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Technical Note

Comparison of Bite-Count and Rumen Evacuation Techniques to Estimate Cattle Diet Quality

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Abstract

We conducted a study to compare the bite-count technique (BC) of estimating forage intake and synthesized diet quality to direct estimates of diet quantity and quality with the use of the rumen evacuation technique (RE). We used four rumen-fistulated steers to evaluate both techniques. Four enclosures in a mixed-conifer rangeland were used. Each enclosure contained two 0.25-ha paddocks that were either nonstocked or stocked by cattle to remove 32 ± 4% of standing crop. We recorded bite-count data during foraging bouts for each steer in each paddock, and then evacuated each rumen following each foraging bout during summer (August). Paddocks stocked prior to each 20-min trial had a reduced ($P < 0.05$) quantity of forage consumed regardless of technique. BC and RE gave similar ($P > 0.10$) results on diet quantity and digestibility. However, BC-derived estimates were lower ($P < 0.05$) for crude protein (CP), acid detergent fiber (ADF), ash, and neutral detergent fiber (NDF). In summary, although BC has the advantage of not requiring rumen-fistulated animals, it did not yield comparable results to RE under range conditions with dense and diverse vegetation. Therefore, investigators should calibrate bite-count technique against fistula technique to solve any accuracy problem in their specific experimental conditions whenever possible.

Key Words: diet sampling, diet selection, foraging trials, free-ranging animals, mixed-conifer rangeland

INTRODUCTION

Quantity and quality of grazed forage has been an area of interest and challenge to nutritionists and resource managers. Widely used techniques to evaluate diet quality (DQ) of free-ranging animals' diets have included the use of rumen fistulated animals, and bite-count (BC) techniques. Each technique has its own particular merits and disadvantages. The rumen evacuation (RE) technique (Lesperance et al. 1960) is a widely accepted technique to evaluate quality of range animals' diets (Holechek et al. 1982; Olson 1991; Ganskopp and Bohnert 2006). In addition, RE is useful for the collection of other data, including rumen fermentation characteristics and kinetics (Olson 1991; Ganskopp and Bohnert 2006).

The BC technique can be used as an alternative to RE when investigating diet selection, diet intake, and diet quality. Specifically, researchers (Wickstrom et al. 1984; Wallis De Vries 1995) pointed out that this technique is feasible to investigate diets of free-ranging or wild ungulates, including rare/endangered species. The bite-count technique has been used for estimating diets of deer (Parker et al. 1993) and elk (Wickstrom et al. 1984), as well as cattle (Wallis De Vries 1995). However, Ortega et al. (1995) reported that in diverse vegetation types such as those found in the Texas Coastal Bend, the BC technique was not as accurate to ascertain diets. Sanders et al. (1980) found that BC gave similar results for estimating major components of cattle diets in north-central Texas; however, BC was not an appropriate technique on large, brush-infested pastures with rough terrain. Thus, previous studies demonstrated that the accuracy of the bite-count technique is variable from region to region and may vary within a region depending on vegetation diversity and availability. The BC technique can be evaluated by RE.

The objective of this study was to compare BC for estimating diet quantity and quality to RE for deriving forage intake and diet quality in diverse mixed-conifer rangelands with and without prior foraging.

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MATERIALS AND METHODS

Study Site and Stocking Treatment

The study was conducted on the Starkey Experimental Forest and Range, located in the Wallowa-Whitman National Forest of the Blue Mountains (lat 45°15′N, long 118°25′W) in eastern Oregon. Four separate enclosures (elevation ranged from 1 120 to 1 500 m) were placed in previously logged (15–20 yr postharvest) grand fir (*Abies grandis* Lindl.) or mixed-conifer rangelands. Each enclosure was divided into two 0.25-ha paddocks. Paddocks were randomly assigned as either non-stocked or stocked. In paddocks to be stocked, 20 plots (caged) were protected with wire cages (1×1 m) before stocking. Stocked paddocks were foraged by cattle in mid-June and mid-July to remove approximately 40% of standing crop, which is

typical grazing practice of forested rangeland in northeast Oregon (DelCurto et al., 2005). Then, immediately after the stocking treatment and prior to foraging bout trials, 20 paired plots (0.25 m^2) per paddock were clipped to ground level. All herbage (standing crop) was separated by botanical species and oven dried at 50°C, then weighed to quantify standing crop. Total standing crop of each plot was determined by summing the aboveground biomass of all species removed from each plot and was expressed in $kg \cdot ha^{-1}$. The difference between the caged and stocked plots represented total forage utilization (Cook and Stubbendieck 1986).

