher in seedheads than in the leaves and sheaths of the plant (Rottinghaus et al., 1991). Cattle have been known to actively graze Tall Fescue Seedheads in the early summer months, when ergovaline levels are at their highest point (Goff et al., 2012). Any way to minimize the number of seedheads present in pastures can decrease the symptoms of Tall Fescue Toxicosis. Common means of eliminating seedheads are clipping, grazing management, and chemical suppression (Roberts and Andrae, 2004).

Increasing stocking rates have been shown to increase animal performance. Intense grazing can increase the leaf to stem ratio which may also decrease the effects of Fescue Toxicosis (Detling and Painter, 1983). Bodyweight gain per unit of land has been shown to increase as stocking rate increases on E+ pasture with no supplementation (Bransby et al., 1988), with the use of steroidal implants (Aiken and Strickland, 2013), and with supplementation (Aiken et al., 1999). Though individual average daily gain does not always increase with increased stocking rate, it generally is a more gradual downward slope on E+ forages than E- (Bransby et al., 1988). It is believed that on pasture with low stocking rates, animal performance is limited by ergot alkaloids and their effects on the animal, whereas on high stocking rates, performance is limited by forage availability (Aiken and Strickland, 2013).

Chaparral herbicide (DowAgroSciences, 2011) is known to suppress seedhead emergence in Tall Fescue plants (Aiken et al., 2012). The seedhead suppression did not affect the ergot alkaloid concentrations in the leaves and sheaths of the E+ fescue. It did,

13

however, reduce the concentration of reproductive tillers, containing seeds and stems. The latter parts of the plant are selectively grazed by cattle in certain time of year, thus their elimination successfully reduced the amount of ergot alkaloids produced by the plant and consumed by animals (Aiken et al., 2012). Though Chaparral application slightly reduced herbage mass, animal performance was greater in steers that grazed E+ pastures treated with the herbicide (Aiken et al., 2012). This was likely due to greater performance in cattle that were not exposed to seedheads, thus mitigating some effects of fescue toxicosis, as well as higher protein, digestibility, and water soluble carbohydrates in forage that was treated with Chaparral (Aiken et al., 2012). All in all, Chaparral has been an effective way to increase ADG in cattle and minimize fescue toxicosis. Before applying the herbicide, producers should evaluate the decision on a financial basis, and follow all label instructions to avoid damage to their pastures.

Tall Fescue is popular forage for winter stockpiling. It is common practice to graze the stockpiled forage in the early part of the winter. Unfortunately, ergovaline concentrations are at their highest levels early, and decrease throughout the winter (Rogers et al., 2011). Producers could decrease the amount of ergot alkaloids consumed by their cattle if harvested storage is fed early in the winter, and stockpiled forage is saved, to minimize ergovaline concentration (Roberts and Andrae, 2004).

Another option for producers that don't want to convert their whole grazing system to E- or E0 pasture is summer rotation. If cattle are moved off of E+ pasture in mid spring and graze an E- pasture through the summer, the negative impacts of Fescue Toxicosis are significantly minimized (Roberts and Andrae, 2004).

Supplementation

        Another strategy to combat Fescue Toxicosis is to supplement the animals grazing E+ pasture with additional feedstuffs. Whether or not the benefits are a result of reactions mitigating fescue toxicosis, or just an improved diet is unknown, but performance is generally increased with additional supplementation (Aiken and Strickland, 2013). Stokes et al. (1988) showed that supplementing ground corn at .65% of BW increased ADG and serum prolactin levels in animals that were grazing E+ pasture versus cattle on E+ pasture that received no supplementation. Goetsch et al. (1987) showed that overall intake increased but the intake of E+ decreased with the supplementation Bermudagrass or Clover hay to cattle grazing E+ hay ad libitum. Serum prolactin levels also significantly increased with supplementation, thus mitigating some effects of Fescue Toxicosis (Goetsch et al., 1987). In a study that evaluated the effects of soybean hull supplementation and steroid implants on cattle grazing E+ fescue pasture, it was shown that soybean hull supplementation increased ADG and was economically justified when cattle prices were high and soybean hull prices were less than $120/ton. However, when a steroid implant was used in conjunction with soybean hull supplementation, it proved economically beneficial when soybean hulls were more expensive and cattle prices were much lower (Carter et al., 2010). Carter et al. (2010) also showed that soybean hull supplementation increased the number of animals with sleek hair coats and decreased the percentage of animals with hair coats described as "rough" while steers were grazing E+ fescue pastures. If producers want to increase

ADG in animals that are grazing E+ pasture, or want to decrease E+ intake and possibly

mitigate some symptoms of Fescue Toxicosis, supplementation is a valid option.

Interseeding

Another way to combat the negative effects of Fescue Toxicosis is to interseed

legumes or other grasses into E+ pastures. Similar to supplementing with grain or by-

products, diluting the diet with non-toxic forage will reduce the concentration of total

toxins consumed by the animal. Legumes such as white and, predominantly, red clover

are popular choices for interseeding into E+ Tall Fescue pastures (Roberts and Andrae,

2004).   Thompson et al. (1993) showed that average daily gains increased when cattle

grazing E+ pastures were interseeded with clover. However, gains also increased in

cattle that were grazing Fescue pastures with low endophyte infestation as well. This

shows that a true dilution effect is not taking place, rather the cattle are benefiting from a

higher quality diet, similar to results shown with grain and byproduct supplementation

(Thompson et al., 1993; Aiken and Strickland, 2013). In addition to providing a higher

quality diet, interseeding pastures with clovers reduce the need for nitrogen fertilizer, due

to the nitrogen fixing nature of legumes. This saves money in fertilizer purchases, as

well as reduces the ergovaline concentrations in E+ pastures.

Some producers also "dilute" E+ Tall Fesuce with other grasses such as

Orchardgrass or brome. Due to the high level of persistence in E+ Tall Fescue, these

grasses are generally not overseeded, but planted at the time of establishment in a

mixture. These pastures must be well managed or E+ Fescue will out-persist the other

varieties (Roberts and Andrae, 2004)

Nitrogen Fertilization

The application of Nitrogen fertilizer in the spring and fall growing seasons is a

common practice for pastures. Unfortunately, as the level of applied nitrogen increases,

ergot alkaloids also increase in E+ pastures (Lyons et al., 1986) (Rottinghaus et al.,

1991). Symptoms of Tall Fescue Toxicosis are exacerbated when animals are grazing E+

pastures that have been heavily fertilized with nitrogen. Williams et al. (1969) observed

a high incidence of severe fat necrosis in a small herd of Angus cattle that had been

continually grazing E+ pasture that had been continually fertilized with broiler litter,

which is high in nitrogen. In a herd of 21 animals, 14 had necrotic fat in the abdominal

cavity and 5 died (Williams et al., 1969). If a producer is trying to minimize the impact

of Tall Fescue Toxicosis, they should avoid applying high rates of nitrogen to their

pastures (Roberts and Andrae, 2004).

