Cattle Preferentially Select Birdsfoot Trefoil from Mixtures of Tall Fescue and Birdsfoot Trefoil

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Abstract

When birdsfoot trefoil (Lotus corniculatus L.) is interseeded into tall fescue (Festuca arundinacea Schreb.) pastures, animal performance often exceeds that expected based on forage samples taken from the pasture. This may be due to cattle (Bos taurus) preferentially selecting birdsfoot trefoil from mixed pastures. Our objective was to investigate the selectivity for birdsfoot trefoil by cattle grazing tall fescue-birdsfoot trefoil pastures. Treatments were 'Phyter' tall fescue sown in a monoculture and in mixtures with 'ARS-2622' and 'Norcen' birdsfoot trefoil. Beef heifers fitted with esophageal cannulas grazed pastures in the spring and autumn of 1998 and again in spring 1999. In the tall fescue-birdsfoot trefoil mixtures, the amount of birdsfoot trefoil on-offer showed a 73% reduction during the study, but the amount of birdsfoot trefoil in esophageal samples declined by an average of only 22%. Although the percentage of birdsfoot trefoil in mixed pastures often declines over time, its value may be underestimated because animals selectively graze this species when its proportion in pastures is low.

Introduction

The proportion of legumes in mixed grass-legume pastures often influences the weight gain of growing ruminants (10,16,17). Previous studies have shown that interseeding birdsfoot trefoil into tall fescue pastures increases total weight gain per hectare compared to grazing monocultures of tall fescue (10,19) (Fig. 1). This improvement in gain is usually attributed to the greater crude protein and lower detergent fiber in the mixtures of tall fescue and birdsfoot trefoil compared to a tall fescue monoculture. However, the change in chemical composition in mixed pastures over the grazing season does not address the influence of animal selectivity on cattle performance.

Fig. 1. Livestock producers often interseed birdsfoot trefoil into tall fescue monocultures to improve the nutritive value of the pasture.
One of the most accurate methods of determining the botanical composition of the forage selected by cattle is sampling masticated forage from animals fitted with an esophageal cannula (4). This technique allows the study of the selectivity by cattle for different forage species and the chemical composition of forage selected by animals throughout the grazing season.

In other studies, animal selection has played a large role in determining animal performance in mixed swards. Forwood et al. (6) studied the selection of cattle grazing binary mixtures of orchardgrass (*Dactylis glomerata* L.) and different legumes. The quantities of birdsfoot trefoil, red clover (*Trifolium pratense* L.), and alfalfa (*Medicago sativa* L.) selected by cattle were similar, although the amount of red clover in pastures was lower than the other legumes. However, little is known about the selectivity of beef cattle grazing birdsfoot trefoil in tall fescue-birdsfoot trefoil mixtures in a continuous grazing system. We hypothesized that grazing cattle would select birdsfoot trefoil from a mixed tall fescue-birdsfoot trefoil pasture. If true, this would improve the quality of their diet over what might be predicted from a nutrient analysis of the forage-on-offer. Our objective was to investigate the selectivity for birdsfoot trefoil by cattle grazing tall fescue-birdsfoot trefoil pastures.

**Pasture Establishment and Management**

‘Phyter’ tall fescue was sown in a monoculture and in a mixture with ‘ARS-2622’ or ‘Norcen’ birdsfoot trefoil at the University of Missouri South Farm near Columbia, MO in April 1997. This provided three pasture treatments: (i) Phyter endophyte-free tall fescue in monoculture; (ii) a mixture of ARS-2622 rhizomatous birdsfoot trefoil + tall fescue; (iii) a mixture of Norcen (non-rhizomatous) birdsfoot trefoil + tall fescue. These treatments are referred to as "tall fescue," "ARS-2622 + tall fescue," and "Norcen + tall fescue," respectively. The monoculture of tall fescue was seeded at 15 lb/acre and the mixtures were seeded at 12 lb/acre of tall fescue and 7 lb/acre of birdsfoot trefoil. Seeding rates were on a pure live seed basis. Birdsfoot trefoil seeds were inoculated with *Bradyrhizobium loti* before planting. Each treatment pasture was 1.3 acres and replicated four times in a randomized complete block.