Foraging Bout Trials

Foraging bouts were conducted in August. Four rumen-fistulated and 29–30-mo-old crossbred steers (same steers used for the pretrial stocking treatments for acclimation in paddock) with an average body weight (BW) of 454 ± 13 kg were used in trials. We measured diet quantity and quality with the use of a BC as described by Wickstrom et al. (1984). Foraging bouts were conducted two steers at a time per paddock with one technician assigned to each steer. Two rumen-fistulated steers were selected at random from morning (0800–1200 hr) or afternoon (1300–1600 hr) foraging bouts, which yielded a total of 36 foraging-bout trials for all experiments. Food was not offered to steers in the morning or between foraging bouts to ensure reasonable and similar appetites each day. Water was provided ad libitum except during foraging trials. Prior to bouts, steers were restrained and subjected to total ruminal evacuation as described by Lesperance et al. (1960). Rumen contents were removed from each animal and stored in 170-L tub for later replacement after foraging bouts. Each animals's ruminal wall was washed with a sponge to remove remaining digesta and ruminal fluid. During each foraging bout, steers were allowed to roam free in one of the paddocks for 20 min while two investigators followed the steers and counted bites by forage species and recorded the data on portable voice recorders. At the end of each bout, the entire ruminal masticate was collected and the steer was immediately taken to the alternate paddock, where the second trial was completed. The rumen masticates were then placed on aluminum trays, dried at 50°C to a constant mass over 7 d in a forced-air oven, weighed, and subsampled for further analysis. Values of rumen masticate subsequently were converted to units of weight for presentation purposes (RE dry matter intake, $g \cdot min^{-1}$). RE bite size (BS) was estimated by dividing ruminal masticate to corresponding bites counted during trial.

Forages selected by steers during the trial were collected simultaneously by hand clipping (Cook and Stubbendieck 1986) and plucking (Wallis De Vries 1995). We collected about 200 simulated bites of each forage species per paddock. Shrubs were hand plucked by plucking samples between the thumb and a backward-bent forefinger.

Samples were dried in a forced-air oven at 50°C and weighed. Steer simulated BC size from each forage species was calculated by dividing simulated weight of samples by total simulated bite number. Steer BC-derived nutrient quantity (NI) from consumed diet (either crude protein [CP], acid detergent fiber [ADF], neutral detergent fiber [NDF], or organic matter digestibility [IVOMD]) was calculated as

$$\mathrm{NI}(g \cdot \mathrm{min}^{-1}) = \sum \mathrm{N}_i \mathrm{BS}_i (\mathrm{FQ}_i/100). \quad (1)$$

Steer BC-derived diet quality (DQ) (either BC-CP, BC-ADF, BC-NDF, or BC-IVOMD) was calculated as

$$\mathrm{DQ}(\%) = \left(\sum \mathrm{N}_i \mathrm{BS}_i (\mathrm{FQ}_i/100) / \sum \mathrm{N}_i \mathrm{BS}_i\right) 100, \quad (2)$$

where N_i is the number of bites of each forage species counted during foraging trial ($n \cdot min^{-1}$), BS_i=simulated bite size of each forage species i (g, OM), and FQ_i=nutrient composition (analyzed) of each forage species i (%, OM).

Diet Quality Assays

After being ground through a 1-mm screen (Wiley Mill, Model 4, Arthur H. Tomas Co., Philadelphia, PA, USA), the masticate and forage samples were analyzed according to Association of Official Analytical Chemists (AOAC, 1990) for DM (AOAC method 930.15); ash (AOAC method 942.05) and CP (AOAC method 984.13) content was determined by the Kjeldahl procedure with the use of a Kjeltec Auto System (Kjeltec Auto System, Büchi, Flawil, Switzerland). ADF and NDF with heat-stable α-amylase were analyzed according to the procedures of Van Soest et al. (1991) with the use of an ANKOM Fiber Analyzer (ANKOM Technology Corporation, Fairport, NY). OM digestibility was determined with the use of a Daisy^{II} incubator (ANKOM Technology Corporation, Fairport, NY) as described by Damiran et al. (2008). Analyses were conducted with two replicates and acceptable coefficients of variation of analyses' means were < 0.5, < 2.0, < 3.0, < 3.0, and $< 4.9\%$ for DM, CP, ADF, NDF, and IVOMD, respectively. Chemical content and digestibility was determined on an OM basis.

