COMPOSITION AND NUTRIENT UTILIZATION BY SHEEP OF ENSILED TALL FESCUE WITH DIFFERENT LEVELS OF ENDOPHYTE INFECTION

by

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Animal Science

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April 10, 1989

Blacksburg, Virginia

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(ABSTRACT)

Low and high endophyte infected stockpiled tall fescue was harvested, chopped and ensiled in 210 liter metal drums, double lined with polyethylene bags. Endophyte infection averaged 4 and 70%, respectively, for the low and high-endophyte fescue. A metabolism trial was conducted with 24 wethers fed diets consisting of 100% low-endophyte fescue silage, 50% low-endophyte and 50% high-endophyte fescue silage, and 100% high-endophyte fescue silage. Chopped alfalfa hay was used as a control forage. Single samples were analyzed, so statistical treatment of chemical composition was not possible. However, certain numerical differences were recorded. Lignin was higher for the high-endophyte than the low-endophyte fescue. Dry matter, CP, and ash were similar for the fescue silages. The high-endophyte fescue silage was lower in P, Mg, S, K, Fe, Cu, Mn, Zn, and Al than the low-endophyte silage. Digestibilities of DM, NDF, and cellulose were higher ($P<.01$) for fescue silages than alfalfa hay. Level of endophyte infection did not affect digestibility of DM, NDF or cellulose. Among silage treatments, apparent absorption of N, expressed as g/d, showed a linear effect (P<.05), with the lowest value obtained for sheep fed 100% high-endophyte fescue silage. Apparent absorption and retention of Ca were higher for silages than alfalfa. Among the silage diets, apparent absoption of P decreased linearly (P<.01) with increased endophyte level. Apparent absorption of K decreased linearly (P<.01) with increased endophyte level, but the effect was related to intake. Serum prolactin concentrations of the wethers fed fescue silage showed a linear decrease (P<.05) with increased proportion of endophyte-infected fescue. Endophyte infection of fescue appears to affect N and mineral metabolism.

DEDICATION

This thesis is dedicated in the memory of

Acknowledgements

I would like to express sincere gratitude to the members of my graduate committee, Dr. J. P. Fontenot, Dr. V. G. Allen, Dr. H. J. Gerken, Jr., and Dr. T. N. Meacham for their professional guidance. Special thanks to Dr. J. P. Fontenot and Dr. V. G. Allen for allowing me to participate in many other projects.

Appreciation is expressed to and , for their laboratory assistance and friendship.

To the following persons go my sincere thanks; and , for doing the seemingly impossible tasks; to the other graduate students, including , , and , for helping me through the crunch situations; to Dr. Paul Graham and Dr. Robert Kelly, for allowing me to expand my knowledge in Meat Science; to my roommate, , for tolerating me through my years of graduate school.

Thanks to Mom and Dad and Uncle , for standing behind my decisions. Thanks to my brother and sisters and , and also my new brothers (brothers-in-law) and , sincere thanks for being the best siblings and friends.

Without exception, I owe gratitude to my fiancé, , for his encouragement and moral support.

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INTRODUCTION

Tall fescue, (Festuca arundinacea screb.), is a forage that is especially adapted to the central eastern part of the United States. However, adverse effects associated with the grazing and the feeding of hay and silage may occur. Symptoms in animals fed tall fescue have led to the description of three noninfectious conditions known as fescue foot, fat necrosis and summer syndrome. Recognition of these conditions prompted early researchers to study the plant effects on animals consuming the forage. Tall fescue has been found to be comparable to other grass forages in minerals, vitamins and crude protein.

Acremonium coenophialum, (Morgan-Jones and Gams, 1982) an endophytic fungus has been related to these deleterious effects. The direct metabolic mechanism of the effects of the fungus is yet undetermined, but it is thought to be related to the presence of certain toxic alkaloids. Known transmission of the fungus among fescue plants is exclusively restricted to seed. Presence of the endophyte fungus is beneficial to the plant, as those varieties with heavy infection with the endophyte are consistently more drought and insect resistant.

With the knowledge that they were working with a nutritionally adequate plant that was tolerant to grazing, researchers initiated performance trials on cattle and sheep fed tall fescue. Some of these performance trials have included effects on weight gain, reproduction in females and milk production. Different varieties of fescue and fescue with differing levels of endophyte infection have been compared with other species of forages. Data from performance studies have led to inconsistent conclusions as to the degree of decreased performance associated with fungal presence. These inconclusive results have directed researchers to postulate that the syndromes associated with the feeding of tall fescue are not simply a direct cause-and-effect mechanism. It appears that a more complex disruption of body processes is occurring, which is manifested most often as poor animal performance.

Researchers have postulated that the endophyte fungus produces a toxic substance, the plant is producing a toxic substance in response to the presence of the fungus, or that a substance from the infected plant is blocking normal animal metabolism. In more in-depth physiological animal experiments, data were obtained on some digestive processes, hormone concentrations and aspects of the nervous system, with no conclusive results. Because minerals play an integral role in many body functions, this investigation was conducted to explore the possibility of a relationship between decreased animal performance and abnormal mineral metabolism in animals.

The general objectives of this research were to compare mineral metabolism in ruminants fed tall fescue silages of low- or high-endophyte infection. The specific objectives were to: 1) explore the possibility of a relationship between decreased animal performance and abnormal mineral metabolism in wethers fed low- or high-endophyte fescue silage; 2) to study ruminal and blood parameters in animals fed low- and high-endophyte tall fescue silages; 3) to study nitrogen utilization in animals fed tall fescue silages; 4) to assess the fermentation characteristics of high- and low-endophyte tall fescue silage. Alfalfa hay was fed as a reference forage.

REVIEW OF LITERATURE

Tall fescue, (Festuca arundinacea Schreb.), is a cool season, perennial bunch grass. Among the attributes of tall fescue are good growth on poorly drained soils, excellent drought resistance and soil conservation charateristics (Buckner and Cowen, 1978). Additionally, because of it's rapid growth and ability to maintain quality late into the fall and winter, tall fescue is an excellent cool season grass for stockpiling (Bagley et al., 1983). The variety, Kentucky-31, which was first discovered in 1931, had by 1973, become the major tall fescue used in pure or mixed stands in the Southeastern United States (Buckner et al., 1979).

Tall Fescue Toxicosis.

Tall fescue toxicosis can be divided into three syndromes known as summer slump, fescue foot and fat necrosis. Although all syndromes are associated with tall fescue, they are usually manifested under different environmental conditions.

Summer Slump. This disturbance is usually observed when ambient temperatures are elevated (Hemken et al., 1979). The usual signs are decreased feed intake, increased respiration rate, increased rectal temperatures, roughening of the hair coat, lower serum prolactin levels, decreased milk production, excessive salivation and a change in grazing patterns to avoid the heat (Hemken et al., 1984). Symptoms of summer slump are most evident to the producer as decreased animal gains. In a study by Bond et al. (1984), Kentucky 31; Kenhy, a variety released by the Kentucky Agricultural Experiment Station and the USDA in December 1976; G1-306, which was high in alkaloid perloline; and G1-307 which was low in perloline were fed to steers. It was observed that G1-307 produced the lowest animal gains.

Hay harvested from toxic tall fescue pastures was fed when ambient temperatures were high and produced summer toxicity symptoms (Jackson et al., 1981). Futhermore, feeding tall fescue seed produced from toxic pastures contained compounds that produced toxic symptoms as severe or more severe than those seen when feeding fresh forage or hay (Jackson et al., 1981; Schmidt et al., 1982).

Fescue Foot. This condition is usually seen in late fall and winter, especially on fall regrowth and total yearly accumulated tall fescue (Cornell and Garner, 1983). The onset of noticeable symptoms usually occurs 5 to 15 d after turning cattle into a new pasture, although it may require several weeks on a pasture of lower toxicity. Symptoms include reduced weight gain or even weight loss, rough hair coat, arched back and soreness in one or both rear limbs (Jacobson et al., 1963; Cornell and Garner, 1983). Hyperemia of the coronary band occurs between the dewclaw and hoof and is generally accompanied by some swelling. All ages of cattle may show a slight to severe loosening of the stool, resembling that seen on lush spring pastures. If the animal is not removed from the toxic fescue, the swelling becomes more severe and the hooves may begin to slough off. In very severe cases, the limb may be lost midway between the dewclaw and the hoof. Moreover, the tail may have a purple black discoloration and eventually the animal may lose the switch (Hemken et al., 1984), and the ear tips may slough off (Cornell and Garner, 1983).

<u>Bovine Fat Necrosis.</u> This condition, sometimes referred to as lypomatosis, is defined as the presence of masses of hard or necrotic fat primarily in the adipose tissues of the abdominal cavity (Wilkinson et al., 1983). Outward signs of the disease are negligible until the fat masses disrupt vital processes such as digestion or reproduction (Forney et al., 1969). Other symptoms that are sometimes observed include loss of weight, poor appetite, listlessness and rough hair coat (Wilkinson et al., 1983).

Necrotic fat is readily distinquishable from normal fat; it appears as yellowish or chalky white irregular masses of very hard fat (Wilkinson et al., 1983). Lesions are often encapsulated or separated from normal fat; fibrous connective tissue. The chemical composition of necrotic fat lesions was determined by Rumsey et al. (1979). Necrotic fat was found to contain 2.4 times as much crude protein, 2.8 times as much cholesterol, 21.8 times as much Ca, 4.7 times as much Mg, 2.6

times as much Na, and similar levels of K, all wet basis, compared to normal fat.

An increased incidence of fat necrosis has been associated with N fertilization, especially when broiler litter was used (Stuedemann et al., 1985). Tall fescue pastures were fertilized with low- medium- or high- levels of N. High N-fertilization consisted of 703(1972), 794(1973), 483(1974) and 0(1975) kg N/ha from broiler litter. The moderate- and low-N rates consisted of 224 and 74 kg $N \cdot ha^{-1} \cdot yr^{-1}$, respectively from NH_4NO_3 Additionally, Bermuda grass pastures were fertilized at two rates of N. Fat necrosis developed only in cows grazing tall fescue, with the occurrence of 60%, 8% and 3% for high-, moderate- and low-N fertilized pastures, respectively. Furthermore, plasma cholesterol concentrations were lowest in cattle grazing high-N fertilized fescue.