The soils at this location are classified as Mexico silt loam (Fine, smectitic, mesic Aeric Epiaqualfs), Moniteau silt loam (Fine-silty, mixed, superactive, mesic Typic Endoaqualfs), and Mandeville silt loam (Fine-loamy, mixed, superactive, mesic Typic Hapludalfs). Soils were tested for pH, phosphorus, and potassium, and fertilized each year based on the recommendations of University of Missouri Soil Testing Laboratory. Nitrogen was applied at 60 lb/acre in March of 1998 and 1999 to the tall fescue pastures. All pastures received N at 30 lb/acre at planting in 1997, but no N was applied to the mixtures thereafter. All N was applied as ammonium nitrate.

Pastures were grazed continuously to maintain a 3- to 4-inch stubble height utilizing the put-and-take grazing method (3). In 1998, the spring grazing season began on 5 May and ended on 30 June, while in 1999, it lasted from 19 April to 14 July. In 1998, autumn grazing occurred from 22 September to 17 November. Dry weather prevented grazing during the autumn of 1999. Grazing during each period was terminated when the pastures would no longer sustain three animals per paddock.

**Grazing Study**

Four yearling Angus crossbred heifers (average body weight 501 lb) were surgically fitted with esophageal cannula (#11E, Bar Diamond, Inc., Parma, ID) according to the procedures approved by the Animal Care and Use Committee at the University of Missouri (Fig. 2). Heifers were allowed to recover from surgery for three-weeks. After recovery, heifers continuously grazed reserve mixed tall fescue-birdsfoot trefoil pastures. On the day prior to sample collection, heifers were placed in a pen with water only. On the initial date of grazing during each period and once per month thereafter, two heifers fitted with esophageal cannulas were placed on each paddock and allowed to graze throughout the paddock for 30 min (4), along with steers already grazing the pasture (19). Grazing began at 6 a.m. each day. A cheese-cloth bag (10 × 14 inches) was secured around the neck to collect the masticate from the esophageal cannula.
After the 30-min grazing period, heifers were removed from pastures, the esophageal samples were collected from the cheese-cloth bags and hand-squeezed to remove excessive moisture (9), and placed on dry ice to prevent further degradation. Esophageal samples were transferred from dry ice and stored in a freezer at -4°F. Forage-on-offer samples were collected prior to grazing by the heifers from 18 to 22 random locations in each pasture by clipping all forage in a 1-sq-ft quadrat to a 1-inch height. After clipping, samples were placed on dry ice and stored at -4°F.

Analysis of Forage

All samples were freeze-dried using a Virtis (Virtis Inc., Gardiner, NY) 36X84 general purpose lyophilizer and ground using a Wiley mill (Arthur H. Thomas, Philadelphia, PA) to pass a 0.04-inch screen. Samples were scanned by near-infrared reflectance (NIR) spectroscopy using a NIRSytems 5000 scanning monochromator (NIRSytems, Silver Spring, MD) with WinISI II software developed by Infrasoft International (Port Matilda, PA). Samples were scanned with NIR radiation from 1,110 to 2,490 nm, and log 1/reflectance (log 1/R) was recorded. Approximately 10% of the samples were selected for chemical analysis based on spectral diversity using the WinISI program.