Calving Season

There are two predominant calving seasons that are typical to US beef production.

If a commercial producer has a defined calving season, it would likely occur between

February and May and to a lesser extent, from September to November. The breeding

season for spring calving cows occurs between mid-spring and early summer, whereas

the breeding season for fall calving cows is generally late fall and early winter. In the

fescue belt, the spring breeding season can be very hot and humid; this coupled with increased levels of ergovaline creates a stressful environment for cows to conceive. It becomes even tougher for young females to conceive, especially those that are still growing or in a lower than ideal body condition. A study conducted at the University of Tennessee did a 19 year evaluation of spring versus fall calving cow herds. Campbell (2012) found that the fall calving herd was more profitable than the spring calving herd which both grazed toxic tall fescue as their predominant forage; despite spring calving's popularity nationwide. Spring calves had a higher ADG than fall calves. However, due to the more favorable conditions during the breeding season, more fall calving cows are able to conceive (Campbell, 2012). A higher number of total calves coupled with traditionally higher feeder calf prices in late spring and early summer, resulted in a greater net profit for the fall calving herd (Campbell, 2012). It also proved more economical to retain and develop replacement females, due to a higher percentage of them remaining in the herd for a longer period of time, thus increasing net profits as well (Campbell, 2012).

Genetic Selection

Due to financial and labor requirements of some of the strategies to minimize the negative effects of fescue toxicosis, producers have selected animals that perform better than others on E+ pastures. Recently, there have been developments to better select "Fescue tolerant" animals from a genetic standpoint.

In a study conducted by Gould and Hohenboken (1993), calves sired by a Polled Hereford bull with a reputation of producing fescue tolerant calves had higher intakes and lower bodyweight temperatures when compared to calves sired by a different Polled Hereford bull. Another study conducted at the Virginia Polytechnic Institute and State University demonstrated that one genetic line of mice was more tolerant to E+ fescue than another (Hohenboken and Blodgett, 1997). Both of these studies show that is possible to genetically select for animals that are more tolerant to E+ fescue, thus have increased performance when compared to animals that are more susceptible to Fescue toxicosis while consuming E+ pasture or hay.

Genetic Testing Potential

With advancing genomic technologies, there have been efforts made to use single nucleotide polymorphisms (SNP) to identify animals that excel in a variety of phenotypic traits. Recently, there has been interest in using the same genomic technologies to select for animals that are more tolerant to toxic tall fescue. Campbell et al. (2014) evaluated the effectiveness of utilizing a SNP to predict tolerance to fescue toxicosis. The SNP was located on the dopamine receptor D2 (DRD2) gene, which is located on bovine chromosome 15. They utilized that particular gene as it is directly related to prolactin levels in the bovine (Campbell, 2012). AgBotanica LLC, in Columbia MO has developed a commercially available genetic test to identify animals that are more tolerant to toxic tall fescue. DNA obtained from blood, hair, or semen is analyzed based on a number of genetic markers. The results obtained from DNA analysis are computed into a

19

T-Snip tolerance index, which is then converted to a T-Snip Star rating. Animals are assigned 0-5 stars, 0 meaning most susceptible to symptoms of fescue toxicosis, and animals with 5 stars being the most tolerant to tall fescue toxicosis. The T-Snip test was validated in a large cow-calf study. The results showed that calves weaned from dams with 0-1 stars were 22.7 kg lighter than calves weaned from cows with 4-5 stars. In another study, heifers were fed either an E+ or E- diet. For the animals receiving an E- diet, performance did not differ among T-Snip scores. However, when fed an E+ diet, tolerant (4-5 star) animals gained more than susceptible (0-1 stars) heifers. Though single trait selection is rarely advantageous for genetic progress, it is advised to use the T-Snip test as a tool when selecting bulls or replacement females if they will be utilizing toxic tall fescue as a primary source of forage. (https://www.agbotanica.com/t-snip.aspx)

Summary

The fescue belt is home to a large proportion of the U.S. beef cowherd. The tall fescue in that region is predominantly of the toxic, KY-31 variety. Though toxic tall fescue has some excellent agronomic characteristics, it also has a detrimental effect on animal performance. Both are related to the symbiotic relationship between the plant and an endophytic fungus, the "endophyte". Novel endophytes and endophyte free varieties of tall fescue have been developed to eliminate animal performance issues attributed to the toxic endophyte. If replacement of the toxic forage is not feasible, there are several strategies to better manage the grass and animals to reduce the negative effects of fescue toxicosis. In addition to management of forage and animals, more recent research has been conducted to genetically identify and select for animals that are more resistant to the toxins. The objective of the following studies was to identify the impact of fescue toxicosis and T-Snip score on post-weaning performance of beef cattle.

CHAPTER 2

THE IMPACT OF FESCUE TOXICOSIS AND T-SNIP SCORE ON POST-WEANING BEEF CATTLE PERFORMANCE

ABSTRACT

It is well known that fescue toxicosis has a negative impact on cattle productivity. This study was conducted to evaluate the effects of fescue toxicosis on post-weaning beef steers as well as the impact of T-Snip score on performance. We hypothesized that cattle that consumed an E+ diet would perform lower than cattle that did not. We also hypothesized that the cattle coming off of an E+ diet would remain at a lower weight than those that did not throughout the feeding period. T-Snip scores were also believed to be indicative of animal performance while consuming an E+ diet. A two-phase feeding trial was conducted to evaluate the aforementioned effects. 306 crossbred steers (288.8 ± 3.81 kg) were blocked by weight, T-Snip score, and color, and assigned to one of two treatments. The grow phase consisted of the first 54 days of the experiment. Throughout this period, high roughage, growing diets were fed to the steers. The treatment group was fed a diet containing toxic tall fescue seed, whereas the control diet was fed a seed-free diet. The finishing phase was day 54-slaughter. In this period, all animals were fed a common, corn-based finishing diet. For the first phase of the experiment, there were no differences between treatments for initial bodyweight (IBW), DMI, dry matter intake as a % BW (DMPW), ADG, GF, or end bodyweight (EBW). There was however differences between T-Snip star scores among treatments. In the control group, animals with 2 and 3

stars had a higher ADG ($P \leq 0.05$) (1.74 kg vs. 1.68 kg) than animals with 0, 1, & 4 stars

(1.59 kg, 1.53 kg vs. 1.53 kg). In the E+ group, animals with zero stars had the lowest

ADG (1.42 kg), animals with 1 or 2 stars had an increased ADG (1.65 kg vs. 1.63 kg) and

animals with 3 or 4 stars had the highest ADG (1.74 kg vs. 1.76 kg) ($P \leq 0.05$). In the

finishing phase, control animals had increased DMI ($P < 0.05$) (8.33 kg vs. 7.82 kg).

