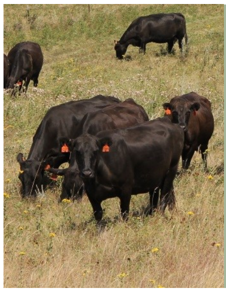

Comparison of Forage Sampling Strategies to Monitor Native Range Pasture Chemical Composition, Forage Intake and Digestibility During the Grazing Season

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Pasture forage sampling normally is accomplished by hand clipping. This two-year study compares hand clipping and rumen evacuation as forage sampling strategies to monitor changes in pasture chemical composition, forage intake and digestibility during the grazing season. Sampling strategy had the biggest impact on forage crude protein (CP) content and in vitro dry-matter digestibility (IVDMD), which were greater in samples collected through rumen evacuation. However, positive linear relationships between hand clipped and masticate samples suggest that hand clipping provides reasonable estimates of pasture forage quality during the grazing season. Rumen evacuation may be a more suitable sampling strategy when a wide range of pasture conditions are anticipated.

Summary

Hand clipping and rumen evacuation were compared as pasture forage sampling strategies to monitor changes in native range pasture chemical composition, forage intake and digestibility during the grazing season. Forage samples were collected by hand clipping or rumen evacuation in four periods in the first year and one period in the second year. Rumen evacuations were conducted with ruminal cannulated Angus heifers (n = 8, body weight [BW] = 597 ± 64 kilograms [kg], year one; n = 9, BW = 602 ± 76 kg, year two) that were kept in continuously-grazed pastures. Hand clipped and masticate samples were collected on the same day. Forage CP content was greater ($P \leq 0.05$; 11.7 vs. 7.6 ± 0.44 percent) in masticate samples relative to clipped samples. Forage CP content declined ($P \leq 0.05$) with advancing season. Regression analysis showed a significant linear relationship ($r^2 = 0.61$; $P \leq 0.05$) in CP content from the two sampling strategies.

Forage neutral detergent fiber (NDF) and acid detergent fiber (ADF) content were not influenced ($P > 0.05$) by sampling strategy and increased linearly ($P \leq 0.05$) with advancing season. Masticate samples had greater ($P \leq 0.05$) acid detergent lignin (ADL) content relative to hand clipped samples (6.3 vs. 5.5 ± 0.16%) and ADL contents from sampling strategies were correlated ($r = 0.72$; $P \leq 0.05$).

In vitro dry-matter digestibility (DMD) was greater ($P \leq 0.05$) in masticate samples relative to hand clipped samples and decreased linearly ($P \leq 0.05$) with advancing season. Dry-matter intake estimated from masticate samples had a greater range (4.1 - 14.3 vs. 4.9 - 8.1 kg/day) and variability (CV; 37.7 vs. 13.2 percent) relative to estimates from hand clipped samples.

Sampling strategy by period interaction ($P \leq 0.05$) in dry-matter intake (DMI) showed that decline in DMI with advancing season was more pronounced in masticate samples relative to hand-clipped samples. Although sampling strategy had the biggest impact on forage CP content and IVDMD, hand clipping can provide useful estimates of pasture forage quality and nutrient changes during the grazing season, provided differences in forage chemical composition and IVDMD are considered. Sampling strategy should be taken into account when evaluating pasture quality.

Introduction

Beef producers in North Dakota depend largely on mixed-grass prairie as the primary forage source for cattle throughout much of the year (Johnson et al., 1998). Pasture productivity of mixed-grass prairie, measured by changes in crude protein content, fiber content and forage digestibility, declines with advancing season (Johnson et al., 1998; Cline et al., 2009; Cline et al,. 2010), the rate of decline depending on time of the year, forage species and environmental conditions (McDowell, 1996). Thus, pasture productivity should be monitored periodically so that decisions for optimal pasture use and cattle management are based on accurate information. In many cases, evaluation of pasture productivity is hindered by the inability to collect a representative sample mainly due to diverse plant communities and the rugged terrain of grazing lands (Holechek et al., 1982).

Pasture forage samples can be collected through several methods. Esophageal fistulation has been evaluated in several studies

Western snowberry (*Symphoricarpos occidentalis* Hook) in a masticate sample following rumen evacuation.

Bryan Neville, NDSU

(Rama Rao et al., 1973; Vavra et al., 1978; Coffey et al., 1991; Olson, 1991) and provides the most representative sample of forage consumed by grazing animals (Holechek et al., 1982). Although sample collection through esophageal fistulation requires less labor, compared with other methods, esophageal fistulated cattle are expensive and difficult to maintain (Coffey et al., 1991).