Performance in Ruminants Grazing Tall Fescue.

Grazing studies were done with cattle and sheep in a study by Schmidt et al. (1983). Cows were grazed on Kentucky 31 tall fescue pastures that were either heavily infected or free of the fungal endophyte. Respective daily gains for the fungus-free versus infected patures were .45 and -.18 kg/d for cows and 1.20 and .80 kg/d for the calves. Milk production, measured at 230 d postpartum was 5.8 kg/d for the cows on the fungus-free pasture while cows on the endophyte-infected pastures had a milk production level of 3.2 kg/d.

The possibility that the decreased performance in cattle fed tall fescue may carry over into the feedlot has concerned both producers and livestock buyers. Hancock et al. (1987) suggested that the lower live weights of cattle previously grazed on tall fescue does not affect their ability to gain while in a feedlot. Tall fescue (17 to 77% endophyte infection), smooth bromegrass-red clover and orchardgrass-red clover pastures were utilized. Fescue fed cattle entered the feedlot and finished at lighter weights, however, their dry matter intakes and feed conversions were similar (P>.05) to other treatments. Additionally, carcass characteristics were similar regardless of previous grazing system. In another study Hancock et al. (1988) reviewed the effects of previous forage systems on feedlot performance and body composition. Liveweight, body protein and body fat were lower (P<.05) in the first 56 d in the feedlot for cattle previouly grazed on endophyte infected fescue versus those which had been on smooth bromegrass-red clover or orchardgrass-red clover. Overall feedlot daily gains, dry matter intake and feed conversions were similar (P>.05) for all previous systems.

Reid et al. (1978) examined the performance of lambs grazed on perennial ryegrass, smooth bromegrass, orchardgrass and tall fescue pastures. Over a grazing season, from April to October, tall fescue and perennial ryegrass produced similar live weight gains, but gains were lower than those on smooth bromegrass and orchardgrass.

Endophyte Fungus Infection.

Acremonium coenophialum (Morgan-Jones and Gams, 1982) resides in tall fescue in a mutualistic symbiotic relationship (Siegel et al., 1985). The fungus belongs to the family Clavicipitaceae. In tall fescue, it is found only as an endophyte and its infection produces no external symptoms, in the plants (Bacon et al., 1983). However, stands of fescue infested with the fungus have shown a greater tolerance to drought and insect infection than their noninfected counterparts.

In tall fescue, Acremonium coenophialum is found in the intercellular spaces as coarse, mostly unbranched, linear or contorted hyphae, which run vertically between the host cells (Bacon et al.,1983). During the vegetative (early spring) and dormant (fall) periods of the growing season, the fungus is located in meristematic tissue of the shoot apex. In spring, when the plant is initiating flower shoots, the endophytic mycelia of the fungus are seen primarily within the intercellular spaces of the pith cells. The only observed mode of transmission of the endophyte is through the seed (Bacon et al., 1983). Within the seed, the fungus is deeply sequestered, and is located between the scutellum of the embryo and the aleuron layer.

Toxic Factors.

Several extracts have been isolated in an attempt to isolate the toxic fraction causing fescue toxicosis. Diazophenanthrene (perloline and perlolidine) has been isolated from fescue and has been shown to inhibit cellulose digestion and VFA production (Boling et al., 1975). However, when low perloline varieties were introduced it was shown that they were high in pyrrolizidine alkaloids (N-acetyl and N-formyl loline) and showed more severe toxicity than high perloline or Kentucky-31 tall fescue (Steen et al., 1979; Hemken et al., 1979).

Jacobson et al. (1963), who initially extracted toxic fescue hay with 80% ethanol and assayed the extracts by intraruminal administration in cattle, reported the toxin to be in the aqueous, nonalkaloidal fraction. Testing of chemical extracts from tall fescue by intraperitoneal injection of calves has shown that the component(s) causing clinical signs of fescue foot are in an anion fraction (Williams et al., 1975). Garner et al. (1982) found the cation fraction to be associated with the symptoms of summer slump. They indicated that the "anion fraction" contains the plant and fungal organic acids, whereas the "cation fraction" contains the plant and fungal alkaloids.

Gentry et al. (1969) examined the alkaloid content of Alta, Kenwell and Kentucky 31 tall fescue at different stages of growth. Eleven alkaloids, consisting mainly of perloline and festucine, were found in mature Kentucky 31 plants. In addition, no alkaloids were found in Alta seed, while only festucine and two unknown alkaloids were found in the seed of Kentucky 31. Concentrations of total alkaloids in Kentucky 31 in the dough stage were found to be in decreasing order in stems > shoots > leaves > roots > heads > seed, while in the vegetative stage roots were higher than shoots. Furthermore, they found perloline content was dramatically reduced when the forage was field-cured as hay. A fertilization study revealed Kenwell had the highest perloline concentration followed by Kentucky 31 and Alta when N, P, and K fertilizer was used. Higher perloline concentration were observed with N, P, and K fertilization than P and K or no fertilization.

The presence of the endophytic fungus has been shown to deter some insects. Johnson et al. (1985) selected four species of aphids and exposed them to either endophyte infested or endophyte free Nui perennial ryegrass, and Kentucky 31 tall fescue. Rhophalosiphum padi and Schizaphis graminum displayed no perference between infected and noninfected ryegrass. However, they preferred endophyte free over infected tall fescue (4 to 1). Sitobion avenae was indifferent to species or infection level. A comparison was made using

R. padi exposed to either infected or noninfected tall fescue and noninfected fescue stems dipped in methanol extracts from infected or noninfected fescue seed. After 66 h 100% of the aphids in the infected and infected-dipped groups were dead, compared to a 20% mortality rate for nondipped endophyte-free tall fescue stems.

Chemical Composition.

Variation in tall fescue composition can be observed at different growth stages and fertilization levels. Stockpiling is the practice of accumulating forages. It is most commonly accomplished by cutting or grazing tall fescue until early or mid August and then allowing the forage to amass. Brown et al. (1963) cut forage in early September, fertilized pastures and collected samples at 2, 4, 7, 9, 11, and 13 wk. Protein concentrations declined from 17.9% at wk 2 to 10.5% at wk 13. Small declines in crude fiber from 26.8 to 25.9% and cellulose from 29.4 to 28.7%, (dry basis) were observed. Lignin declined from wk 2 (9.3%) to wk 9 (7.1%) and then rose again to wk 13 (8.4%). Soluble carbohydrates rose from 10.5% in wk 2 to 29.2 in wk 11 and then declined to 21.3% in wk 13.

Chemical composition of autumn-accumulated tall fescue and orchardgrass was examined by Sheehan et al (1985). Across all sampling dates tall fescue showed higher ($P<.01$) total nonstructural carbohydrates while CP, ADF, lignin, and cellulose contents were lower ($P<.001$). Both grasses showed a decline in proportion of CP and DM, while total nonstructural carbohydrates, ADF, cellulose, and lignin increased. Spears et al. (1981) collected tall fescue samples on a monthly basis on pastures for wintering beef cows. Forage CP contents for November through April were 10.5, 7.6. 7.3, 7.7, 9.6 and 15.4%, dry basis, respectively. In another study, Ocumpaugh and Matches (1976) observed that autumn-grown tall fescue had CP concentrations of 15 and 19%, respectively, in two consecutive years.

Composition of tall fescue through the grazing season has been examined as well. On N-fertilized pastures, Bagley et al. (1983) harvested Kentucky 31 tall fescue on May 23, August 1, November 16 and March 4 and observed CP levels of 10.4, 10.3, 10.6 and 9.5%, dry basis, respectively. Cell wall constituents, ADF and cellulose, were higher (P<.05) for tall fescue harvested in May and July, compared to November and February and for November compared to February. Higher CP levels were observed by Steen et al. (1979). These researchers found mean CP levels of 17.6, 18.4, 16.8 and 16.7%, dry basis for Kentucky 31, G1-306, G1-307, and Kenhy varieties, respectively, during a March through September grazing season. Perloline contents for these grasses were 172.9, 432.0, 66.5 and 164.2 ug/g, while perlolidine contents were 115.7, 257.7, 50.0 and 165.8 ug/g, respectively. Acid detergent fiber and NDF were similar for all grasses, and averaged 33.1 and 57.1%, respectively.

Pendlum et al. (1980) found CP levels of 17.6, 7.7 and 11.1%, dry basis, for early vegetative, dough, and regrowth vegetative Kenhy tall fescue. Similar organic matters were obtained while ADF, NDF and lignin were higher in the dough stage. Early bloom alfalfa and orchardgrass hay was compared to Kentucky 31 hay harvested in the jointing and boot by Warren et al. (1974). On DM basis, alfalfa was higher in protein (16.1%), ADF (43.2%), lignin (11.4%), and cellulose (30%) and lower for fescue with values of 11.2, 39.2, 6.6, and 29%, respectively. Tall fescue contained more ADF, ash, and NDF, while alfalfa was lowest for these components.

Mefluidide treatment of fescue pastures has recently been used to regulate the growth of tall fescue. Mefluidide maintains tall fescue in an immature vegetative stage and inhibits seedhead formation. Increased CP and ash levels coupled with decreased fiber and lignin levels are usually observed from mefluidide treatments (Ely et al., 1985). Glenn et al. (1980) found a significant ($P<.05$) increase in CP and a decrease ($P<.05$) in cellulose content when mefluidide was applied to fescue pastures.

Fermentation characteristics and composition of ensiled tall fescue have been investigated. Torres et al. (1986) ensiled stockpiled Kentucky 31 tall fescue either alone, with formic acid(.3%), ground corn(5%), or dry molasses(5%). Crude protein levels of ensiled material were similar and averaged 13.7%. Soluble carbohydrate content of fresh forage averaged 18.1%, while ensiled values were 8.0, 10.5, 8.7 and 9.5% of dry matter for control, formic acid, ground corn, and dry molassess treatments, respectively. Lactic acid contents were 8.0, 1.2, 7.2 and 7.2%, dry basis, and pH values were 4.4, 5.0. 4.4 and 4.4, respectively. Neutral detergent fiber values ranged from 47.8 for the molasses treatment to 51.1%, dry basis, for control, while cellulose was 18 and 21%, dry basis, for ground corn and control treatments, respectively.