DMIPW, ADG, and EBW tended ($P < 0.10$) to be higher for the control groups. There

were no differences between T-Snip star scores among treatments during the finishing

phase. HCW was higher for control animals than E+ animals ($P \leq 0.05$) (343.01 kg vs.

331.13 kg) Marbling scores were lower in E+ animals than control ($P \leq 0.05$) (4.41 vs.

4.71) Carcass value was higher for control treatment than E+ ($P \leq 0.05$) ($1486.93 vs.

$1420.68). The only difference among T-Snip star scores occurred in the control group,

where 0 star animals had increased backfat (BF) ($P \leq 0.05$).

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INTRODUCTION

In the humid transition zone of the United States, Tall Fescue is the primary
source of forage for over 8.5 million head of cattle (Stuedemann and Hoveland, 1988).
Stuedemann and Hoveland (1988) reported that Tall Fescue is easily adapted, has long
growing seasons, and is resistant to drought, over-grazing, trampling, flooding and pests.
Those agronomic traits are due to the presence of an endophytic fungus (*Neotyphodium
coenophialum),* referred to as the "endophyte", that produce ergot alkaloids that are toxic
to animals (Bacon et al., 1977). When animals consume endophyte infected tall fescue,
they suffer from a disorder known as Tall Fescue Toxicosis. Symptoms of Fescue
Toxicosis include: reduced feed intake, reduced bodyweight gains, increased body
temperature, increased respiration rates, rough hair coats, reduced reproductive
performance, excessive salivation and low serum prolactin levels (Strickland et al.,
1993). Fescue Toxicosis is estimated to cost the beef industry $1 billion annually, with
the losses being attributed to poor reproductive performance and reduced gains (Roberts
and Andrae, 2004). There are many forage management strategies used to mitigate the
effects of fescue toxicosis, due to the costs and labor associated with combatting fescue
toxicosis, some producers have tried to select animals that display a higher degree of
tolerance to the ergot alkaloids. The T-Snip is a commercially available genomic test that
assigns a score that is indicative of the animal's predicted tolerance or susceptibility to
fescue toxicosis. Fescue toxicosis and its effects have been well studied on cow/calf and
growing calf models. However, there is not as much documented research on the effects
of fescue toxicosis in the post-weaning beef animal after animals quit consuming an E+
diet. We hypothesized that cattle consuming an E+ diet in the grow phase would have

24

lower ADG and DMI thus, entering the feedlot at a lower weight. We also hypothesized

that once in the finishing phase, ADG would be the same as control but E+ calves would

still have a lower EBW. This study evaluates the effects of Fescue toxicosis on post-

weaning beef cattle performance in addition to monitoring the efficacy of the T-Snip test

on predicting tolerance to toxic tall fescue. In addition to post-weaning performance of

animals that previously consumed an E+ diet, we also validated the T-Snip test's

predictions for fescue toxicosis tolerance.

MATERIALS AND METHODS

Experimental Design

A two-phase experiment was conducted to evaluate the impact of fescue toxicosis and T-SNIP score on post-weaning beef steers. In December 2016, 306 crossbred steers (288.8 ± 3.81 kg) were stratified by T-SNIP score and randomly assigned to one of two treatments with animal being the experimental unit. The control group was fed a forage-based diet throughout the growing phase (C) (Table 2.1). The treatment group was fed a similar ration (Table 2.1); however the treatment diet contained toxic tall fescue seed (E+) (Tables 2.2 & 2.3). After 54 days of the forage based diet, steers were transitioned onto a common corn based finishing ration and fed until time of slaughter (Table 2.4).

Animals and Management

All animals used in this study were managed and handled in accordance with a protocol that was approved by the University of Missouri-Columbia Animal Care and Use Committee. 306 crossbred steers were sourced from Joplin Regional Stockyards, Carthage, MO in two groups, one week apart. Upon arrival to the University of Missouri-Columbia Beef Research and Teaching Farm (BRTF), Columbia MO, animals were individually identified with a numbered ear tag (AllFlex, Dallas, TX) in the right ear. In the upper portion left ear, cattle received a radio frequency identification tag (RFID;AllFlex, Dallas, TX). Any bulls were surgically castrated with a Newberry knife (SyrVet, St-Alphonse-de-Granby, QC, Canada). Animals were given a metaphylactic dose of Draxxin (Zoetis, Parsippany, NJ), and orally de-wormed with SafeGuard (Merck

Animal Health, Madison, NJ). Hair (from the tail switch) and/or blood (collected from the coccygeal vein) samples were also taken and collected on a sample card (NeoGen, Lansing, MI) for T-Snip analysis (AgBotanica LLC, Columbia, MO). Immediately following initial processing, animals were randomized and assigned to one of three treatments for a 21 day receiving study. Throughout the receiving period, animals consumed one of three diets (Table 2.5) and became acclimated to a GrowSafe feed intake monitoring system (GrowSafe Systems, Airdrie, AB, Canada). The steers were transitioned onto the control (C) experimental diet over a minimum of 2 weeks.

On day 0, animals received vaccinations (Endovac-Beef- IMMVAC Columbia, MO; Bovi Shield Gold 5- Zoetis Parsippany, NJ; Vision 7- Merck Animal Health Madison, NJ) and a steroid hormone implant (Component TE-IS with Tylan- Elanco, Indianapolis, IN) and were blocked by weight and T-SNIP star and were randomly assigned to one of two treatments.

Animals were randomly allocated to one of 6 pens (36.6 x 23.4 m) n=51 steers/pen. 6.1 x 36.6 m of the pen was concrete with the balance being dirt and gravel. Animals were provided two structures per pen to provide shelter (7.6 x 9.1 m) from the sun and precipitation. Feed and water were provided ad libitum via 5 GrowSafe bunks (GrowSafe Systems, Airdrie, AB, Canada) and 2 automatic waterers (Ritchie Industries Inc. Conrad, IA) per pen. Feed was delivered at approximately 0800 each morning with a truck-mounted mixer (Reel Auggie 3120, KUHN North America, Inc., Bordhead, WI).

On days 53 and 54, 2 consecutive day weights were taken and the grow phase was ended. Animals were transitioned onto a common finishing diet over a 2 week period.