Statistical Analyses

Standing crop, as well as standing crop summed by growth form, was analyzed with the use of the MIXED procedure in SAS (SAS, 2002) with the block (four replicated enclosures) effect considered random. Diet quantity and quality data were analyzed as a split plot. Stocking treatment was treated as the whole plot with research technique as the subplot. Statistical significance in analyses was assumed at $P < 0.10$, and mean separations were accomplished with the use of the LSD procedure of SAS (SAS, 2002).

RESULTS

Standing Crop and Forage Utilization on Study Site

Standing crop in nonstocked paddocks was 1 088 ± 95 $kg \cdot ha^{-1}$ and comprised 42 ± 3% graminoids, 34 ± 3% forbs, with the remainder being shrubs (24 ± 3%) before foraging bouts. Thirteen species of graminoids contributed to the total graminoid crop, with the most prevalent species being mountain brome (*Bromus carinatus* H. & A; $\bar{x}$=159 ± 18 $kg \cdot ha^{-1}$), western fescue (*Festuca occidentalis* Walt.; $\bar{x}$=106 ± 21 $kg \cdot ha^{-1}$), elk sedge (*Carex geyeri* Boott; $\bar{x}$=70 ± 11 $kg \cdot ha^{-1}$), and pinegrass (*Calamagrostis rubescens* Buckl.; $\bar{x}$=53 ± 9 $kg \cdot ha^{-1}$). Nineteen species of forbs were

Table 1. BC simulated vs. RE-derived steer diet bite size (bite), diet quantity, and nutritive quality of forage on mixed-conifer rangelands that had previously been stocked by cattle to remove 32 ± 4% of standing crop or nonstocked.[1]

	Nonstocked		Stocked			*P* values		
Item	RE	BC	RE	BC	SEM[2]	Treat	Tech	Graze × tech
Bite (mg, DM)	661	677	615	421	123	0.27	0.49	0.42
OMI ($g \cdot min^{-1}$)	17.9	18.7	13.1	8.7	3.5	0.04	0.59	0.44
Ash (%, DM)	16.0	12.2	17.3	11.6	1.3	0.82	0.01	0.16
CP (%, OM)	9.8	6.6	10.5	8.3	0.8	0.16	0.06	0.45
ADF (%, OM)	47.2	41.5	50.0	39.3	1.3	0.75	0.01	0.02
NDF (%, OM)	70.4	66.3	66.1	57.1	2.0	0.03	0.01	0.06
IVOMD (%)	67.0	64.3	63.8	68.3	2.2	0.83	0.66	0.11

[1]BC, bite count; RE, rumen evacuation; Treat (treatment), nonstocked vs. stocked; Tech, research technique (technique), bite count vs. rumen vacuation; DM, dry matter; CP, crude protein; OM, organic matter; OMI, organic matter intake; ADF, acid detergent fiber organic matter; NDF, neutral detergent fiber; IVOMD, organic matter digestibility.
[2]Pooled standard error of LSMeans ($n=4$).

present within the enclosures. Willow-herb (*Epilobium paniculatum* Nutt.; $\bar{x}=64 \pm 13$ $kg \cdot ha^{-1}$), lupine (*Lupinus* spp.; $\bar{x}=52 \pm 16$ $kg \cdot ha^{-1}$), and western yarrow (*Achillea millefolium lanulosa* L.; $\bar{x}=38 \pm 7$ $kg \cdot ha^{-1}$) were the most common forbs. Standing crop was 927 ± 31 $kg \cdot ha^{-1}$ for stocked paddocks before foraging bouts. Graminoids, forbs, and shrubs contributed 30 ± 2%, 36 ± 3%, and 30 ± 3% to the standing crop, respectively. Utilization level in stocked paddocks was 32 ± 4%.

Quantity and Nutritive Quality of Steer Diet

Among the foraging trials, steers selected 13 graminoid, 8 forbs, and 11 shrub species. In nonstocked paddocks, steers selected mainly graminoids, whereas in previously stocked paddocks diets were more diverse. Overall, steers took more ($P < 0.01$) bites in nonstocked paddocks compared to stocked paddocks (28 ± 2 vs. 21 ± 2 bites $\cdot min^{-1}$). Furthermore, steers took more ($P < 0.01$) bites from shrubs (4 ± 1 vs. 1 ± 0 bites $\cdot min^{-1}$) and forbs (4 ± 1 vs. 2 ± 0 bites $\cdot min^{-1}$), and fewer bites from graminoids (14 ± 2 vs. 26 ± 1 bites $\cdot min^{-1}$) in stocked paddocks compared to nonstocked paddocks.