Chestnut et al. (1987) found ammoniation of fescue reduced alkali-labile phenolics by 37% for P-hydroxybenzoic acid, 67% for ferulic acid, 48% for p-coumaric and up to 100% for p-hydoxybenzaldehyde and syringic acid.

Mineral Composition of Tall Fescue.

Steen et al. (1979) examined the mineral content of Kentucky 31, G1-306, G1-307 and Kenhy from March through September. Average values for the four varieties were .36% Ca, .22% Mg, .25% P, 3.7% K, .21% S, 732.9 ppm Al, 21.3 ppm Ba, 8.6 ppm B, 16.5 ppm Cu, 389.9 ppm Fe, 121.3 ppm Mn, .063 ppm Se, 112.8 ppm Na, 8.5 ppm Sr, and 17.7 ppm Zn, dry basis. Fescue was higher than quackgrass in Cu (6.6 vs 4.6 ppm), Mo (2.3 vs 1.2 ppm), S (.34 vs .16%), and Mn (91 vs 38 ppm) (Stoszek et al., 1979).

Kenhy tall fescue was harvested in the early vegetative, dough or regrowth vegetative stages (Pendlum et al., 1980). Phosphorus, K, Ca, Mg, S, Mn, and Cu were lowest in the dough stage. Iron, Al, Zn, Sr were lowest in regrowth forage, while B, Mo, and Ba were lowest for early vegetative forage.

Some mineral levels of tall fescue were measured in a winter grazing study conducted from November 26 through March 6, (Spears et al., 1981). Pastures were allowed to accumulate during summer and fall. Calcium values remained relatively constant through the period and averaged .59%, dry basis. Phosphorus and K started at .29 and 2.63%, dry basis, declined and then increased to final concentration of .37 and 2.5%, dry basis, repectively. Magnesium levels continuously declined from .31 to .17%. The trace minerals observed increased continously, from 25 to 41 ppm for Zn, 4.4 to 5.8 ppm for Cu and 100 to 265 ppm for Mn, dry basis. Ocumpaugh and Matches (1977) observed that K declined about .1 percentage unit/wk in a 2-yr study of autumn-grown tall fescue.

Sulfur fertilization of 132 kg/ha increased tall fescue and orchardgrass nonprotein S concentrations by 17.5 and 21.6% (Spears et al., 1985) and 21.2 and 27.6% (Chestnut et al., 1986), respectively. Spears et al. (1985) observed an increase in forage K and a decrease in Fe, while Ca, P, Mg, Cu, Zn, and Mn were not affected.

Intake and Digestibility in Ruminants.

Brown et al. (1963) attributed a relatively constant DM digestibility to an increase in soluble carbohydrate and no increase in crude fiber and lignin in fall-accumulated tall fescue. Ocumpaugh and Matches (1977) observed in vitro DM digestibilities of 66 and 67% for consecutive years on autumn-grown tall fescue. Powell et al. (1978) observed no significant differences in in vitro DM digestibility among tall fescue, perennial ryegrass, smooth bromegrass or orchardgrass samples from June to September. However, fescue DM was lower in digestibility in April than perennial ryegrass and smooth bromegrass, and lower than all grasses in October regrowth. Lignin concentrations contributed 79.9% of the variation in in vitro DM digestibility. Conversely, Sheehan et al. (1985) found tall fescue was higher ($P<.01$) in in vitro DM digestibility than orchardgrass in a study conducted on autumn-accumulated forage. In vitro cellulose digestibility was increased when .28 kg/ha of the plant growth regulator mefluidide was applied to tall fescue pastures (Glenn et al., 1980).

Reid et al. (1978) conducted a 2-yr study utilizing lambs fed cut herbage. Tall fescue was shown to have a lower DM digestibility in pre-bloom and vegetative stages than perennial ryegrass, smooth bromegrass or orchardgrass, which paralleled a trend of lower intake for tall fescue. Tall fescue fed during the dough stage produced lower DM intake than early vegetative or regrowth vegetative stages. Apparent digestibiities of DM, CP, organic matter, NDF and ADF were highest for fescue in the early vegetative stage and lowest for the dough stage (Pendlum et al., 1980). Goetsch et al. (1988) noted that supplementation of infected tall fescue hay with bermuda grass hay or wheat hay increased intake in steers.

Added perloline was shown to decrease apparent digestibility of CP ($P<.05$) and cellulose ($P<.08$) in lambs (Boling et al., 1975). Addition of perloline also tended to increase urine volume and urinary N excretion, while tending to lower apparent digestibility of crude fiber, nitrogen-free extract, ether extract, and plasma urea-N. Nitrogen retention was lower for the perloline-fed lambs than controls. Ruminal acetic, isovaleric and valeric acids were lower, while propionic acid was higher when perloline was added to the diet.

Torres et al. (1986) found similar apparent digestibilities of CP in lambs fed tall fescue silage with no additive, formic acid, ground corn or dry molasses. Dry matter and NDF digestibilities were highest for the ground corn additive, while cellulose and ADF digestibilities were highest with the control silage. Dry matter, NDF, ADF, and cellulose digestibilities were lowest for the dry molasses additive. No significant difference was observed between treatments for N retention, ruminal fluid pH, NH_3-N, VFA, or DM intake. Blood urea-N was highest for control (19.0 mg/dl) and lowest for the dry molasses treatment (15.6 mg/dl).

Muntifering et al. (1983) ensiled reconstituted tall fescue hay with whole stillage or ground corn and soybean meal, which were compared to fescue hay supplemented with distillers dried grain with solubles, or corn and soybean meal. Utilizing abomasally cannulated wethers, these authors reported total tract DM digestibilty was greatest ($P<.05$) for fescue-corn-soybean silage (56.8%) and lowest ($P<.05$) for whole stillage silage (47.5%). Apparent ruminal and total digestion coefficients for NDF and hemicellulose were greater for hay than silages. In a related metabolism study using growing lambs, N retention was greater ($P<.05$) for fescue-whole stillage silage than the fescue-corn-soybean silage.

The effects of high- and low-fiber supplements on fermentation characteristics and in vivo and in situ digestibilities of low quality fescue hay was studied by Highfill et al. (1987). Fescue hay was supplemented with 95% corn-5% soybean meal, soyhulls, dried corn gluten feed or 87% citrus pulp-12.5% soybean meal, at 25% of the diet DM. No significant differences were obtain for DM intake, total tract DM or true ruminal organic matter digestibilities, ruminal pH, or ruminal NH_3-N. Neutral detergent fiber digestibility was higher with soyhulls than corn-soybean meal supplemented diets. Acetate and total VFA concentrations 4 h post feeding were higher ($P<.05$) for citrus pulp-soybean meal than corn-soybean meal supplemented diets.

Chestnut et al. (1987) found that ammoniation of tall fescue hay supplemented with corn or corn gluten meal increased intake, compared to fescue hay supplemented with corn and urea or corn gluten meal. These researchers claimed that intakes were probably increased because of increased rate of fiber digestion resulting from ammoniation. They showed that digestibilities of NDF and ADF were higher ($P<.001$) for steers fed ammoniated forage. Ruminal pH values were similar at equal intakes, but were lower during ad libitum feeding. Ruminal NH_3-N concentrations were higher in both feeding regimes when ammoniated hay was fed. In addition, in situ DM disappearance was greater ($P<.05$) for ammoniated hay.

Sulfur fertilization did not affect fiber digestibility (Spears et al., 1985; Chestnut et al., 1986), while protein digestibility was increased (Spears et al., 1985) in steers. Chestnut et al. (1986) observed the digestibility of alkali-labile phenolic compounds of forages obtained from S-fertilized plots and found a greater apparent digestibility for p-hydroxybenzoic acid, a negative apparent digestibility of vanillin and no affect on para-coumaric and ferulic acid digestibilities.

Tall fescue seed and forage and climate control chambers have been used in an attempt to concentrate the factor(s) causing deleterious effects. Hannah et al. (1988) observed the effect of increasing the alkaloid, ergovaline, through use of endophyte infected tall fescue seed fed to sheep. Total tract DM, organic matter and NDF digestibilities decreased, while increasing fluid dilution rate as level of alkaloid increased. In addition, total VFA concentration at feeding was lowest for low ergovaline and increased as ergovaline level increased. Solid dilution rate and fluid volume were similar between treatments.

Peters et al. (1988) utilized bulls housed in climate controlled chambers fed a diet of 60% infected or noninfected tall fescue seed. At 33 C, animals fed infected seed had reduced DM intake, total quantity of nutrients digested and increased water intake. Osborn et al. (1988) monitored calves in a controlled environment of 21 or 32 C consuming infected or noninfected tall fescue and ergotamine tartrate. Animals fed infected fescue or added tartrate exhibited decreased feed intake, heart rate, infrared earcanel temperature, tail temperature, pastern temperature, and front coronary band temperature, when compared to noninfected diets. Moreover, measured effects were amplified at 33 vs 21 C.

Utilizing rumen cannulated steers, Warren et al. (1974) compared alfalfa, tall fescue and orchardgrass. Digestibility and rate of passage were measured in environmentally-controlled chambers at 18 and 32 C. Intake was highest for alfalfa and lowest for fescue and no significant effect was seen with a change in temperature. Mean rentention times and maximum excretion rates were not different between treatments. However, mean retention times were higher ($P<.05$) at 32 C. Alfalfa lignin and N were more digestible than in grasses, while ADF and cellulose were similar among all treatments. Hemken et al. (1981) noted depressed forage intake and elevated rectal temperatures at 34 to 35 C in calves fed G1-307 vs G1-306, and orchardgrass all in soilage form. Symptoms produced by G1-307 were alleviated at ambient temperatures below 21 to 23 C.

Mineral Utilization and Supplementation.