On day 165 and 166, 24 steers were weighed 2 consecutive days. The cost of gain was exceeding daily feed costs and those animals were shipped approximately 415 miles to a commercial packing plant for humane slaughter and processing (JBS, Grand Island, NE). When the remainder of animals (n=262) were estimated to grade 60% USDA Choice by visual appraisal, they were weighed on 2 consecutive days (180 and 181) and shipped to the same processing facility. Animals were removed from the study (n=20) due to chronic bovine respiratory disease (receiving 3 or more antibiotic treatments), chronic bloating, failure to adapt to the GrowSafe system, or mortality.

Treatments

Animals were stratified by T-SNIP score and randomly assigned to one of two treatments. The control (C) group was fed a forage based growing ration ad libitum. The treatment group was fed a similar ration that contained 7.6%DM of ground toxic Tall Fescue seed. Both rations contained equal amounts of corn, dried distillers grains with soluble (DDGS), rye baleage, and a vitamin/mineral premix. Both rations contained soyhulls, however the treatment contained toxic tall fescue seed and 43%DM soy hulls whereas the control diet contained no toxic tall fescue seed and 50%DM soy hulls.   The growing rations were fed from day 0 to day 54. From day 54 until the end of the study, all animals were fed a common corn-based finishing ration. All diets were balanced to meet or exceed growing cattle requirements for protein, amino acid, and vitamin and minerals (NRC, 1994) as well as effective energy requirements (Emmans, 1994),. The supplement was mixed at the University of Missouri Feed Mill. Supplement contained

lime, salt, Vitamin ADE blend, Vitamin E, UREA, University of Missouri mineral premix, a rumen protected encapsulated lysine (AjiPro, Ajinomoto Heartland, Inc., Eddyville, IA), ground E+ fescue seed (E+ grow diet) and a rumen modifier (Rumensin 90, Elanco Animal Health, Greenfield, IN) in the finishing diet. Ground corn served as the carrier for additives. Supplement was mixed in 909kg batches and stored on the BRTF in upright bins. At the time of feeding, supplement was mixed with other ingredients in the truck mounted mixer.

Measurements

Rye baleage dry matter (DM) was calculated weekly from samples collected with a drill-operated bale sampler (HAYPROBE, Hart Machine Co., Madras, OR). To ensure constant DM% of each feed ingredient, adjustments were made weekly according to forage DM. Weekly feed samples were collected as feed was dispensed from the truck-mounted mixer to the GrowSafe bunk. Samples were dried at 55ºC and ground to pass through a 2mm screen (Thomas Wiley Mill, Thomas Scientific; Swedesboro, NJ). A representative sample from each week was composited into 2-3 week samples. Composites were ground to pass through a 1mm screen in a Cyclotec Sample Mill (FOSS, Hillerod, Denmark). Each composite sample was dried at 105ºC and analyzed for DM (Isotemp Oven 255 G, Fisher Scientific, Pittsburg, PA), OM (Isotemp Muffle Furnace, Fisher Scientific, Pittsburg, PA), N content (vario Micro Cube, Elementar Americas, Mt. Laurel, NJ), and fiber (NDF&ADF) (ANKOM[200] Fiber Analyzer, ANKOM Technology, Macedon, NY).

All animal weights were measured at 0700. Two day consecutive weights were taken on day -1 and day 0 and averaged to establish initial body weight (IBW). Following day 0, animals were weighed every 28 (±4) days. Day 53 and 54 weights were averaged to determine the end bodyweight for the grow phase (EBWG) and initial bodyweight for the finishing phase (IBWF). On days 165, 166, 180, and 181, 2 consecutive day weights were taken and averaged to mark the end of the study (EBW). Daily feed intake was monitored each morning by trained personnel and intake data was collected every 28±4 days on corresponding weigh days from the GrowSafe system (GrowSafe Systems, Airdrie, AB, Canada).

Carcass measurements were taken post-slaughter after a chilling period, with the exception of hot carcass weight (HCW). Measurements of the ribeye area (REA), back fat (BF), marbling scores (MARB), USDA quality grade (QG), USDA yield grade (YG), and kidney, pelvic, and heart fat (KPH) were obtained by trained personnel (GeneNet LLC, Hays, KS). In addition, all premiums or discounts assigned to each animal as well as the carcass price/cwt and total carcass value were also provided.

Statistical Analysis

Data were analyzed as a completely randomized design with animal as the experimental unit. Treatment and T-Snip star were the independent variables, whereas IBW, DMI, DMI%BW, ADG, GF, and EBW were the dependent variables for both the growing and finishing phase, and HCW, REA, BF, YG, MARB, Price, and Value were the dependent variables used for carcass data. LS MEANS of all dependent variables

were analyzed using the GLM Procedure of SAS (SAS version 9.4, SAS Inst. Inc., Cary,

NC). Significance was set at $\alpha \leq 0.05$ with tendencies at $\alpha \leq 0.10$.

RESULTS

Grow Phase

In the grow phase (D0-D54) there were no treatment differences (Table 2.6) in IBW (P=0.27), DMI (P=.043), DMIPW (P=0.99), ADG (P=0.62), GF (P=0.30), or EBW (P=0.49). When analyzed for differences among T-SNIP star scores (Table 2.7), there were differences in ADG (P=.05). Within the treatment group, animals with a T-SNIP star score of 0 (1.42kg) had a lower ADG than animals with a score of 3 (1.74kg) and 4 (1.76kg) and tended to be lower than animals with a score of 1 (1.65kg) and 2 (1.63kg). The 1 star animals (1.65kg) tended to gain more than 0 star animals (1.42kg). The 2 star animals (1.63kg) showed a tendency to gain less than 3 star animals (1.74kg). Within the control group, animals with 1 star (1.53kg) gained less than animals with 2 stars (1.74kg). Animals with 2 (1.74kg) stars gained more than animals with 4 stars (1.53kg). Animals with 3 stars (1.68kg) gained more than animals with 1 star (1.53kg). There were no significant differences in IBW, DMI, DMIPW, GF, or EBWG between T-SNIP star scores within treatments.

Finishing Phase

In the finishing phase (d54-slaughter) there were no statistical differences in IBWF or GF. However, DMI was lower (P=.01) for E+ animals (7.82kg) than Control animals (8.33kg) and DMIPW also tended to be lower (P=.07) in E+ animals (1.67%) versus Control animals (1.73%). ADG tended (P=.08) to be greater in the Control group (1.63kg) than the E+ animals (1.54kg) with EBW tending (P=0.06) to be higher in the control group (583.94kg) as well when compared to the E+ animals (566.35kg) (Table

2.8). When T-SNIP star scores were compared within each treatment (Table 2.9), there

were no significant differences for IBWF, DMI, DMIPW, ADG, GF, or EBW.