Chemical analysis of ground samples included acid detergent fiber and neutral detergent fiber determination by the procedures of Goering and Van Soest (7) and N concentration with a Leco FP-480 Nitrogen Determinator (St. Joseph, MI). Crude protein was estimated as 6.25 × N. Prediction equations for these indices were developed by regressing first and second derivatives of log 1/R against chemical data. Equations were developed and validated using modified partial least square regression with cross validation (15). Validation accuracy was evaluated with high values of 1-variance ratio (1-VR) and low standard errors of calibration (Table 1).
Table 1. Calibration and performance statistics for near infrared reflectance spectroscopy for determination of chemical constituents and the percentage of birdsfoot trefoil in forage-on-offer and esophageal samples.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>R²†</th>
<th>1-VR‡</th>
<th>n</th>
<th>Mean % of DM</th>
<th>SEC¶</th>
<th>SECV#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid detergent fiber (%)</td>
<td>0.89</td>
<td>0.74</td>
<td>62</td>
<td>29.7</td>
<td>3.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Neutral detergent fiber (%)</td>
<td>0.98</td>
<td>0.97</td>
<td>63</td>
<td>52.6</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>0.99</td>
<td>0.98</td>
<td>64</td>
<td>19.3</td>
<td>0.5</td>
<td>0.73</td>
</tr>
<tr>
<td>Birdsfoot trefoil (%)</td>
<td>0.99</td>
<td>0.99</td>
<td>94</td>
<td>50.6</td>
<td>2.0</td>
<td>2.8</td>
</tr>
</tbody>
</table>

† Calibration coefficient of determination achieved in modified partial least squares regression of spectra on chemical data.
‡ 1-VR = 1 minus the variance ratio calculated in cross validation in modified partial least squares regression.
¶ SEC = standard error of calibration.
# SECV = standard error of cross validation.

Percentage of birdsfoot trefoil in samples was determined by NIR based on artificially-mixed standards. Roberts et al. (13) concluded that artificial equations can be accurate when samples used to construct the calibration standards are collected from the same study and are processed in the same way as samples to be analyzed by NIR. In making esophageal standards for percentage birdsfoot trefoil, mixed tall fescue-birdsfoot trefoil samples were clipped from non-grazed areas between paddocks. Mixed samples were hand-separated into tall fescue and birdsfoot trefoil portions. Each portion was fed separately to esophageal-cannulated heifers, and masticated samples were collected as previously described. These pure samples of tall fescue and birdsfoot trefoil, which were collected from the pasture and masticated by the heifers, were freeze-dried and ground in a Wiley mill as previously described. The ground samples were mixed in five percentage unit increments to create a set of masticated tall fescue-birdsfoot trefoil samples containing 5% to 95% (w/w) birdsfoot trefoil. The artificially mixed samples were used to develop prediction equations using the same regression methods used to create equations for forage quality constituents.

Statistical Analysis
The experimental design was a randomized complete block in a split-split-plot arrangement of treatments with four replications. Analysis of variance was conducted on pasture types (main plots), sample type (forage-on-offer versus esophageal samples; sub-plots), grazing periods (sub-sub-plots), and all possible interactions using the model outlined by Steel and Torrie (16). The Proc GLM function of SAS (version 8) was used for statistical analyses (SAS Institute, Cary, NC). Forage-on-offer and esophageal data from the multiple samplings within each period were pooled for analysis. There were three samplings for the spring and autumn of 1998 and four during the spring of 1999. Main effects and all interactions were considered significant when P < 0.05. When the F test was significant (P < 0.05), means were separated using Fisher’s protected LSD (alpha = 0.05) (16).

Nutritive Value of Forage-on-offer and in Esophageal Samples
The nutritive value of forage-on-offer was typically greatest for Norcen + tall fescue, intermediate for ARS-2622 + tall fescue, and lowest for the tall fescue monoculture (Table 2). The nutritive value of birdsfoot trefoil often exceeds that of tall fescue (2,11,19). Thus, it is no surprise that the inclusion of birdsfoot trefoil into grass monocultures improves the nutritive value of the forage-on-offer, with the proportion of birdsfoot trefoil in the pasture being a major factor involved (19).
The diet selected by heifers was almost always higher in nutritive value than the forage-on-offer. With one exception (acid detergent fiber for tall fescue in Spring 1999), esophageal samples had greater crude protein and lower detergent fiber concentrations than the forage-on-offer in all treatments. In addition, esophageal samples from either of the mixtures were usually lower in detergent fiber and higher in crude protein than samples from the tall fescue monoculture. However, there were no differences between Norcen + tall fescue and ARS-2622 + tall fescue in the nutritive value of forage selected by heifers.