Suboptimal performance of animals fed tall fescue may be related to poor ruminal utilization of nutrients in fescue (Glenn and Ely 1981). From chemical analysis, Kentucky 31 tall fescue appears to contain adequate S for optimum microbial activity, but in vitro additions of either elemental or methionine increased cellulose digestion (Spears et al., 1976). Spears et al. (1978) found that ruminal digestibilities of dry matter, NDF, and ADF were increased over control values when lambs fed tall fescue were supplemented with .15% S. However, total digestion of DM and fiber were not affected by S supplementation.

Spears et al. (1985) found S-fertilization of tall fescue and orchardgrass increased apparent absorption of S and urinary S excretion. The apparent absorption of Mg and Ca was reduced while K absorption and retention were increased. Mineral supplementation and its effects on abomasal amino acid recovery and circulating plasma amino acid concentration was investigated by Glenn and Ely (1981). Wethers were supplemented with S, nitrate or starch to a diet of dehydrated Kenhy tall fescue harvested in early to mid-bloom. Abomasal quantities of amino acids were higher than amino acid intake in supplemented groups. The authors concluded that the increased recoveries indicated ruminal microbial amino acid synthesis had been increased. Nitrogen retention was not affected by dietary treatment. Total plasma amino acid concentrations were decreased in the nitrate and S supplemented groups.

Morrow et al. (1985) examined the effect of Na_2SeO_3 injections on blood plasma and milk Se levels and cow-calf performance of cows grazing tall fescue pastures. Sodium selenite at 2.5 $mg \bullet ml^{-1} \bullet 45\ kg^{-1}$ liveweight was administered to beef cows An increase ($P<.05$) in blood plasma Se levels and no change in milk Se levels were observed between treatment and control cows. Sodium selenite had no effect on birth weight, weight gain, retained placentas, or rebreeding percentage between groups.

Steen et al. (1979) examined plasma Na, K, Mg, and P in steers grazing Kentucky 31, G1-306, G1-307, and Kenhy tall fescue. Variety produced no significant ($P>.01$) effect across all sampling times on plasma Na, K, Mg, and P, which averaged 314.1, 23.81, 2.22, and 4.2 mg/100 ml, respectively. Stoszek et al. (1979) monitored the effect of tall fescue and quackgrass on Cu metabolism. In this 2-y experiment yearling beef heifers were fed chopped fescue or quackgrass forage. No clinical symptoms of fescue toxicosis were observed. In less than 4 mo, animals receiving the tall fescue diet showed reduced liver Cu (P<.01) and decreased ceruloplasma oxidase (P<.001) to a deficiency level. Simultaneously, quackgrass-fed animals maintained normal blood Cu and ceruloplasmin activity, while increasing liver Cu stores. Liver Fe, Mo, and Zn and blood Zn were not affected by species of grass fed. Reduced daily gains, .55 kg for fescue vs .71 kg for quackgrass were not increased with Cu supplementation.

Tall fescue, perennial ryegrass, smooth bromegrass, and orchardgrass all showed decreases in concentration and apparent absorption of Ca and P with maturity, while Mg concentration remained relatively constant its availability increased (Powell et al., 1978). Apparent absorption of Ca, P and Mg were lower in lambs fed tall fescue herbage. Retention of P was lowest for lambs on tall fescue, while retentions on ryegrass, bromegrass, and orchardgrass were .29, .28, and .28 g/d, respectively. Magnesium retention was higher, when orchard-grass was fed .29 g/d vs .15 g/d for fescue-fed lambs, even though herbage Mg concentration was higher for tall fescue (.24 g/d vs .15 g/d).

Hormones.

Serum prolactin has been the most extensively monitored hormone when tall fescue is fed (Stabenfeldt and Edqvist, 1984) The primary function of prolactin is the development of secretory tissue in the mammary gland, and maintenance of lactation. Dopamine, a catecholamine is thought to be the controlling inhibitory factor for prolactin secretion from the anterior pituitary. Thyroid stimulating hormone, stress, and an increase in day length should normally stimulate the release of prolactin.

Because decreased prolactin levels can also be seen when animals are fed ergot alkaloids, a possible similar relationship has been explored with fescue (Porter, 1983). Ergot alkaloids exhibit their biological affects by stimulation of dopamine receptors which bring about the inhibition of prolactin secretions from the anterior pituitary.

Plasma prolactin is greatly reduced in cattle (Hurley et al., 1981) and sheep (Bolt et al., 1982) when toxic tall fescue is fed. Bond and Bolt (1986), in a comparison of fungus-infected versus noninfected tall fescue varieties fed to heifers, found that plasma prolactin levels and average daily gains were reduced in cattle grazing the fungus infected pastures. However, initiation of cycling activity was not delayed in this study and there was no cessation of estrous cycle in heifers already cycling. McCann et al. (1988) observed that prolactin was significantly depressed ($P<.05$) when gestating mares grazed high-endophyte pastures.

While increased ambient temperature is usually associated with an increase in basal prolactin, Hurley et al. (1981) found that when G1-307 fescue was fed to calves at high environmental temperatures (34 to 35 C) or at low temperatures (10 to 13 C) basal prolactin levels were depressed, compared to G1-306 fescue. Also, thyrotropin-releasing hormone (TRH) stimulation of prolactin secretion was inhibited in G1-307 fed animals. However, triiodothyronine (T3) and thyroxine (T4) levels were not significantly changed, suggesting there is no altered regulation of thyroid function.

The effects of induced fescue toxicosis on plasma and tissue catecholamine concentrations in sheep were examined by Henson et al. (1987). Catecholamines have been implicated in numerous control mechanisms, including prolactin secretion. Wethers were fed a diet based on either endophyte infected Kentucky 31 tall fescue or rye-orchardgrass. Norepinephrine and epinephrine levels were not affected by diet. Plasma prolactin levels were decreased and dopamine levels were elevated in the fescue-fed wethers. Since dopamine is important as a central nervous system neurotransmitter controlling numerous functions, dopamine mediated reactions other than prolactin secretion may be affected when toxic tall fescue is fed.

Elasser and Bolt (1987) concluded that endophyte infested tall fescue was producing a dopaminergic compound which altered prolactin but not growth hormone or thyroid stimulating hormone in ewes. They speculated that infected tall fescue contains a dopaminergic ligand, possibly an alkaloid, that binds to dopamine receptors on the pituitary.

Increased levels of serum prolactin were observed in ewes given haloperidol, a dopamine hydorchloride receptor blocking drug.

Several feed additives were chosen to possibly absorb the toxic substance produced in infected tall fescue (Goetsch et al., 1987). However, no serum prolactin differences were observed between treatment groups.

Schillo et al. (1988) grazed steers on endophyte infested tall fescue. Reduced levels of dopamine in the stalk median eminence of the hypothalamus and decreased pituitary concentrations of prolactin were observed and associated with hypoprolactinemia. They concluded that inhibited prolactin release led to a decrease in dopamine content and activity in the tuberoinfundibular neurons.

Hancock et al (1988) reviewed the effects of previous forage systems on plasma variables of finishing feedlot steers. After 56 d cattle previously grazed on fescue had lower T_3 and plasma urea-N, and a trend for lower thyrosine, than their counterparts previously grazed on smooth bromegrass-red clover or orchardgrass-red clover pastures. However, former grazing system did not affect plasma glucose or insulin concentrations. In a subsequent trial no significant differences were observed in T_3, T_4 or plasma urea-N between treatment groups.

Thompson et al. (1987) examined the effects of low- and high-endophyte tall fescue, 16 and 44% infestation rate, respectively, and two N-fertilization rates, low and high, 134 and 336 kg $N \cdot ha^{-1} \cdot yr^{-1}$, respectively, on some hormone concentrations. Blood samples were obtained before and after TRH hormone was administered. No significant effects of N on prolactin, growth hormone, or average daily gain were noted. In their first trial, high-endophyte depressed prolactin levels only in an October sampling after TRH injection. However, in a subsequent trial, high-endophyte levels significantly decreased prolactin. High-endophyte fescue also elevated growth hormone, while not affecting insulin. There was no significant effect of TRH on growth hormone between treatments.

EXPERIEMENTAL PROCEDURE

Ensiling Tall Fescue Forage.

Kentucky 31 tall fescue certified seed, known to have either low or high endophyte infection was planted in the fall of 1986 in randomly assigned 1.62 hectare plots with two replications of each treatment at the Glade Spring Experiment Station. Soils were Fredric (silt loam mixed, mesic, Typic Paleult) and Hagerstown (fine, mixed, mesic, Typic Hapludalf). Analysis of endophyte infestation rates[1] in June 1987 showed 70% for the high-endophyte and 4% for the low-endophyte. Subsequent testing of seed indicated that the high endophyte fescue was actually Alta or Falcon (Livestock and Seed Division, USDA, Beltsville MD)

On October 21, 1987, tall fescue was harvested, chopped and packed into 210 liter metal drums which were double lined with .08 mm polyethylene bags. Drums were packed by trampling and each bag was tied separately after expelling the air. Weight of forage in drums averaged 93 kg. Silage fescue treatments consisted of low- and high-endophyte. Alternating forage was cut from low- and high-endophyte fescue throughout the day to achieve a more uniform DM between treatments. Alternate cutting resulted in two groups of samples for each treatment. Several grab samples were taken as each drum was

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[1] Auburn Fescue Diagnostic Center, Auburn Univ.

filled, composited to represent individual drums and frozen for later analysis.

The silos were opened after an average fermentation period of 94 d. One silo from each group was opened 2 d prior to the start of the metabolism trial to allow for determination of DM. Other silos were likewise opened 2 d prior to their use. Upon opening the silos, observations were made on appearance and odor of the silages. To insure freshness of silages, the top 5 cm of material were discarded. Respective silos were selected from each of the four groups to ensure uniform DM between diets.

Chemical Analysis.

A forage subsample from the silos was used to prepare water extracts by blending 25 g of sample material with 225 ml of deionized water in .5 liter jars using a Waring blender at full speed for 2 min. The samples were then filtered through four layers of cheese cloth. Filtrate was used for determination of water-soluble carbohydrates (Dubois et al., 1956 as adapted to corn plants by Johnson et al., 1966). Dry matter determination on samples was by drying duplicate 200 g samples in a forced draft air oven at 60 C until a constant weight was obtained.

Metabolism Trial.