Carcass Characteristics

HCW was lower (P=.05) for animals that received an E+ diet in the growing

phase (331.13kg) than animals that were fed the control diet in the growing phase

(343.01kg). REA did not differ between treatments, there was however a tendency

(P=0.10) for the control group to have more BF (1.37cm) versus the E+ animals

(1.22cm). YG did not differ between treatments. Marbling score was higher (P=0.05)

for the control group (4.71) than E+ (4.41). Carcass price ($/cwt.) did not differ,

however, carcass value ($/head) was higher ($P$=0.05) for the control group ($1486.93)

than the E+ group ($1420.68). There was a difference among star scores within

treatments in BF (P=0.01), BF generally increased as star score increased in the E+

treatment (Table 2.10). There were no significant differences among star scores within

treatments for HCW (P=0.47), REA (P=0.38), YG (P=0.16), MARB (P=0.66), Carcass

Price (P=0.30), or Carcass Value (P=0.54) (Table 2.11).

DISCUSSION

Grow Phase Animal Performance

It is well known that the consumption of E+ Tall Fescue has negative effects on animal performance. For growing cattle in particular, intake and ADG are much lower for animals that are consuming an E+ diet than for those that are not (Stuedemann and Hoveland, 1988). The decreases in those traits are exacerbated by heat stress, so the most dramatic changes in performance are noted in summer months in the Fescue Belt. In this study, we did not find there to be any differences between treatments for any performance traits. The average temperature in Columbia, MO during the 54 day growing period of this study was 3.3ºC. Hemken et al. (1981) showed that the symptoms of fescue toxicosis were not apparent until ambient environmental temperatures reached approximately 20ºC. The low temperature is believed to be the primary reason for equal performance between the treatments. The ergot alkaloid composition of the seed used for this trial was unlike other seeds used in previous studies. Diets were formulated to contain 600-800 ppb of total ergot alkaloids rather than ergovaline due to the profile of the seed. Perhaps this can also account for the minimal effects of E+ fescue seed in the treatment diet.

There was a significant effect of T-SNIP star score on ADG within the E+ treatment group. As T-SNIP star score increased, ADG increased as well, indicating that the T-SNIP test was predictive of tolerance to E+ tall fescue. Though not significant (P=0.21, P=0.19) DMI and DMIPW also numerically increased as T-SNIP star score increased, further suggesting that the T-SNIP is indicative of tolerance or susceptibility to

toxic tall fescue. Even though there were not treatment differences in performance, it

seems as though within the E+ treatment, the ergot alkaloids had an effect on animals

based on their predicted tolerance/susceptibility due to the trends in gain and intake.

There were no other significant differences between star scores within treatments.

Finish Phase Animal Performance and Carcass Characteristics

During the finishing period, both treatments received a common, no-roughage

finishing diet. Studies conducted by Aiken et al. (2008) and (Stuedemann et al., 1998)

showed quick recovery from fescue toxicosis based on rectal temperature, serum

prolactin concentrations, and urinary alkaloid concentrations (Aiken, 2011) In one study,

wintertime rectal temperatures remained lower in cattle that came from E+ pastures than

animals that grazed E- pastures (Allen et al., 2001). That data would suggest that the

alkaloids were still present in animals and effecting circulation, even for an extended

period of time after exposure to an E+ diet.

It appears that there was a carryover effect from the E+ diet in the finishing phase

of this experiment. Control animals consumed 0.5 kg more dry matter on a daily basis

than animals in the E+ group. The decrease in intake would suggest that the ergot

alkaloids from the E+ diet have a residual effect or remain in the vasculature of animals.

DMIPW also tended to be higher in control animals as well. There was also a tendency

for ADG to be 0.09 kg higher in the control group, as well as a 17.59 kg increase in

EBW. There were no differences in IBW or GF. The average ambient temperature in

Columbia, MO during the finishing phase of the experiment was 16ºC, with daily high

temperatures reaching up to 33ºC. Increased temperature coupled with the residual effect of the ergot alkaloids resulted in lower intake and gain in the cattle from the E+ treatment.

Marbling score was higher in control cattle, probably due to the higher HCW and the tendency for more BF. Similar to the results of Duckett et al. (2001), carcass value was lower ($66.25) for the E+ cattle than control, this was primarily driven by a lower HCW as Price ($/cwt) did not differ between treatments.

CONCLUSION

Throughout the grow phase of the experiment, the T-Snip test was a valid predictor of animal performance while consuming an E+ diet. Though there were no differences in performance at the end of the growing phase, there was confirmation that the consumption of E+ diets during the grow phase has a negative effect on feedlot performance and ultimately the bottom line at time of marketing. Though it is not recommended to utilize the T-Snip test on feeder calves, it could be beneficial for producers to use the test when selecting replacement females or herd bulls, especially if the calves will be grown on fescue pasture. To maximize performance during the finishing phase, producers should avoid using E+ forage as a primary diet.

Table 2.1. Dietary nutrient composition fed during growing phase

Ingredient (%DM)	Treatment	
	E+	Control
Soy Hulls	42.95	50.43
DDGS	21.24	21.29
Triticale Baleage	13.30	13.33
E+ Fescue Seed[1]	7.60	X
Corn	11.68	11.70
Lime	1.62	1.62
Trace Mineral Premix[2]	0.77	0.77
ADE[3]	0.26	0.26
Salt	0.26	0.26
Urea	0.13	0.13
Vitamin E[4]	0.11	0.11
AjiPro[5]	0.10	0.10
Nutrient Composition		
DM, %	67.20	68.85
CP, %DM	14.56	14.25
NDF, %DM	45.41	45.35
ADF, %DM	28.21	28.73
OM, %	92.10	92.22

[1] Ergot Alkaloid Composition in Table 2.3
[2] Trace Mineral Premix= 24% Ca, 3.0% Zn, 2.5% Fe, 2.0% Mn, 1.0% Cu, 100 ppm Co, 500 ppm I, 100 ppm, Se)
[3] ADE= 8,800,000 IU/kg Vitamin A, 1,100 IU/kg Vitamin E, 1,760,000 IU/kg Vitamin D
[4] Vitamin E= 44,000 IU/kg
[5] AjiPro-L; Ajinomoto, Chicago, IL

Table 2.2. Ergot alkaloid concentration of Tall Fescue Seed

Ergot Alkaloid	Concentration (µg/kg)
Ergosine	4670
Ergotamine	2220
Ergocristine	2170
Ergocryptine	1900
Ergocornine	1500
Ergovaline	1110
Total	13,570