Pasture sampling through rumen evacuation also has been used to obtain representative pasture samples (Olson, 1991; Hughes et al., 2010). Compared with esophageal fistulation, rumen fistulated animals are easier to maintain and representative samples can be collected during longer collection periods (Olson, 1991). A major limitation of rumen evacuation includes time and labor to evacuate and clean the rumen, as well as depressed digestibility if evacuations are repeated frequently (Olson, 1991).

Nutritional management decisions for cattle often are based on pasture productivity estimated from hand-clipped forage samples (Hughes et al., 2010). Unlike sampling through esophageal fistulation or rumen evacuation, hand clipping requires less equipment and time and also produces sample free of salivary contamination (Holechek et al., 1982). However, hand clipping may misrepresent forage consumed because this strategy does not take into account diet selection (Holechek et al., 1982).

Despite these setbacks, clipping likely will remain the most practical strategy for pasture sampling. This study was conducted to compare hand clipping and rumen evacuation as sampling strategies for monitoring seasonal variation in forage intake, digestibility and forage chemical composition of mixed-grass prairie pastures.

Procedures

This two-year study was conducted at the North Dakota State University Central Grasslands Research Extension Center near Streeter, N.D. Animal handling and care procedures in this study were approved by the North Dakota State University Animal Care and Use Committee. The study was conducted with ruminal cannulated Angus heifers (n = 8, BW = 597 ± 64 kg, year one; n = 9, BW = 652 ± 91 kg, year two) that were kept in continuously grazed pastures and were co-grazed with cow-calf pairs (year one) and heifers (year two).

The grazing season was divided into four collection periods corresponding to May, June, July and August in the first year. Logistics resulted in late pasture turnout in the second year (2018), resulting in sample collection in July and August. Hand-clipped samples were collected by walking diagonally across pastures and hand clipping forage from 20 different locations in the pasture. The samples were clipped to a height of 3.75 centimeters (cm) above ground. Masticate samples were collected through a rumen evacuation technique described by Cline et al. (2010).

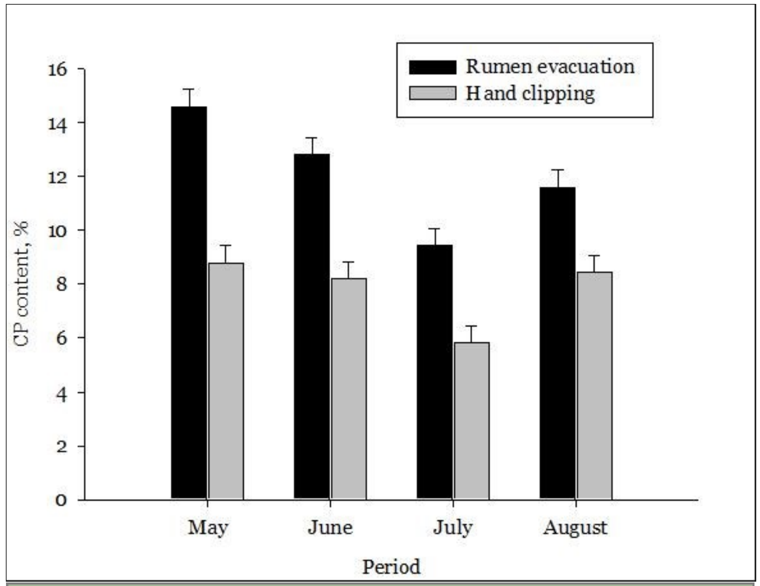

Figure 1. Change in forage CP content with advancing season estimated from forage samples collected by hand clipping or rumen evacuation.

Results

The effect of sampling strategy on pasture forage nutrients, intake and IVDMD in year one is shown in Table 1. Masticate samples had greater ($P \leq 0.05$) CP content relative to hand-clipped samples. As well, forage CP content declined quadratically ($P \leq 0.05$) with advancing season (Table 1; see next page). The tendency toward a sampling strategy by period interaction ($P = 0.09$) suggests that the magnitude of change in CP content with advancing season depended on sampling strategy (Figure 1).