Twenty four crossbred wethers with an average weight of 46 kg were assigned to six blocks of four animals. Animals were blocked according to weight, and were randomly allotted within blocks to the following diets; (1) 100% low-endophyte fescue silage; (2) 50% high-endophyte and 50% low-endophyte fescue silage, mixed at feeding time; (3) 100% high-endophyte fescue silage (dry basis); (4) 100% chopped alfalfa hay.

Prior to the initiation of the trial all animals were injected intramuscularly with Ivermectin[2] to control internal parasites, 500,000 I.U. of vitamin A and 75,000 I.U. of vitamin D. Wethers were placed in metabolism stalls similar to those described by Briggs and Gallup (1949) which allowed for seperate collection of urine and feces.

Animals were fed 800 g of basal diet consisting of 61.4% mixed grass hay, 28.8% corn, and 9.6% soybean meal, dry basis, during a 4-d adaptation period. Transition to the experimental diets was done by substituting the experimental diets at a rate of 15% per feeding. If sheep failed to consume a particular diet that same percentage of basal and experimental diet was fed until it was consumed. Due to the bulk of the silage animal DM intake was decreased to 700 g during an 8-d transition period. Throughout a 10-d preliminary period and a 10-d collection period, 100% of the experimental diets were fed. Rectal temperatures were taken daily

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[2] MSDGVET, Div. of Merck & Co., Rahawas, NJ.

during the collection period at 0830 h. Diets were fed twice daily, one half at 0600 h and the remaining at 1800 h. Animals received 5 g iodized salt at each feeding.

Samples of diets were obtained at each feeding from 2 d prior to the beginning to 2 d prior to the end of the collection period. These samples were then placed in double lined polyethylene bags and frozen. At the conclusion of the trial, the samples were thawed, composited and subsampled. A further subsample was obtained, dried and ground in a stainless steel Wiley Mill through a 1 mm screen for proximate and mineral analysis. Water extracts and determination of dry matter were done on fresh samples as described above. Filtrate was used for determination of pH (electrometrically), lactic acid (Barker and Summerson, 1941 as modified by Pennington and Sutherland, 1956), and water-soluble carbohydates (Dubois et al., 1956 as adapted to corn plants by Johnson et al., 1966)

Feces were collected once daily and dried in a forced air oven at a maximum temperature of 60 C for a minimum of 24 h. Feces from each animal were then composited in metal cans double lined with polyethylene bags and loosely covered to permit equilibration of moisture. Three days following the completion of the trial, each total fecal collection was weighed, mixed, subsampled and ground in a stainless steel Wiley Mill through a 1 mm screen for later anaylsis. Urine was collected in 3.8 liter polyethylene containers containing

100 ml of a 1:1 solution of concentrated HCL, and dionized water. Additionally, 500 ml of deionized water were used to rinse collection funnels at each collection. Urine was collected daily and further diluted to 4200 g with deionized water. A 2% aliquot (by weight) was obtained, stored in tight capped polypropylene containers and refrigerated.

Blood samples were taken via jugular puncture 6 h after feeding before the transition period and at the end of the collection period. Blood tubes for mineral analysis were centrifuged and serum was seperated and frozen. A preheparinized tube was used to collect a blood sample for the determination of blood urea-N by the method of Coulombe and Favreau (1963). Prolactin was determined on serum samples by the method of Akers (1984).

Ruminal fluid samples were obtained 2 h post feeding on the last day of the collection period by use of a stomach tube with a metal strainer on the end. Samples were immediately strained through four layers of cheese cloth, and the filtrate was used for determination of pH (electrometrically). Five milliliters were added to tubes prepared for the determination of ruminal NH_3-N (Beecher and Whitten 1970). An additional 5 ml were added to prepared tubes for later determination of VFA (Erwin et al. 1961).

Oven dried, air equilibriated feed and fecal samples were anaylzed for DM (A.O.A.C. 1980), ADF (Goering and Van Soest, 1970), NDF (VanSoest and Wine, 1967), lignin, cellulose (VanSoest and Wine, 1968), and ash (A.O.A.C. 1980). Hemicellulose was determined by difference between ADF and NDF. For determinations of Ca, Mg, Mn, Na, K, Cu, S, Zn, Fe, and Al, feed and feces samples were digested with a 2 to 1 mixture of $HNO_3$and HCO_4.

Determination of Ca and Mg in urine, serum and digested feed and fecal samples was done by atomic absorption spectrophotometry after dilution with a .5% solution of lanthanum chloride. Sodium, Se, and Mn were also determined by atomic absorption spectrophotometry. Total P was obtained by colorimetric methods (Fiske and Subbarrow, 1925) and S, Zn, Fe, Al, Cu, and K were determined by an inductively-coupled plasma optical emissions spectrophotometer (ICP-OES).

Statistical Analysis

The data for the metabolism were treated by analysis of variance by the general linear model procedure of SAS (1982). The silage diets were compared by the general linear model procedure. Low-endophyte, (4% infected), high-endophyte, (70% infected), and the mixed diet, (37% infected) silages were tested for linear and quadratic trends. Single samples, of diets were chemically analyzed so statistical treatment of these data was not possible

RESULTS AND DISCUSSION

Composition of Tall Fescue Silage and Alfalfa Hay.

Dry matter content of the low-endophyte and high-endophyte silages, averaged 28.0 and 29.6, respectively (Table 1). The crude protein content of the silages was similar for low- and high-endophyte fescue. These values are slightly higher than those obtained by Torres et al. (1983) for stockpiled ensiled tall fescue. Similar values have been reported in fall-grown fescue (Brown et al., 1963). Higher CP levels have been seen in low- and high-endophyte Kentucky 31 soilage (Strahan et al., 1987). Alfalfa protein content averaged 11.58%, dry basis, which was lower than expected, but may have been due to the loss of the leaf portion during harvesting.

Average ash content was lower for the alfalfa hay than fescue silages. Averaged ash values were lower for the high-endophyte than the low-endophyte silage. Lower ash contents than those reported here have been reported for fescue forage harvested in the fall (Pendlum et al., 1980; Bagley et al., 1983). Boling et al. (1981) observed an ash content of 8.8%, dry basis, for two strains of ryegrass-tall fescue hybrids in soilage form and Torres et al. (1983) noted a 9.8% ash content dry basis, in stockpiled ensiled fescue.

Acid detergent fiber was numerically lower for the low-endophyte than the high-endophyte silage. Alfalfa contained

TABLE 1. COMPOSITION OF TALL FESCUE SILAGES AND ALFALFA HAY FED TO WETHERS

Item	Low:high endo. fesc. sil.[a]			Alfalfa
	100:0	50:50	0:100	hay
	%			
Dry matter	28.0	28.8	29.6	91.0
Crude protein[a]	14.8	14.7	14.6	11.6
Ash[a]	9.8	9.2	8.7	6.3
Neutral detergent fiber[a]	54.7	55.2	55.7	58.5
Acid detergent fiber[a]	30.5	30.9	31.4	43.9
Cellulose[a]	23.8	24.0	24.3	33.5
Hemicellulose[a]	24.2	24.2	24.3	14.5
Lignin[a]	3.8	4.4	5.0	9.8

[a] Dry basis.

43.9% ADF, dry basis. Strahan et al. (1987) reported an ADF value similar to the values obtained in the present study for endophyte free Kentucky 31 forage, while obtaining a higher level in infected forage. The silage ADF values for tall fescue are lower than previously reported in fall grown fescue (Owen et al., 1976; Pendlum et al., 1980; Buettner et al., 1982; Bagley et al., 1983; Torres et al.,1983).

Neutral detergent fiber was also lower for the low-endophyte silage. Higher values for NDF in tall fescue forage than those reported here have been published (Owen et al., 1976; Pendlum et al., 1980; Buettner et al., 1982; Torres et al., 1983). Bond et al. (1984) found no differences in ADF, NDF or crude protein among Kentucky 31, Kenhy, G1-306, and G1-307 grown from May through October.

Lignin content was 3.8, 5.0, and 9.8%, dry basis, for low- and high-endophyte silages and alfalfa, respectively. Several researchers have reported higher (Brown et al., 1963; Owen et al., 1976; Bagley et al., 1983) and lower (Pendlum et al., 1980) levels than those reported here for fescue.

Cellulose averaged 24.0% dry basis, for the silages. Buettner et al. (1982) reported a higher level for ammoniated and control fescue harvested in July. Researchers have reported higher levels for fescue forage (Brown et al., 1963; Bagley et al., 1983) than the values reported here.

Hemicellulose levels averaged 24.2%, dry basis, for tall fescue and 14.5%, dry basis, for alfalfa. Higher values than those reported here for fescue forage have been reported (Bagley et al., 1983) while a lower level was observed by Buettner et al. (1982) in ammoniated tall fescue.

Mineral Concentrations of Forages.

The silages contained sufficient levels of Ca, P, S, Zn, Fe, Mn, Mg, and Na to meet the requirements for sheep (NRC, 1985). Copper was slightly below recommended levels.

The optimum Ca:P is suggested to be 2:1 (NRC, 1980). Fescue silages were slightly below this recommendation (Table 2). Calcium and P concentrations in fescue were similar to those observed for fescue by Pendlum et al. (1980) in the regrowth vegetative stage, and lower than those obtained by Hagsten et al. (1976), and Powell et al. (1978) in winter- and summer-grown fescue, respectively. Spears et al. (1981) reported higher Ca and lower P in winter-harvested fescue. Stoszek et al. (1979) reported a lower Ca concentration in fescue grown from May through September. Buttery (1989) reported lower Ca levels in stockpiled high- and low endophyte tall fescue.