Table 2.3. Ergot alkaloid concentration of growing diets

Diet	Total Ergot Alkaloid Concentration (µg/kg)
Control	179
E+	711

Table 2.4. Dietary nutrient composition fed during finishing phase

Ingredient (%DM)	
Corn	79.58
Wet Distillers Grain	8.98
AminoPlus[1]	8.66
Premix[2]	2.32
Urea	0.39
Ajipro-L[3]	0.05
Rumensin 90[4]	0.01
Nutrient Composition	
DM, %	76.68
CP, % DM	14.24
NDF, % DM	13.27
ADF, %DM	3.7

[1]AminoPlus; Ag Processing Inc., Omaha, NE

[2]Premix contained: salt, limestone, vitamins ADE, magnesium oxide and trace minerals

[3]AjiPro-L; Ajinomoto, Chicago, IL

[4]Rumensin 90; Elanco Animal Health, Greenfield, IN

Table 2.5 Receiving study diet composition

Ingredient (%DM)	Control	AA	AAXS
	Treatment		
Corn	66.84	69.38	69.35
Cotttonseed Meal	X	14.43	14.43
Soybean Meal	8.03	2.27	2.27
Rye Baleage	8.11	8.12	8.12
DDGS	7.6	X	X
Bloodmeal	4.81	X	X
Limestone	1.08	1.5	1.5
Dyna K[1]	0.99	0.9	0.9
CocciCurb[2]	0.68	0.67	0.67
AjiPro[3]	X	0.6	0.6
Fat	0.5	0.5	0.5
Salt	0.48	0.36	0.36
Vit. E[4]	0.24	0.25	0.25
Trace Mineral Premix[5]	0.21	0.24	0.24
MgO[6]	0.2	0.25	0.25
Aureomycin[7]	0.11	0.11	0.11
Urea	0.1	0.12	0.12
ADE[8]	0.05	0.12	0.12
Sucram[9]	X	X	0.02
Xtract[10]	X	X	0.01
Nutrient Composition			
DM,%	77.74	78.99	78.60
CP,% DM	17.50	14.66	14.65
NDF,% DM	14.09	15.15	15.03
ADF,% DM	5.53	7.14	6.95
OM,%	92.76	92.21	93.11

[1]The Mosaic Company, Plymouth MN; Contains 50% K, 46.4% Cl-, 95.3% KCl
[2]NutraBlend, LLC, Neosho, MO
[3] AjiPro-L; Ajinomoto, Chicago, IL
[4] Vitamin E= 44,000 IU/kg
[5] Trace Mineral Premix= 24% Ca, 3.0% Zn, 2.5% Fe, 2.0% Mn, 1.0% Cu, 100 ppm Co, 500 ppm   I, 100 ppm, Se)
[6]Magnesium Oxide 54, Feed Products and Services Company, Madison Il; 93% MgO loss free
[7]Zoetis, Parsippany, NJ
[8]ADE= 8,800,000 IU/kg Vitamin A, 1,100 IU/kg Vitamin E, 1,760,000 IU/kg Vitamin D
[9]Pancosma, Le Grand, Saconnex, Geneva, Switzerland
[10] Pancosma, Le Grand, Saconnex, Geneva, Switzerland

Table 2.6. Grow phase performance traits, feed intake, and feed efficiency of steers consuming a control or E+ diet

| Item | Treatment | | SEM | P-Value |
	Control	E+		
IBW, kg[1]	291.71	285.82	3.82	0.27
DMI, kg	8.97	8.78	0.17	0.43
DMI, %BW[2]	2.67	2.67	0.04	0.99
ADG, kg	1.61	1.64	0.04	0.62
G:F	0.18	0.19	0.00	0.30
EBWG, kg[3]	378.91	374.43	4.58	0.49

[1] IBW = Initial BW
[2] DMI, %BW = Calculated DMI as a percent of calculated midpoint BW
[3] EBW = End BW for growth period

Table 2.7. Performance traits, feed intake, and feed efficiency of steers between T-SNIP star scores among treatments

Star	C					T						
	0	1	2	3	4	0	1	2	3	4		
Item											Root MSE	P-Value
IBW, kg[1]	309.54	286.95	291.64	288.49	281.98	296.76	283.56	285.21	295.74	267.8	30.82	0.42
DMI, kg	9.72	8.39	9.17	9.04	8.52	8.58	8.47	8.61	9.06	9.18	1.38	0.21
DMI %BW[2]	2.75	2.55	2.71	2.71	2.63	2.57	2.58	2.62	2.64	2.94	0.34	0.19
ADG, kg	1.59^{ab}	1.53^{ab}	1.74^{a}	1.68^{a}	1.53^{ab}	1.42^{b}	1.65^{ab}	1.63^{ab}	1.74^{a}	1.76^{a}	0.3	0.05
G:F	0.16	0.19	0.19	0.19	0.18	0.17	0.2	0.19	0.19	0.19	0.03	0.88
EBWG, kg[3]	395.43	369.76	385.47	379.28	364.61	373.56	372.45	373.45	389.55	363.14	36.97	0.22
N=	5	26	53	51	10	6	26	53	55	7		

[1] IBW = Initial BW
[2] DMI, %BW = Calculated DMI as a percent of calculated midpoint BW
[3] EBWG = End BW for growth period
[a, b] = Least square means within a row with different superscript differ (P < 0.05)

Table 2.8. Finishing phase performance traits, feed intake, and feed efficiency of steers consuming a control or E+ diet

Item	Treatment		SEM	P-Value
	Control	E+		
Finish IBW, kg[1]	378.55	373.95	4.72	0.48
DMI, kg	8.33	7.82	0.15	0.01
DMI %BW[2]	1.73	1.67	0.00	0.07
ADG, kg	1.63	1.54	0.03	0.08
G:F	0.20	0.20	0	0.69
EBW, kg[3]	583.94	566.35	6.92	0.06

[1] IBW = Initial BW
[2] DMI, %BW = Calculated DMI as a percent of calculated midpoint BW
[3] EBW = End BW

Table 2.9. Performance traits, feed intake, and feed efficiency of steers between T-SNIP star scores among treatments

	C					T						
Star	0	1	2	3	4	0	1	2	3	4		
Item											Root MSE	P-Value
Finish IBW, kg[1]	395.43	369.76	384.11	378.86	364.61	368.1	375.49	373.47	389.55	363.14	36.41	0.19
DMI, kg	9.12	7.89	8.21	8.29	8.14	7.99	7.46	7.71	7.88	8.05	1.13	0.85
DMI %BW[2]	1.82	1.67	1.7	1.72	1.74	1.72	1.59	1.65	1.64	1.72	0.20	0.97
ADG, kg	1.66	1.64	1.61	1.63	1.6	1.61	1.51	1.51	1.45	1.65	0.26	0.52
G:F	0.18	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.18	0.21	0.03	0.40
Finish EBW, kg	606.36	576.71	585.11	583.72	567.82	563.78	563.25	563.15	568.79	572.75	53.33	0.81
N=	5	26	53	48	10	5	25	52	55	7		