Forage NDF and ADF content were not influenced ($P > 0.05$) by sampling strategy but increased linearly ($P \leq 0.05$) with advancing season (Table 1). Hand-clipped samples had lower ($P \leq 0.05$)

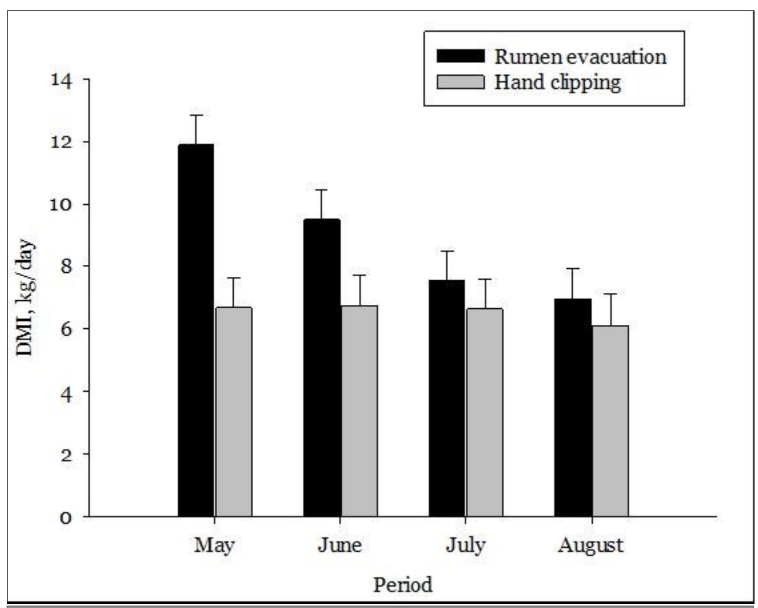

Figure 2. Change in DMI with advancing season estimated from forage samples collected by hand clipping or rumen evacuation.

Table 1. Pasture chemical composition, intake and digestibility estimated from forage samples collected by hand clipping or rumen evacuation (year 1).

	Strategy (S)[1]			Period (P)[2]					P-value			Period effect[3]	
Item	HC	RE	SE	E-Jun	L-Jun	E-Aug	L-Aug	SE	S	P	S x P	L	Q
CP, %	7.8[b]	12.1[a]	0.32	11.7[a]	10.5[a]	7.6[b]	10.0[a]	0.46	<0.001	<0.001	0.089	0.008	<0.001
NDF, %	66.2	65.3	1.06	63.8[b]	61.8[b]	67.9[a]	69.7[a]	1.50	0.412	0.003	0.237	0.004	0.115
ADF, %	37.5	36.2	0.69	35.8[b]	34.5[b]	38.2[a]	39.1[a]	0.98	0.087	0.005	0.624	0.010	0.155
ADL, %	5.6[b]	6.4[a]	0.16	5.7[b]	5.1[c]	6.4[a]	6.6[a]	0.23	0.002	0.001	0.221	0.006	0.048
IVDMD, %	59.9[b]	61.4[a]	0.79	65.1[a]	64.5[a]	54.5[b]	56.6[b]	1.11	0.015	<0.001	0.091	<0.001	0.1333
DMI, kg/d	6.6[b]	8.9[a]	1.02	9.3[a]	8.1[ab]	7.1[bc]	6.5[c]	0.51	0.027	<0.001	<0.001	<0.001	0.406

[1]Sampling strategies were hand clipping (HC) and rumen evacuation (RE).

[2]Periods were early June (June 7), late June (June 27), early August (Aug. 2) and late August (Aug. 30).

[3]Linear (L) and quadratic (Q) orthogonal polynomial contrasts.

[a – c] Means within sampling strategy and within period with a different letter differ ($P \leq 0.05$).

Table 2. Pasture chemical composition and digestibility estimated from forage samples collected by hand clipping or rumen evacuation (year 2).				
	Strategy[1]			
Item	HC	RE	SE	P-value
CP, %	6.9[b]	10.1[a]	0.48	0.023
NDF, %	63.0	68.3	3.35	0.253
ADF, %	33.8	35.6	2.61	0.577
ADL, %	5.2	5.9	0.55	0.329
IVDMD, %	51.1	52.4	5.31	0.896

[1]Sampling strategies were hand clipping (HC) and rumen evacuation (RE).

[a – b] Means within sampling strategy with a different letter differ ($P \leq 0.05$).

ADL content relative to masticate samples (Table 1). Also, forage ADL content increased linearly ($P \leq 0.05$) with advancing season.