Average K concentrations were higher in the low-endophyte silage. Similar K values for low- and high-endophyte fescue have been reported (Stoszek et al., 1979; Pendlum et al., 1980). Other researches have reported lower (Hagsten et al., 1976; Spears et al., 1981) and higher (Powell et al., 1978; Steen et al., 1979; Buttery, 1989)

TABLE 2. MINERAL CONTENT[a] OF TALL FESCUE SILAGES AND ALFALFA HAY FED TO WETHERS

Item	Low:high endo. fesc. sil.[a]			Alfalfa hay
	100:0	50:50	0:100	
Calcium, %	.48	.51	.54	.68
Phosphorus, %	.36	.35	.33	.26
Magnesium, %	.36	.37	.37	.25
Sulfur, %	.22	.22	.21	.17
Sodium, %	2.60	1.94	1.28	1.96
Potassium, %	2.08	1.94	1.79	1.64
Iron, ppm	627	532	437	90
Copper, ppm	6.20	5.82	5.44	5.55
Manganese, ppm	155	145	136	30
Zinc, ppm	25	24	22	19
Aluminum, ppm	792	678	564	35

[a] Dry basis.

levels than those reported in this study. Sodium concentration tended to be highest for the low-endophyte silage. Steen et al. (1979) reported lower Na concentrations than those reported here in fescue forage harvested from March through September. Buttery (1989) reported higher Na levels in stockpiled low- and high-endophyte tall fescue.

Magnesium averaged .37%, dry basis, for the silages and was not affected by endophyte infection. Concentrations were higher than reported by many researchers (Hagsten et al., 1976; Powell et al., 1978; Pendlum et al., 1980; Spears et al., 1981) and similar to the values reported by Stoszek et al. (1979). Buttery (1989) reported slightly higher Mn levels in stockpiled tall fescue.

Sulfur contents were similar between the silages and averaged .22%, dry basis. These values are similar to those levels reported by Steen et al. (1979). Levels were lower than those observed by Powell et al. (1978), Stoszek et al. (1979), Pendlum et al. (1980), and Chestnut et al. (1986). Slightly lower S concentrations were reported by Buttery (1989).

Iron concentrations were higher for the low-endophyte than the high-endophyte silage. Values for Fe were higher than those reported by Steen et al. (1979), Pendlum et al. (1980) and Buttery (1989). Copper concentration between treatments ranged from 5.4 ppm, dry basis, for the high-endophyte to 6.2 ppm for the low-endophyte silage. Researchers have reported similar Cu concentrations as those reported here for fescue (Stoszek et al., 1979; Spears et al., 1981). Steen et al. (1979) found higher levels, while Pendlum et al. (1980) and Buttery (1989), observed a lower Cu in fescue in the regrowth vegetative stage, compared to those of the present study.

Manganese was numerically higher in the low-endophyte fescue, averaging 155 ppm, dry basis. Manganese levels in fescue were higher than those seen by Steen et al. (1979), Pendlum et al. (1980), and Buttery (1989) and lower than those reported by Spears et al. (1981). Zinc values tended to be higher for the low-endophyte silage. Zinc values of fescue were higher than those observed by Pendlum et al. (1980) and Buttery (1989) in the regrowth stage. Lower Zn contents were reported for fescue by Spears et al. (1981) and Steen et al. (1979).

Average Al concentrations were lower in the high-endophyte silage than the low-endophyte silage. These values were higher than those reported by Steen et al. (1979), Pendlum et al. (1980), and Buttery (1989) for fescue forage.

Fermentation Characteristics of Tall Fescue Silages.

All silages were desirable in appearance and aroma. The high- and low-endophyte silages were similar in pH (Table 3) and averaged 4.4, respectively. This was similar to the pH

TABLE 3. FERMENTATION CHARACTERISTICS OF TALL FESCUE SILAGES FED TO WETHERS

Item	Low:high endophyte fescue silage[a]		
	100:0	50:50	0:100
pH	4.42	4.38	4.34
Water soluble carbohydrates, %[a]			
Intial forage	16.32	16.54	16.74
Ensiled forage	8.83	8.88	8.93
Lactic acid, %[a]	8.07	8.56	9.05

[a] Dry basis.

of 4.4, obtained by Torres et al. (1983), and higher than the value reported by Chestnut et al. (1988).

Initial forage samples contained 16.3 and 16.7%, water soluble carbohydrates, dry basis, for low- and high-endophyte silages, respectively. These values are similar to those reported by Torres et al. (1983). Ensiled values averaged 8.9% dry basis, which indicate ensiling had occurred. These values were higher than those obtained by Torres et al. (1983).

Lactic acid averaged 8.6%, dry basis, in silage treatments, which were higher than the values found by Torres et al. (1983). Volatile fatty acids were similar among the silage treatments (Table 4). Torres et al. (1983) reported a higher acetic acid concentration in stockpiled ensiled tall fescue.

<u>Apparent Digestibilities.</u>

Apparent digestibilities of DM among silage treatments were not significantly different and averaged 60.9% (Table 5). These digestibilities were higher ($P<.01$) than for alfalfa hay. Similar values to those obtained in the present study for fescue silage have been reported for stockpiled fescue forage (Brown et al., 1963). Lower values than those reported here have been observed in ammoniated fescue (Buetner et al., 1982). Higher DM digestibilities were also noted by several researchers in lambs fed fall-grown fescue

TABLE 4. VOLATILE FATTY ACIDS IN TALL FESCUE SILAGES[a]

Item	Low:high endophyte fescue silage[a]		
	100:0	50:50	0:100
	------------- % -------------		
Total	2.08	2.10	2.12
Acetic	1.02	.971	.922
Propionic	.383	.396	.409
Isobutyric	.395	.431	.467
Valeric	.103	.105	.106
Isovaleric	.182	.201	.220

[a] Dry basis.

TABLE 5. APPARENT DIGESTIBILITY OF TALL FESCUE SILAGES AND ALFALFA HAY FED TO WETHERS

Component	Low:high endo. fesc. sil.[a]			Alfalfa	
	100:0	50:50	0:100	hay	SE
	%				
Dry matter[d]	60.9	61.0	60.6	59.1	.53
Crude protein	66.4	66.2	65.4	66.2	.48
NDF[bd]	54.9	54.6	54.7	47.9	1.29
ADF[c]	48.1	47.1	48.6	44.0	1.20
Cellulose[d]	65.4	66.8	63.4	56.0	1.75
Hemicellulose	86.7	86.9	86.5	86.4	.60

[a] Dry basis.
[b] Neutral detergent fiber.
[c] Acid detergent fiber.
[d] Means for alfalfa differ from silages ($P<.01$).

(Brown et al., 1963; Pendlum et al., 1980; Torres at al., 1983) and cattle (Jacobson et al., 1963; Owen et al., 1976). Hunt et al. (1985) observed that DM digestibilities were higher in an ad libitum fed diet containing 50% alfalfa and 50% fescue, compared to diets consisting of only one of these components. These researchers also noted that in lambs fed a restricted diet, DM digestibilities were higher for alfalfa.

Apparent digestibility of crude protein was not different among silages and averaged 66.0%. Lower digestibilities were reported for lambs by Pendlum et al. (1980) and higher values were reported by Torres et al. (1983). Brown et al. (1963) found both similar and lower values in lambs fed fall-grown tall fescue while Jacobson et al. (1963) observed higher averages in cattle grazed on fescue from March through September. The values for alfalfa hay were similar to those for the fescue silages in the present study.

Digestibility of NDF was higher for fescue silage (P<.01) than for alfalfa hay. Values were similar for low- and high-endophyte fescue silages. Values for fescue silages are higher than those reported by Buettner et al. (1982). Researchers have reported higher NDF digestibilities in sheep fed fall-grown tall fescue (Pendlum et al., 1980; Buettner et al., 1982), and cattle (Chestnut et al., 1986) than those reported in the present study. Hunt et al. (1985) noted lambs on both restricted and ad libitum diets had NDF digestibilities that decreased with increasing increments of alfalfa added to a fescue diet.

Acid detergent fiber digestibilities were not significantly affected by treatment, however, values for the silage diets tended to be higher than for alfalfa. Higher values than those obtained in the present study were observed by several researchers in lambs fed fall harvested tall fescue (Pendlum et al., 1980; Buettner et al., 1982; Torres et al., 1983) and in steers by Chestnut et al. (1986).

Cellulose digestibility was higher ($P<.01$) for silages than alfalfa. Higher values than those obtained in the present study were noted in ensiled fescue by Torres et al. (1983) and in ammoniated fescue by Buettner et al. (1982). Cellulose digestibility tended to be lower for the high-endophyte silage.

Hemicellulose digestibility was similar among treatments and averaged 86.6%, dry basis. Buettner et al. (1982) reported a higher digestibility in ammoniated tall fescue harvested in July.

Nitrogen Utilization.

A N:S ratio of 10:1 has been suggested for ruminants as ideal for normal microbial activity (NRC, 1985). The N:S ratio in the present study was slightly higher (11:1) than the recommended level. Nitrogen intakes by wethers were similar between silage treatments and tended to be higher than for alfalfa hay (Table 6). Apparent absorption of N, expressed as grams per day, showed a linear effect among the silage treatments ($P<.05$), with the highest value obtained for lambs fed 100% low-endophyte silage. Differences were small and may have reflected differences in intake, since no differences were noted ($P<.05$) when expressed as a percentage of intake. These absorption values were similar to those reported by Torres et al. (1983) and higher than reported by Buettner et al. (1982). Nitrogen retention, expressed as a percent of intake, was higher ($P<.01$) for lambs fed silage than those fed alfalfa. Retention tended to be higher for lambs fed the low-endophyte fescue silage. Retention values for silages were lower than those of Bagley et al. (1983) and Torres et al. (1983) when fall-grown fescue was fed. Pendlum et al. (1980) observed rentention values similar to those for the high-endophyte diet in regrowth vegetative Kenhy fescue.

Mineral Utilization.

Animals fed the alfalfa hay diet consumed a higher level of Ca, hence, excreted more ($P<.01$) in feces (Table 7). Lambs receiving the silage treatments had a net absorption of Ca. Among the silage treatments fecal Ca excretion was higher for the animals fed the high-endophyte than from those fed the low-endophyte diet (linear effect, $P<.01$). Total Ca excretion also increased linearly ($P<.01$) as endophyte infection increased. A lower apparent absorption, expressed

TABLE 6. NITROGEN UTILIZATION BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Intake, g/d	16.62	16.35	16.49	12.97	
Excretion, g/d					
Fecal[b]	5.58	5.57	5.66	4.39	.08
Urinary	9.97	10.45	10.10	11.17	.34
Total	15.54	16.02	15.76	15.56	.32
Apparent absorption					
g/d[bc]	11.04	10.92	10.69	8.58	.08
% of intake	66.43	66.22	65.39	66.16	.48
Retention					
g/d	1.07	.47	.59	-2.59	.32
% of intake[b]	6.45	2.84	3.61	-19.94	2.25

[a] Dry basis.
[b] Means for alfalfa differ from silages ($P<.01$).
[c] Linear effect of silages ($P<.05$).