[1] IBW = Initial BW

[2] DMI, %BW = Calculated DMI as a percent of calculated midpoint BW

[3] EBW = End BW

Table 2.10. Carcass characteristics of steers fed a control or E+ diet

Item	Treatment		SE	P-Value
	Control	E+		
HCW, kg	343.01	331.13	4.36	0.05
REA[1], cm^2	77.53	77.24	1.11	0.58
BF[1], cm	1.37	1.22	0.06	0.11
YG[2]	3.28	3.09	0.10	0.15
MARB[3]	4.71	4.41	0.11	0.05
Price[4]	196.49	194.65	1.85	0.47
Value[5]	1486.93	1420.68	24.57	0.05

[1] REA = LM area, BF = 12th rib backfat depth
[2] YG = Calculated USDA Yield Grade
[3] MARB = Marbling score
[4] Price = $/45.4 kg
[5] Value= Carcass Value ($)

Table 2.11. Carcass characteristics of steers between T-SNIP star scores among treatments

Star	C					T						
Item	0	1	2	3	4	0	1	2	3	4	Root MSE	P-Value
HCW, kg	357.21	335.6	346.09	345.16	331.01	329.15	336.72	329.39	330.46	329.93	33.53	0.47
REA[1], cm^2	78.45	78.79	77.59	74.87	77.94	76.65	76.86	76.01	77.52	79.17	8.51	0.38
BF[1], cm	1.95^a	1.33^b	1.27^b	1.24^b	1.04^b	1^b	1.18^b	1.36^b	1.23^b	1.35^b	0.50	0.01
YG[2]	3.92	3.21	3.13	3.25	2.90	2.94	3.08	3.30	3.11	3.01	0.75	0.16
MARB[3]	5.38	4.72	4.76	4.55	4.16	4.44	4.63	4.50	4.43	4.07	0.86	0.66
Price[4]	198.55	199.65	199.79	195.08	189.38	200.92	196.62	192.8	196.62	186.3	14.30	0.30
Value[5]	1562.5	1480.08	1522.9	1483.55	1385.64	1456.81	1457.73	1402.06	1432.8	1354	188.99	0.54
N=	5	26	53	48	10	5	25	52	55	7		

[1] REA = LM area, BF = 12th rib backfat depth
[2] YG = Calculated USDA Yield Grade
[3] MARB = Marbling score
[4] Price = $/45.4 kg
[5] Value= Carcass Value ($)
[a, b] = Least square means within a row with different superscript differ (P < 0.05)

CHAPTER 3

THE IMPACT OF T-SNIP SCORE AND FESCUE TOXICOSIS ON GRAZING BEEF HEIFER PERFORMANCE

ABSTRACT

Fescue toxicosis is detrimental to animal performance. It is known that animals consuming toxic (E+) tall fescue have lower bodyweight gains and intakes than animals not consuming E+ tall fescue. It has also been observed that animals vary in performance when consuming E+ tall fescue. T-Snip is a commercial genetic marker that has been shown to predict tolerance of cows to E+ tall fescue.   This study was conducted to evaluate if performance of beef heifers grazing E+ pasture differed among T-Snip score. It was hypothesized that as T-Snip score increased (increased tolerance to E+ tall fescue) average daily gain of heifers would increase. 180 angus-based commercial heifers (343.22±17.87 kg) grazed E+ tall fescue pasture for 75 days. Each animal had a hair sample taken and submitted for a T-Snip score and tolerance rating, where animals with 0-1 star were considered susceptible, animals with 2-3 stars were average, and animals with 4-5 stars were considered the most tolerant to fescue toxicosis. As hypothesized, there were differences in ADG between tolerance ratings. ADG for susceptible animals was 0.20 kg, average animals gained 0.25 kg, and the tolerant heifers gained 0.29 kg/d (P=0.07). Average daily gains were as expected for heifers grazing E+ tall fescue pastures. Heifers identified as tolerant had 45% greater average daily gain

than heifers identified as intolerant. The objective of this study was to determine if genetic testing for fescue tolerance used in cows had relevance for calves as well. This research demonstrated that genetic selection to improve fescue tolerance could improve progeny performance.

INTRODUCTION

Tall Fescue is a persistent, easily adapted forage that has long growing seasons

and is resistant to drought, over-grazing, trampling, flooding, and pests (Stuedemann and

Hoveland, 1988). It is the most common forage in the humid transition zone of the

United States, an area deemed the "Fescue Belt", where over 8.5 million head of cattle

utilize tall fescue as their primary source of forage (Stuedemann and Hoveland, 1988).

The positive agronomic characteristics are due to a symbiotic relationship between the

plant and an endophytic fungus, known as the endophyte (Bacon et al., 1977). The

endophyte produces ergot alkaloids that are toxic to animals, the consumption of these

compounds results in a disorder known as Tall Fescue Toxicosis. Reduced feed intake,

bodyweight gains, reproductive performance, and serum prolactin levels, as well as rough

hair coats, and increased respiration rates and body temperatures can be attributed to

fescue toxicosis (Strickland et al., 1993). Approximately $1 billion in annual losses to

the beef industry are attributed to the poor reproductive performance and depressed gains

caused by fescue toxicosis (Roberts and Andrae, 2004). There are many strategies to

mitigate the symptoms of fescue toxicosis. Through forage management such as

replacement of toxic tall fescue, interseeding with legumes, supplementation of other

feedstuffs or non-toxic forage, maintaining a vegetative state, reducing N fertilization,

and seedhead suppression have been shown to combat fescue toxicosis, though not

completely eradicating symptoms.

There has also been emphasis in selection of animals that are more tolerant to

fescue toxicosis. Gould and Hohenboken (1993) demonstrated that calves sired by a

polled Hereford bull with a reputation for being fescue tolerant had higher intakes and

lower bodyweight temperatures than calves sired by a polled Hereford bull without a

reputation for fescue tolerance. In another study, it was shown that one genetic line of

mice was more tolerant to fescue toxicosis than another (Hohenboken and Blodgett,

1997). The T-Snip test (AgBotanica, LLC, Columbia, MO) is a genetic test thatwas

shown to predict tolerance to toxic tall fescue in beef cows, using weaning weight as the

phenotype. No research has been done to study T-Snip prediction of growing calf

performance when grazing E+ tall fescue. This study evaluated the average daily gain of

heifers with differing T-Snip scores.