In vitro DMD was greater ($P \leq 0.05$) in masticate samples relative to hand-clipped samples. In vitro DMD decreased linearly ($P \leq 0.05$) with advancing season (Table 1) but the rate of decline tended ($P = 0.09$) to depend on sampling strategy. The sampling strategy by period interaction ($P \leq 0.05$) in DMI shows that the linear decline in DMI with advancing season was more pronounced in masticate samples relative to hand-clipped samples (Figure 2).

Late pasture turnout in the second year limited sampling to only one period (Table 2). Masticate samples had greater ($P \leq 0.05$) CP content relative to hand-clipped samples. We found no differences ($P > 0.05$) in NDF, ADF and ADL content, as well as IVDMD, between masticate and hand-clipped samples.

When year one and two samples were pooled, forage CP content of masticate forage samples ranged from 8.6 to 15.1 percent, with a mean CP content of 11.7 percent, which was greater ($P \leq 0.05$) than the CP content of hand-clipped samples (Table 3; see next page). Forage CP content resulting from the two sampling strategies were highly correlated ($r = 0.81$; $P \leq 0.05$), and regression analysis showed a significant linear relationship ($r^2 = 0.61$; $P \leq 0.05$) between masticate and hand-clipped samples.

Pooled masticate and hand-clipped samples had similar ($P > 0.05$) forage NDF and ADF content (Table 3). Pooled masticate samples had greater ($P \leq 0.05$) ADL content relative to hand-clipped samples (Table 3), but ADL content were correlated ($r = 0.72$; $P \leq 0.05$; Table 3).

In vitro DMD of masticate and clipped samples were highly correlated ($r = 0.91$; $P < 0.005$; Table 3), and regression analysis showed a significant linear relationship ($r^2 = 0.81$; $P \leq 0.05$) between the two sampling strategies. Dry-matter intake estimated from masticate samples had a greater range relative to estimates from hand-clipped samples (Table 3). As well, DMI estimates from masticate samples were more variable as indicated by relatively greater CV. Dry-matter intakes estimated from the two sampling strategies were not correlated (Table 3).

Discussion

Nutritional management decisions for cattle often are based on pasture productivity estimated from hand-clipped forage samples (Rama Rao et al., 1973; Dubbs et al., 2003; Hughes et al., 2010). This study compared rumen evacuation and hand clipping as sampling strategies to monitor seasonal nutritional quality changes of mixed-prairie pasture.

In this study, hand clipping followed normal practice as would be practiced by grazers, with no attempt to identify specific areas of the pastures where the animals were grazing. Hand clipping requires less equipment and time, and also produces samples free of salivary contamination (Holechek et al., 1982). However, hand clipping may misrepresent forage consumed because this strategy does not take into account diet selection (Holechek et al., 1982). Despite these limitations, we anticipate that hand clipping will remain a method of choice for most grazers because it does not require cannulated animals.

Pasture sampling through rumen evacuation has been used to obtain representative pasture samples (Olson, 1991; Hughes et al., 2010) since samples collected represent forage consumed by animals. Rumen evacuation requires cannulated animals, and the process of collecting masticate samples can be labor-intensive (Olson, 1991). In the present study, four individuals took at least six hours to collect masticate samples from nine cannulated heifers during each sampling cycle.

Forage CP content declined with advancing season as previously reported in the northern Great Plains (Johnson et al., 1998; Cline et al., 2009; Cline et al., 2010). The difference between sampling strategies was in magnitude of change in CP content (Figure 3). Forage CP content was 54 percent greater in masticate samples relative to clipped samples.

Table 3. Pooled[1] data comparing forage sampling strategies to estimate pasture chemical composition, dry-matter intake and digestibility.

	Sampling strategy	Statistics					Correlation	
Item		T-test	SD	CV	Min.	Max.	HC[2]	RE[2]
CP, %	Rumen evacuation	11.7[a]	2.18	18.86	8.6	15.1	0.81**[3]	-
	Hand clipping	7.6[b]	1.24	16.18	5.8	9.2	-	0.81**
	SE	0.44						
NDF, %	Rumen evacuation	65.9	4.58	6.95	58.0	72.2	0.44NS	-
	Hand clipping	65.6	2.98	4.55	60.6	70.1	-	0.44NS
	SE	1.34						
ADF, %	Rumen evacuation	36.1	2.39	6.63	32.2	38.6	0.56NS	-
	Hand clipping	36.8	2.54	6.91	32.6	40.9	-	0.56NS
	SE	0.73						
ADL, %	Rumen evacuation	6.3[a]	0.64	10.22	5.3	7.0	0.72*	-
	Hand clipping	5.5[b]	0.70	12.81	4.7	6.5	-	0.72*
	SE	0.16						
IVDMD, %	Rumen evacuation	59.5[a]	6.44	10.83	48.8	67.2	0.91**	-
	Hand clipping	57.3[b]	6.00	10.46	46.7	64.5	-	0.91**
	SE	0.84						
DMI, kg/day	Rumen evacuation	7.4[a]	2.49	37.91	4.1	14.3	0.23NS	-
	Hand clipping	6.6[b]	1.14	13.17	4.9	9.7	-	0.23NS
	SE	0.39						

[1]Pooled year one and two data (n= 10) except DMI (n = 16).