TABLE 7. UTILIZATION OF CALCIUM AND PHOSPHORUS BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Calcium					
Intake, g/d	3.36	3.57	3.77	4.74	
Excretion, g/d					
Fecal[bc]	3.31	3.49	3.66	5.24	.06
Urinary[d]	.16	.30	.37	.14	.05
Total[bc]	3.47	3.79	4.03	5.38	.08
Apparent absorp.					
g/d[b]	.05	.07	.12	-.50	.06
% of intake[b]	1.46	2.04	3.07	-10.57	1.73
Retention, g/d[b]	-.11	-.23	-.25	-.63	.07
% of intake	3.42	-6.36	-6.77	-13.44	1.99
Phosphorus					
Intake, g/d	2.52	2.42	2.32	1.81	
Excretion, g/d[e]					
Fecal	2.11	2.29	2.26	1.91	.05
Apparent absorp.					
g/d[d]	.41	.14	.06	-.09	.05
% of intake[d]	16.27	5.63	2.62	-5.09	2.49

[a] Dry basis.
[b] Means for alfalfa differ from silges ($P<.01$).
[c] Linear effect of silages ($P<.01$).
[d] Linear effect of silages ($P<.05$).
[e] Phosphorus was not detected in urine; dilution factor was 1:25.

as percentage of intake, was observed than reported by Pendlum et al. (1980) when regrowth fescue was fed to lambs.

Fecal excretion of P was lowest in sheep fed 100% low-endophyte silage (Table 7). Within the silage diets, P absorption decreased linearly (P<.01) with endophyte level. Pendlum et al. (1980) observed a net secretion of P in lambs fed regrowth stage tall fescue. In consecutive years, Powell et al. (1978) found first a positive and then a negative absorption of P in lambs fed fescue harvested in May and June.

A linear decrease (P<.01) in K absorption was seen with increased endophyte level, which was related to intake (Table 8). Retention of K as grams per d and percentage of intake decreased linearly (P<.01) with endophyte infection. Apparent percentage of absorption values were similar to those obtained by Pendlum et al. (1980) and slightly higher than seen by Powell et al (1978). Most of the intake of Na was from the salt. Sodium excretion in feces and urine and apparent absorption and retention of Na were similar among lambs fed the fescue diets.

Animals fed alfalfa consumed a lower level of Mg and excreted lower (P<.01) quantities in feces and absorbed less (P<.01) and retained the lower (P<.01) amounts(%) of Mg (Table 9). Excretion, absorption and retention of Mg were similar between silage treatments. Apparent absorption of Mg was lower than that found by Pendlum et al. (1980) and Powell

TABLE 8. UTILIZATION OF POTASSIUM AND SODIUM BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Potassium					
Intake, g/d					
Forage	14.57	13.55	12.53	11.50	
Salt	.068	.068	.068	.068	
Total	14.64	13.62	12.60	11.57	
Excretion, g/d					
Fecal	.79	.65	.53	.58	.1
Urinary[bc]	15.77	16.02	14.98	12.95	.34
Total[bd]	16.56	16.67	15.51	13.53	.30
Apparent absorp.					
g/d[bd]	13.85	12.96	12.06	11.00	.10
% of intake	94.59	95.20	95.77	94.97	.71
Retention					
g/d[d]	-1.92	-3.06	-2.91	-1.96	.30
% of intake[d]	-13.12	-22.44	-23.11	-16.97	2.46
Sodium					
Intake, g/d					
Forage	.182	.136	.090	.137	
Salt	4.0	4.0	4.0	4.0	
Total	4.18	4.14	4.09	4.14	
Excretion, g/d					
Fecal	.41	.49	.50	.68	.08
Urinary	2.09	1.95	2.00	1.65	.09
Total	2.49	2.44	2.50	2.33	.08
Apparent absorp.					
g/d	3.77	3.54	3.59	3.45	.08
% of intake	90.24	88.05	87.69	83.46	1.84
Retention, g/d	1.69	1.70	1.59	1.81	.08
% of intake	40.35	41.00	38.91	43.70	1.85

[a] Dry basis.
[b] Means for alfalfa differ from silages (P<.01).
[c] Linear effect of silages (P<.05).
[d] Linear effect of silages (P<.01).

TABLE 9. UTILIZATION OF MAGNESIUM AND SULFUR BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a]			Alfalfa	
	100:0	50:50	0:100	hay	SE
Magnesium					
Intake, g/d	2.52	2.55	2.57	1.76	
Excretion, g/d					
Fecal[b]	1.96	2.00	2.01	1.40	.04
Urinary	.732	.826	.779	.698	.08
Total[b]	2.70	2.83	2.79	2.10	.04
Apparent absorp.					
g/d[b]	.56	.54	.57	.36	.04
% of intake	22.07	21.37	21.97	20.44	1.75
Retention, g/d	-.177	-.282	-.214	-.338	.04
% of intake[b]	-7.01	-11.08	-8.30	-19.20	2.05
Sulfur					
Intake, g/d	1.52	1.49	1.46	1.20	
Excretion, g/d					
Fecal[b]	.87	.87	.82	.58	.02
Urinary[c]	.50	.53	.50	.60	.01
Total[bc]	1.37	1.40	1.32	1.18	.02
Apparent absorp.					
g/d	.65	.63	.64	.62	.02
% of intake[b]	43.06	42.04	43.80	51.74	1.08
Retention, g/d[c]	.149	.097	.146	.024	1.32
% of intake[c]	9.84	6.46	9.93	2.02	.02

[a] Dry basis.
[b] Means for alfalfa differ from silages (P<.01).
[c] Quadratic effect of silages (P<.05).

et al. (1978) for fall- and summer-harvested fescue, respectively.

Sulfur intake tended to be higher for animals fed silage than alfalfa hay, which resulted in a higher (P<.01) fecal S, but similar apparent absorption, compared to sheep fed alfalfa. Among the silage treatments, apparent absorption and retention of S was similar for the lambs fed the fescue diets. Lower apparent absorptions of S were obtained than in the experiment of Powell et al. (1978) and Pendlum et al. (1980).

Iron intake tended to be highest for the 100% low-endophyte silage and lowest for the alfalfa hay (Table 10). Total Fe excreted showed a linear (P<.05) effect within the silage-fed lambs, with lower values for lambs fed 100% high-endophyte fescue. Negative retention and absorption values were obtained for lambs fed all diets.

Fecal Mn followed the same trend as the level of intake and showed a linear effect (P<.05) among the silage treatments; values were lower for lambs fed the high-endophyte fescue. Among the silage treatments, animals fed the low-endophyte and mixed diets were similar in the Mn excreted in the feces while the sheep fed high-endophyte diets excreted less.

Intake of Zn tended to be higher in the low-endophyte diet (Table 11). Similar negative absoption values were observed from all treatment groups. Intake of Al tended to be

TABLE 10. UTILIZATION OF IRON AND MANGANESE BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Iron					
Intake, g/d	.44	.37	.31	.06	
Excretion, g/d					
Fecal[bc]	.47	.48	.32	.17	.03
Urinary	.006	.007	.004	.005	.001
Total[bc]	.48	.48	.33	.17	.029
Apparent absorp.					
g/d	-.034	-.104	-.017	-.103	.03
% of intake[c]	-7.84	-28.00	-5.60	-162.67	22.23
Retention, g/d	-.04	-.11	-.02	-.11	.029
% of intake[c]	-9.27	-29.76	-6.85	-170.62	22.16
Manganese					
Intake, g/d	.105	.102	.096	.022	
Excretion[d]					
Fecal, g/d[bc]	.052	.055	.045	.018	.001
Apparent absorp.					
g/d[c]	.054	.052	.051	.003	.001
% of intake[c]	50.86	50.53	53.04	14.75	2.75

[a] Dry basis.
[b] Linear effect of silages (P<.05).
[c] Means for alfalfa differ from silages (P<.01).
[d] Manganese was not detected in urine; dilution factor was 1:25.

TABLE 11. UTILIZATION OF ZINC AND ALUMINUM BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a]			Alfalfa	
	100:0	50:50	0:100	hay	SE
Zinc					
Intake, mg/d	18.20	17.00	15.81	13.77	
Excretion, mg/d					
Fecal	35.16	24.11	28.79	27.33	4.62
Urinary	.779	.906	.684	.835	.15
Total	35.94	25.02	29.48	28.17	4.62
Apparent absorp.					
mg/d	-16.96	-7.11	-12.98	-13.56	4.62
% of intake	-93.22	-41.83	-82.08	-98.41	26.47
Aluminum					
Intake, mg/d	554.97	475.17	395.38	24.50	
Excretion, mg/d					
Fecal[bc]	587.69	530.44	436.22	43.22	8.88
Urinary	1.25	2.22	1.83	1.51	.40
Total[bc]	588.94	532.66	438.05	44.72	8.88
Apparent absorp.					
mg/d	-32.72	-55.26	-40.84	-18.71	8.88
% of intake[c]	-5.90	-11.63	-10.33	-76.36	2.00
Retention, mg/d	-33.97	-57.49	-42.66	-20.22	8.83
% of intake[c]	-6.12	-12.10	-10.79	-82.52	2.31

[a] Dry basis.
[b] Linear effect of silages ($P<.05$).
[c] Means for alfalfa differ from silages ($P<.01$).

highest for the low-endophyte and lowest for the alflafa hay. Copper excretion parelled Cu intake trends (Table 12). Negative aborption and retention values were obtained.

Blood and Serum Parameters.

