Diurnal Variation in Forage Quality Affects Animal Preference and Production

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Introduction

In 1993, we began to evaluate animal grazing preferences among eight tall fescue cultivars, including HiMag which had been selected to reduce risk of grass tetany. Two years of preference studies indicated that some cultivars were better liked by heifers than other cultivars (Shewmaker et al., 1997). One of us (JCB) and others asked WHY. This led to quantifying various chemical and physical characteristics of these cultivars and determining their relationship to grazing preference. It also led to an evaluation of animal preference among these same tall fescues when harvested in late afternoon and conserved as hay (Burns et al., 'a', submitted J. Anim. Sci.). In the grazing study, we had found a close relationship between total nonstructural carbohydrate (TNC) levels and animal grazing preferences among the cultivars (Mayland et al., 'c', revised for Agron. J.). However, TNC values change during the day. What effect might variation in harvest time have on TNC concentration and ultimately animal preference?

This diurnal cycling of forage sugars had been known for many years, but had been dismissed as not affecting feed value or animal behavior. We checked the literature (August 1996) but found no documentation of animal responses to diurnal changes in forage composition. The challenge seemed obvious and the potential impact seemed great; so, we decided to test ruminant animals' ability to differentiate between hays harvested in afternoon and subsequent morning. We completed several studies and will share some exciting results with you. Animals demonstrated strong preference for afternoon-harvested compared to morning-harvested forage. This led to questions concerning 1) animal preferences among other forage types and cultivars, 2) more detailed characterization of diurnal changes occurring in forages, 3) effects on energy and crude protein digestibility, and 4) effects on animal production?

Could ruminants distinguish between evening- and morning-cut hay and did this occur over a range of conditions? If they could, then we needed to know what was going on in the plant. We would then need to determine management strategies to take advantage of possible benefits. We first discuss the animal studies and then close with plant studies.

PM vs. AM-Harvesting Effects on Animal Performance:

Twice in August and once in September 1996, vegetative HiMag tall fescue grown near Kimberly, Idaho; was cut at sundown (PM) and paired with another cut the next morning at sunup (AM). These six hays were pair fed in all combinations to six steers, six sheep, and six goats at Raleigh, NC. Dry matter intake by each group of animals and supporting laboratory data confirmed that animals had a strong preference for PM-harvested grass hay (Fisher et al., 1999). Preference was strongly associated with increased concentration of total nonstructural carbohydrate (TNC) in PM-harvest grass forage.

During 1997, alfalfa was cut at sundown (PM) and sunup (AM) from an eleven acre, irrigated field near Kimberly, Idaho. Hay was field dried, baled, covered and transported to Raleigh, NC where second, third, and fourth harvests were fed to cattle, sheep, and goats. Animals showed a strong preference for PM-harvested vs. AM-harvested alfalfa (Fisher et al., 'a', in preparation). Preference was strongly associated with increased concentration of TNC and decreased fiber components in PM-harvested alfalfa (Mayland and Shewmaker, 1999).

The 1997-harvested alfalfa was also offered to steers in an intake and digestibility study. Results of this study should tell us if continued intake of PM-harvested alfalfa is the same as that of AM-harvested alfalfa (Burns et al., 'c' in preparation). We also hope to obtain information on dry matter digestibility of PM- vs AM-harvested hay. We have studied animal preference responses during testing of PM- vs AM-harvested alfalfa. It appears that some animals, as they walk up to the tubs containing test hays, can identify the PM- from AM-harvested hay by aroma (Mayland et al., 1997, Mayland et al. 'a'). After the feeding trial, volatiles were collected from each of the six hays. The GC-MS data are still being scrutinized, but the same profile of compounds appear in all hays, but those from the PM-harvested may have a greater intensity (Roitman, et al., personal communication 2000).

During 1997 we became aware of a lactation study completed at Utah State University (Kim, 1995 and Kim et al., 'a'). In his dissertation chapter, Kim found that dairy cows ate **8% more** of a total mixed ration (TMR) containing 40% afternoon-cut alfalfa hay than the TMR containing morning-cut alfalfa hay and **produced 8 % more milk**. Adjusting schedules to cut hay in afternoon and early evening can increase feed value of hay by 15%. This practice can be adopted without any additional investment.