MATERIALS AND METHODS

All animals used in this study were managed and handled in accordance with a protocol that was approved by the University of Missouri Animal Care and Use Committee. 180 angus-based commercial heifers (343.22±17.87 kg) were sourced from 2 east-central Missouri livestock auction facilities (Eastern Missouri Commission Company, Bowling Green, MO; Missouri Valley Commission Company, Boonville, MO). The heifers were weaned, vaccinated, and dewormed prior to being transported to the Southwest Research Center (SWRC), near Mt. Vernon, MO (37.07N, -93.87E). Upon arrival to SWRC, the heifers were placed into endophyte infected (E+) KY-31 tall fescue pasture and supplemented with E+ hay when forage became limiting. At arrival and prior to beginning the study, hair was taken and collected on a sample card (NeoGen, Lansing, MI) for T-Snip analysis (AgBotanica LLC, Columbia, MO).

18, 1.72 ha pastures were grazed for 75 days (June 28, 2016 - September 11, 2016) with 10 heifers/pasture. The pastures were seeded from 2004 to 2006 with KY31 E+ tall fescue. Previous analyses indicated an endophyte infection level upwards of 80%. 20 tillers from each pasture were collected to confirm endophyte levels using an immunoblot assay (Agrinostics, LTD, Watkinsville, GA). 84 kg/ha N was applied in the form of ammonium nitrate to all pastures on April 6, 2016. On April 8, 2016 Grazon P+D (Dow AgroSciences, Midland, MI) was appliede to eliminate all legumes and ensure a pure stand of KY31 E+ tall fescue. Excess forage was removed and harvested as hay on May 10, 2016, early enough to provide vigorous regrowth to accommodate the high

stocking rate for the study. Each 1.72 ha paddock was divided in half with a protable

electric fence to allow for rotational stocking. Animals remained on one side of the

paddock until a residual height of 80 mm was reached, at that point the heifers were

rotated to the other half. That method continued until the pastures could no longer

support grazing, at which time animals were supplemented with E+ hay until pasture was

able to sustain grazing. Free-choice loose mineral was provided in all pastures. 22.3 m^2

of shade was provided in each paddock using 80% shade cloth.

Animals were weighed on days 0 and 1, weights were averaged to establish an

initial body weight (IBW). Animals grazed for 75 days and were weighed again on days

74 and 75, weights were averaged to establish an end bodyweight (EBW).

Heifers were classified as either susceptible, average, or tolerant to E+ tall fescue

based on their T-Snip star scores. Animals with 0 or 1 star were analyzed as being

susceptible, animals with 2 or 3 stars were considered average, and animals with 4 or 5

stars were considered the most tolerant to fescue toxicosis.

Data were analyzed as a completely randomized design, with animal as the

experimental unit. Fescue tolerance classification (Susceptible, Average, Tolerant) was

the independent variable, whereas IBW, ADG, and EBW were the dependent variables,

LS MEANS of all dependent variables were analyzed using the GLM Procedure of SAS

(SAS version 9.4, SAS Inst. Inc., Cary, NC). Significance was set at $\alpha \leq 0.10$.

RESULTS

The number of animals that scored low, average, and high for tolerance to E+ tall fescue was , , and, , respectively. IBW of heifers did not differ among E+ tall fescue classifications, however tolerant heifers did have a 9 kg heavier IBW than susceptible heifers. Differences in ADG did occur among fescue tolerance classifications (P=0.07). Susceptible animals had the lowest ADG (0.20 kg), animals with average tolerance gained more than susceptible animals (0.25 kg) and the most tolerant animals had the highest ADG (0.29 kg). (Table 3.1) EBW tended (P<0.13) to be greatest for calves with the highest fescue tolerance and lowest for calves classified as susceptible to fescue toxicosis. Concluded from these data were that calves with genetic tolerance to E+ tall fescue have better growth performance than calves with less tolerance to E+ tall fescue.

DISCUSSION

Previous research had shown that cows with higher tolerance to E+ tall fescue, as identified using the T-Snip genetic marker test, had calves with greater weaning weights. Though IBW was not statistically different among classifications, it was numerically higher for animals classified as tolerant. Since these calves were procured from livestock auction facilities where E+ tall fescue is prevalent, this result was not surprising. The tolerant calves would have been expected to have had an advantage pre-weaning due to their dam and/or sire being more tolerant to fescue toxicosis, resulting in a higher than their more susceptible counterparts. They increased their weight advantage throughout the grazing experiment, believed to be due to their advantages in tolerance to fescue toxicosis. The T-Snip test was predictive of performance for heifers that were grazing E+ fescue. As hypothesized, the susceptible heifers had the lowest ADG, and the tolerant heifers had the highest ADG. Because the T-Snip test was indicative of growth performance for animals consuming toxic tall fescue, it was concluded that genetic differences exist that are unique to tolerance to E+ tall fescue and are not exclusively due to general growth traits or physiology.

This is the first research that has demonstrated that post-weaning growth performance on E+ tall fescue is influenced by tolerance to E+ tall fescue that can be identified using a genetic test. Previous research had shown that tolerance to E+ tall fescue of the cow influenced progeny weaning weight. Summarized from these

experiments is that selection for animals with tolerance to E+ tall fescue can potentially

improve post-weaning performance in addition to pre-weaning performance.

IMPLICATIONS

The T-Snip test proved to be indicative of growth performance of calves consuming E+ tall fescue, with tolerant animals gaining more than susceptible animals. With the advantages in ADG, profits on tolerant animals will be higher than susceptible animals if they are consuming an E+ diet. If producers are able to select for tolerant animals utilizing the T-Snip score, profits can be increased through advantages in performance due to tolerance to fescue toxicosis. The removal of E+ tall fescue is regarded as the best method to offset negative consequences of fescue toxicosis. Likewise, management practices such as interseeding legumes is recommended with selection for E+ tall fescue tolerance. This research demonstrates that selecting for tolerance to E+ tall fescue would be expected to improve post-weaning performance of calves consuming an E+ diet as well as improve weaning weight.

Table 3.1 Animal bodyweight and gain for susceptible, average, and tolerant Animals

Item	Susceptible	Average	Tolerant	SE	P-Value
		Tolerance Classification			
IBW[1], kg	233.03	234.65	241.88	4.09	0.20
ADG, kg	0.20^A	0.25^{AB}	0.29^B	0.03	0.07
EBW[2], kg	250.18	253.25	262.57	4.87	0.13

[1]IBW = Initial BW

[2]EBW = End BW

A, B = Least square means within a row with different superscript differ (P < 0.10)

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