[2]Sampling strategies were hand clipping (HC) and rumen evacuation (RE).

[3]*P ≤ 0.05; **P ≤ 0.005; NS, P ≥ 0.05.

[a - b] Means in within t-test and within item followed by a different letter differ (P ≤ 0.05).

Studies that have reported greater CP content in esophageal collected (Rama Rao et al., 1973; Coffey et al., 1991) or masticate samples (Dubbs et al., 2003; Hughes et al., 2010) relative to clipped samples attributed the lower CP content in clipped samples to failure of clipped samples to mimic grazing by not accounting for animal selection.

Coupled with a greater CP content range of masticate samples (8.6 - 15.1 percent), results from this study suggest that grazing cattle have the ability to select forage with higher CP content and will likely select forage with greater CP forages, even when forage quality is declining. This likely would occur only in cases where forage availability is not a limiting factor. A significant correlation between masticate and clipped CP values suggests that, despite limitations of clipping, this strategy still has value and can be used in situations where masticate samples cannot be obtained.

Contrary to studies that have reported greater NDF and ADF content in clipped samples relative to masticate (Dubbs et al., 2003; Hughes et al., 2010) samples, NDF and ADF contents of masticate and clipped samples in this study were similar. Differences between this and others studies could be due to clip sampling location where samples were collected in the same location as grazing animals or across pastures.

Forage NDF and ADF content increased with advancing grazing season, which previously has been reported in the northern Great Plains (Johnson et al., 1998; Cline et al., 2009; Cline et al., 2010) and reflects the association of advancing forage maturity with increased cell wall constituents (Van Soest, 1982).

Forage ADL content increased with advancing season mainly due to advancing forage maturity, which is associated with increased cell wall constituents including lignin (Van Soest, 1982). The lower ADL content in clipped relative to masticate samples was unexpected and contrary to studies (Rama Rao et al., 1973; Coffey et al., 1991) that have shown greater ADL content in clipped samples.

In vitro DMD of masticate samples was greater than IVDMD from clipped samples and the two sampling strategies were highly correlated. A similar trend was reported in bahiagrass pastures where in vitro digestible organic matter (OM) of masticate samples were greater (60 percent) than hand-clipped samples (48.7 percent; Hughes et al., 2010). Decline in IVDMD with advancing grazing season also has been reported in other studies in the northern Great Plains (Johnson et al., 1998; Cline et al., 2009; Cline et al., 2010).

Typically, nutrition of ruminants grazing rangelands is complicated by diverse plant communities, changing topography and large seasonal and yearly variations in quantity and quality of available forage (Wofford et al., 1985). Precise estimation of forage intake by cattle on pasture depends on accurate determination of consumed forage components because chemical composition of consumed forage may differ from that of available forage resulting from animal selectivity and other processes involved with ingestion and mastication (Coffey et al., 1991). This is why determining a sampling strategy that provides a reliable estimate of consumed forage is important.

Forage samples for intake estimation can be obtained by following grazing animals for short durations and sampling grazed area (Wilson et al., 2010) or through rumen evacuation (Cline et al., 2010). A comparison of the two sampling strategies in this study shows that dry-matter intakes estimated from masticate samples were greater than estimates from hand clipped samples.

As well, masticate samples showed a greater DMI range and variability relative to clipped samples, indicating the ability of rumen evacuation to capture animal differences. Clearly, forage sampling strategy during individual animal DMI estimation on pasture will have an impact on intake estimations, and use of cannulated animals for forage sampling will provide more realistic DMI estimations.

This study suggests that hand clipping can provide reasonable estimates of pasture forage quality during the grazing season, provided you account for differences in CP, ADF content and IVDMD. Further, hand clipping can be a useful strategy in simple swards while rumen evacuation may be more suitable when a wide range of pasture conditions are anticipated.

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