During 1998 and 1999, switchgrass was cut at sundown (PM) and sunup (AM) from fields at Raleigh, field cured, stored under cover, and offered to cattle, sheep, and goats in a preference study. Switchgrass is a C-4 plant in which the amplitude of TNC concentration with time is much subdued from that of C-3 tall fescue and alfalfa. As anticipated, animal preference results were mixed (Fisher et al., 'b').

Greenchop is a process where forage is cut in morning, wilted, chopped into a feed wagon later in the afternoon, and fed in the evening and the next morning. Dr. Greg Ledbetter, DVM, Jerome, Idaho, owner/manager of the 1000 hd milking herd, had followed this practice in the past and fed greenchop for about five to six months in summer. In early 1999, Greg, forage producer Ralph May, and forage testing lab manager Dr. Bob Whitchurch were introduced to the benefits of PM harvesting. During 1999, Ledbetter converted the forage harvesting operation entirely to afternoon swathing followed by chopping next afternoon. This worked for about 95% of his green chopped forage harvested during 1999 and he is very happy with the results (Neal Martin and Hank Mayland, personal communication, Nov 99).

In southwestern United Kingdom, Orr et al. (1997) reported that grazing animals ate more grass and clover in afternoon than morning and related that to increases in soluble carbohydrates. They later reported that dairy cows foraging pastures under 24-h strip grazing management produced 8% more milk when the fence was moved at 4 pm vs 6 am (Orr et al., 1998). This response may occur because when the fence is moved in AM, animals are subsequently cropping leaves of plants that are beginning to accumulate sugars via photosynthesis. When the fence is moved in PM, animals are eating plants that accumulated sugars throughout the day. At night, these accumulated sugars are moving to growing points and down the stem to roots. The net result is that more TNC's are available for animal ingestion when the fence is moved in evening rather than morning. This management practice also takes advantage of the longest natural grazing period that occurs during afternoon and evening. The natural occurrence of this grazing period may be a behavioral response to increased sugars in afternoon forage.

PM vs. AM-Harvesting Effects on Plant Composition

When making silage from alfalfa or clover hay, one can enhance the fermentation process by cutting the hay in afternoon compared to cutting in morning (Owens, 1996).

Learning about benefits of PM-harvesting, Dr. Raymond Ward, President of Ward Labs, Kearney Nebraska, had his staff sample some alfalfa in late afternoon and next morning. They found that early-evening cut hay had a Relative Feed Value (RFV) 10% greater than hay cut in morning (WARDletter, XIV (3) 1998).

Potential economic value of PM vs AM-harvesting was presented to the California/Nevada Alfalfa Growers in their December 1998 meeting (Mayland et al., 1998b and Putnam et al., 1998). An update was presented at their December 1999 meeting. A mini-questionnaire was distributed to one group of 1999-meeting participants asking about their familiarity and adoption of afternoon harvesting strategies. The 1999 response of 50 alfalfa growers (representing 80,000 acres) from California and five other states indicated that 94 % were aware of afternoon harvest benefits to forage quality, 58% had cut during PM in 1999, and 80 % were planning to cut during PM in 2000. This represented 58 % of acreage in 1999 and 86 % in 2000 (Mayland and Shewmaker, unpublished).

Shewmaker and Mayland (1999a) reported that TNC concentration curves were sinusoidal from sunup to sundown, but increased linearly at least during the 0900 to 2000 MDT period. During May, TNC's increased at 2.9 g TNC/ kg × h (r^2 = 0.90) dry weight and during September, TNC's increased at 4.6 g TNC/ kg × h (r^2 = 0.88). Shewmaker et al. (1999b) recommended when determining animal grazing response or sugar level in forage that samples be taken within 1 h to control daily variation within 5 %. Similar recommendations were made for tall fescue grass (Shewmaker et al., 'c' in review).

Conclusions

Many questions are yet to be researched. However, the bottom line is that cutting forage in late afternoon and early evening produces higher valued forage. Ruminants will recognize the afternoon cut hay and dairy cows will eat more of the late afternoon-harvested forage and produce more milk. Differences in PM- and AM-harvested hay is indicated by dilution of ADF and NDF values by presence of sugars. However, the size of the error term associated with ADF and NDF measurements causes us to look for more appropriate forage-sugar methodology.

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