Blood urea N (BUN) was not significantly different at the initial sampling (Table 13). At the end of the trial, BUN values of animals on the silage treatments were similar, and different ($P<.05$) from that of sheep fed the alfalfa hay. Torres et al. (1983) found levels of 17.4 mg/100 ml in lambs fed untreated fescue silage. Boling et al. (1975) also obtained similar values and found no significant differences in lambs fed high- or low-perloline fescue. Steen et al. (1979) and Bond et al. (1984) found no BUN differences in steers grazing four varieties of tall fescue.

Serum mineral concentrations (Table 14) were not statistically different in samples taken at either the initiation or termination of the trial. Similar results have been seen in several studies in cattle. Steers grazing two varieties and two experimental lines of tall fescue showed no differences in serum Na, K, Mg, P, (Steen et al., 1979; Bond et al., 1984) Ca, Fe, Se, Zn, Mo, or Cu (Bond et al., 1984) across sampling times. Stoszek et al. (1979) found cattle fed tall fescue showed significantly decreased plasma copper concentrations, compared to steers fed quackgrass.

TABLE 12. UTILIZATION OF COPPER BY WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Copper					
Intake, mg/d	4.34	4.07	3.81	3.96	
Excretion, mg/d					
Fecal	6.09	5.07	4.26	4.40	.67
Urinary	.145	.195	.216	.275	.07
Total	6.24	5.26	4.47	4.68	.67
Apparent absorp.					
mg/d	-1.75	-.994	-.450	-.446	.67
% of intake	-40.39	-24.39	-11.83	11.25	15.17
Retention, mg/d	-1.90	-1.19	-.666	-.720	.67
% of intake	-43.73	-29.17	-17.50	-18.19	15.33

[a] Dry basis.

TABLE 13. BLOOD UREA NITROGEN AND RUMINAL FLUID pH AND AMMONIA NITROGEN IN WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a]			Alfalfa	
	100:0	50:50	0:100	hay	SE
Start of trial					
Blood urea, mg/dl	12.50	11.25	10.19	11.02	1.73
End of trial					
Blood urea, mg/dl[b]	14.81	15.49	14.14	17.36	.63
Ruminal pH	6.72	6.56	6.73	6.59	.06
Ruminal NH_3-N, mg/dl[cd]	33.77	40.51	36.14	28.16	1.21

[a] Dry basis.
[b] Means for alfalfa differ from silages ($P<.05$)
[c] Quadratic effect of silage treatments ($P<.01$).
[d] Means for alfalfa differ from silages ($P<.01$)

TABLE 14. SERUM MINERAL CONCENTRATIONS IN WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE
Start of trial					
Calcium, mg/dl	10.36	10.20	10.53	10.20	.27
Phosphorus, mg/dl	7.34	7.19	6.26	7.60	.54
Magnesium, mg/dl	2.45	2.34	2.32	2.31	.08
Sodium, mg/dl	287.50	310.0	345.67	343.33	17.38
Potassium, mg/dl	24.33	27.00	28.25	28.42	1.95
Manganese, mg/dl	.017	.018	.020	.020	.001
Sulfur, mg/dl	83.20	81.85	84.03	82.83	2.12
Copper, mg/dl	.086	.071	.088	.084	.01
Iron, mg/dl	.221	.246	.169	.222	.026
Zinc, mg/d	.069	.070	.067	.072	.005
End of trial					
Calcium, mg/dl	10.60	11.11	10.65	10.08	.31
Phosphorus, mg/dl	5.59	5.90	5.33	6.41	.43
Magnesium, mg/dl	2.44	2.41	2.28	2.34	.06
Sodium, mg/dl	341.67	350.83	340.83	345.83	7.16
Potassium, mg/dl	31.75	32.25	30.92	32.75	1.20
Manganese, mg/dl	.013	.018	.014	.016	.002
Sulfur, mg/dl	75.96	76.65	79.46	76.96	1.49
Copper, mg/dl	.073	.062	.064	.064	.005
Iron, mg/dl	.202	.199	.178	.232	.029
Zinc, mg/dl	.059	.048	.057	.068	.01

[a] Dry basis.

Prolactin was not significantly different at the onset of the trial and averaged 13.84 ng/ml (Table 15). However, at the termination of the trial, animals fed low-endophyte silage had the highest prolactin concentration (63.65 ng/ml). The prolactin concentrations of the silage-fed whethers showed a linear ($P<.05$) decrease with increased proportion of endophyte-infected fescue. On d 9 and d 10 of a trial conducted by Henson et al. (1987), lower prolactin concentrations were found in sheep fed endophyte infected tall fescue vs those fed a rye-orchardgrass diet. Others have noted a suppression in prolactin in sheep (Elsasser and Bolt, 1987) and cattle (Hurley et al., 1981; Stidham et al., 1982; Bond and Bolt, 1986; Goetsch et al., 1987; Strahan et al., 1987; Thompson et al., 1987) fed endophyte infected tall fescue.

Ruminal Parameters.

Ruminal fluid pH was not affected by treatment; the average was 6.7 (Table 13). The values were similar to those reported by Torres et al. (1983). Ruminal fluid NH_3-N was lower ($P<.01$) in animals fed alfalfa hay. Silage treat- ments produced a linear effect ($P<.01$) with the lowest value of 33.8 mg/dl for wethers consuming low-endophyte and the highest value of 40.5 mg/dl for those fed the mixed diet. Torres et al. (1983) reported slightly lower values than those reported here.

TABLE 15. PROLACTIN CONCENTRATION IN WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Time	Low:high endo. fesc. sil.[a]			Alfalfa	SE
	100:0	50:50	0:100	hay	
	ng/ml				
Start of trial	14.53	10.22	16.72	13.87	2.80
End of trial[b]	63.65	29.75	20.30	58.27	9.33

[a] Dry basis.
[b] Linear effect of silage treatments ($P < .05$).

Ruminal acetic, propionic, isobutyric, butyric and valeric acids were not affected by treatment (Table 16). Animals fed silages had higher ($P<.01$) isovaleric concentrations than animals fed alfalfa. Torres et al. (1983) found similar acetic, isobutyric and isovaleric acid, higher propionic and butyric acid and a lower valeric acid concentration in sheep fed fescue silage. Bagley et al. (1983) fed November-cut fescue to sheep and reported a similar acetic acid concentration, a higher propionic acid level and lower butyric, isobutyric, valeric and isovaleric acids. Grimes et al. (1967) grazed wethers on tall fescue pastures in the fall and found higher acetic and lower propionic acids than those of the present study.

Rectal Temperatures.

Rectal temperatures tended to be lowest for animals on the alfalfa diet (Table 17). Among the silage treatments temperatures of sheep fed the low-endophyte diet tended to be lower on January 31, and Febuary 1, 2, 7, 9,. Ambient barn temperature dropped to the lowest level on d 5, but did not appear to affect rectal temperatures. Boling et al. (1975) observed higher body temperatures in lambs fed a diet with added perloline. Lambs fed a diet with added perloline had average temperature of 39.86 and 39.91 C on d 10 and 11, respectively, while control animals averaged 39.60 and 39.64 for the 2 d, respectively. Jackson et al. (1984) found

TABLE 16. RUMINAL VOLATILE FATTY ACIDS FROM WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Item	Low:high endo. fesc. sil.[a]			Alfalfa hay	SE
	100:0	50:50	0:100		
Total, u mole/ml	90.87	95.42	94.17	92.58	
Moles/ 100 moles					
Acetic	58.96	58.71	60.16	64.61	3.31
Propionic	26.87	26.27	25.94	22.96	1.61
Isobutyric	1.58	1.78	1.48	1.42	.16
Butyric	7.90	8.47	8.20	6.87	.57
Isovaleric[b]	2.34	2.44	2.27	1.86	.10
Valeric	2.36	2.32	1.95	2.27	.11

[a] Dry basis.
[b] Mean for alfalfa differs from silages ($P < .01$).

Table 17. RECTAL AND AMBIENT TEMPERATURES (C) OF WETHERS FED TALL FESCUE SILAGES AND ALFALFA HAY

Time	Low:high endo. fesc. sil.[a] 100:0	50:50	0:100	Alfalfa hay	SE	Ambient Temp.
	----------	C	----------			C
Jan. 13	38.8	39.0	39.1	38.9	.13	19
Feb. 1	39.0	39.3	39.2	38.8	.12	20
Feb. 2	39.1	39.3	39.2	38.9	.09	21
Feb. 3	39.1	39.0	39.0	38.7	.08	21
Feb. 4	38.9	39.0	39.1	38.7	.09	20
Feb. 5	39.0	39.0	39.0	39.0	.10	20
Feb. 6	39.0	39.0	39.0	38.8	.10	15
Feb. 7	38.7	38.8	38.8	38.8	.11	17
Feb. 8	38.9	38.9	38.8	38.6	.09	18
Feb. 9	38.7	38.9	38.9	38.7	.09	20
Average	38.9	39.0	39.0	38.8		

[a] Dry basis.

higher ($P<.05$) rectal temperatures for steers fed fescue seed, versus orchardgrass seed. Steers fed fungus-free seed or hay displayed lower rectal temperatures than those fed infected seed or hay (Schmidt et al., 1982). Toxic tall fescue extracts produced higher rectal temperatures than controls in rabbits (Ahmed et al., 1982). However, no significant differences in rectal temperatures were seen by Steen et al. (1979) in grazing steers or by Hemken et al. (1979) in lactating Holsteins. Hemken et al. (1981) noted an interaction between environmental temperature and fescue toxicosis. At lower ambient temperatures, differences in rectal temperatures of calves were not statistically different, while significant differences were observed at higher ambient temperatures.

Conclusions.

The results of this study indicate that the presence of the endophyte, Acremonium coenophialum, does not affect the apparent digestibilities of DM, CP, NDF, ADF, cellulose or hemicellulose. Nitrogen retention tended to be higher for the low-endophyte fescue silage. Apparent absorption of P and K decreased linearly with increased endophyte level but was related to intake. Apparent absorption and retention of S, Mg, Fe, Mn, Zn, and Al were not affected by level of endophyte infection. Presence of the endophyte did not affect blood or serum parameters, or ruminal fluid pH, NH_3-H and volatile fatty acids. Prolactin concentrations decreased linearly with increased proportions of endophyte-infected fescue. Thus, presence of the endophyte did not have major effects on nutrient utilization by sheep.

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