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These results are supported by research in Washington and Kansas in the USA as well as Saskatchewan and Manitoba in Canada that shows grazing cattle select forage with lower fiber and higher crude protein concentrations when compared to the forage-on-offer (5,8,12). This tends to occur in both monocultures as well as in mixed pastures, but the differences are often larger for mixed pastures than for monocultures (5).

**Birdsfoot Trefoil Selection by Heifers**

In the spring of 1998, the forage-on-offer in both of the mixtures had more than 30% birdsfoot trefoil (Fig. 3). The esophageal samples from this period showed that the heifers selected birdsfoot trefoil at a similar percentage. By the autumn of 1998, the percentage of birdsfoot trefoil on-offer declined to 19% for Norcen + tall fescue and 8% for ARS-2622 + tall fescue (Fig. 3). However, the esophageal samples from this period showed that heifers selected proportionally more birdsfoot trefoil than that on-offer. The percentage of birdsfoot trefoil in the esophageal samples was 25% and 21% for Norcen + tall fescue and ARS-2622 + tall fescue, respectively, in the autumn of 1998. A similar trend was observed in the spring of 1999, when the forage-on-offer contained 14% birdsfoot trefoil for Norcen + tall fescue and 9% for ARS-2622 + tall fescue, but the percentage of birdsfoot trefoil in the esophageal samples was approximately 29% for both treatments.

Our data show that in mixtures of tall fescue and birdsfoot trefoil, heifers select birdsfoot trefoil at a relatively constant level of 20 to 35% of their diet. Thus, even though the percentage of birdsfoot trefoil in the forage-on-offer declined dramatically over time, heifers compensated for this decline by preferentially selecting birdsfoot trefoil. In addition, heifers selected similar amounts of birdsfoot trefoil from both of the mixtures, even though the amount of birdsfoot trefoil on-offer for ARS-2622 + tall fescue was 11 and 5 percentage units lower than for Norcen + tall fescue in the autumn of 1998 and spring of 1999, respectively.

This is significant because birdsfoot trefoil stands often decline due to their susceptibility to root and crown rot organisms (1). Thus, as the percentage of birdsfoot trefoil in a pasture declines, animal preference for birdsfoot trefoil further compounds this problem by selective grazing. Similarly, Forwood et al. (6) reported that birdsfoot trefoil and red clover were preferentially selected by
grazing steers in legume-orchardgrass mixtures, particularly when the legume proportion was low.

Although this study was conducted under continuous grazing, a typical management system in the lower Midwest, animal selectivity would likely be different under a rotational grazing system. Rotational grazing systems have been shown to improve stand persistence of birdsfoot trefoil (2). Grazing schemes that offer a rest period may partly improve stand persistence of birdsfoot trefoil by reducing constant, selective grazing pressure. These rest periods allow birdsfoot trefoil to recover physiologically and/or give plants time to produce seed (2).

Previous work with the birdsfoot trefoil cultivars used in this study showed that the condensed tannin concentration in ARS-2622 is higher than in Norcen (18). However, the similar levels of birdsfoot trefoil in the esophageal samples collected from heifers grazing both of these cultivars suggested that condensed tannin concentration did not influence animal selection. Roberts et al. (14) found that birdsfoot trefoil cultivars that were rejected by grazing sheep (Ovis aries) did not always have a high concentration of condensed tannins. According to McGraw et al. (11), differences in palatability among varieties of birdsfoot trefoil are often related to crude protein concentration and in vitro dry matter digestibility as well as canopy architecture (decumbent or upright).

**Conclusion**

Mixtures of ARS-2622 or Norcen with tall fescue provided animals with a greater level of nutrients than might have been expected from a nutrient analysis of the forage-on-offer. The amount of birdsfoot trefoil in the mixtures declined from more than 30% at the beginning of the study to as low as 8% at the end of the study, a reduction of more than 73%. However, the amount of birdsfoot trefoil selected by grazing heifers during the same period declined by an average of only 22%. Although the percentage of birdsfoot trefoil in mixed pastures often declines over time, its value may be underestimated because animals selectively graze this species when its proportion in pastures is low.

**Literature Cited**