Stocking reduced ($P < 0.05$) diet quantity during the foraging trials regardless of technique used; however, BC and RE techniques gave similar ($P > 0.10$) diet quantity (Table 1). Ash content from the BC-derived diets was less ($P < 0.05$) compared to RE diets. However, previous stocking did not affect ($P > 0.10$) the ash content of steer diets. The mean CP of BC-derived diets ($8 \pm 1\%$) was lower ($P < 0.05$) compared to RE-derived diets ($10 \pm 1\%$). Steer diet CP content tended ($P < 0.2$) to be higher in stocked paddocks compared to nonstocked paddocks. Treatment × technique interaction was detected ($P < 0.05$) for diet ADF. ADF content of steer diets was higher in RE diets compared to BC-derived diets in both nonstocked and stocked paddocks with the magnitude of difference being greater in the stocked paddocks. Treatment × technique interaction also existed ($P < 0.10$) for NDF. As with ADF, the magnitude of NDF differences was greatest on stocked paddocks. Diet digestibility was not influenced by treatment or technique ($P > 0.10$). However, BC-derived estimates for IVOMD tended to be lower in nonstocked paddocks and higher in stocked paddocks as compared to RE values ($P < 0.20$).

DISCUSSION

Several possible reasons may explain the differences found between RE and BC used to estimate quantity and nutritive quality of steer diets. Sometimes the RE technique has resulted in inflated ADF and NDF, and slightly lowered IVOMD values because of soluble mineral contributions from saliva and possible absorption of soluble carbohydrates through the rumen wall (Lesperance et al. 1960; Bohman and Lesperance 1967). Salivary and bacterial contamination (Hart 1983), and direct infusion of urea from blood to the rumen (Church 1976) are also potential routes that can raise RE-CP content of masticate. However, because essentially all the rumen bacteria were removed with the rumen contents and washes prior to each foraging trial, contamination from bacteria likely had little effect in our experiment. In addition, in our trial, because collection periods were short, we speculated that the addition of nitrogen to rumen masticates or absorption through the rumen wall of soluble carbohydrates of ingesta should be slight. Our speculation is supported by work of Olson (1991), who concluded that soluble carbohydrate loss through disappearance may be minimized by using relatively short collection periods (30–45 min). Hence, in the present study, the main reason for the differences observed between the two techniques was most likely due to inaccuracies in estimating bite size and plant parts consumed by steers among the diverse species of plants, especially in the enclosures with limited forage biomass.

Forbs (1988) pointed out that in temperate grass swards, leaf surface height appears to be a dominant influence on bite size. When we simulated samples from graminoids with high sward height and/or less bulk density, we may have obtained larger bite sizes, similar to the observations of Forbs (1988) and Henley et al. (2001). Consequently, we probably collected samples with lower quality. In contrast, when forage standing crop was low we may have simulated smaller size bites compared to actual size bites taken by foraging steers. Simulating the portion of the shrub chosen by foraging steers is difficult. Steers are able to strip leaves from stems as well as browse both leaf and stem material. In addition to being tedious and time-consuming, it is difficult to simulate steer forage preference (Parker et al. 1993; Wallis De Vries 1995; Henley et al. 2001). We were able to exclude most twigs and

stems, so the majority of our simulated diets were composed of leaves. In previously stocked paddocks, which, in turn, had higher proportions of shrubs in the steer diets, BC-derived estimates of digestibility tended to be higher than diets from rumen masticate. Previous stocking causes changes in the composition of diets for subsequent foragers (DelCurto et al. 2005). Grings et al. (2001) also demonstrated that clipped samples either underestimated or overestimated diet quality in their trial, depending on season and class of fistulated animal used. The observed interaction between diet research technique and previous stocking in this study is likely related to the changes in forage availability and the nutritive variation in forage growth form (DelCurto et al. 2005).

IMPLICATIONS

Our results show that BC-derived diets do not match diets obtained with the use of rumen evacuation techniques, especially when range condition differs with respect to vegetation density and composition. On ranges with dense and diverse vegetation, the RE technique should be used when information on intake and nutritive quality of cattle diets is needed. If dietary information is to be used to rank forage species important to a herbivore, determine their seasonal diets, or assess effects of different management practices on food habits of range herbivores, either technique tested could provide reasonably accurate data. In general, our findings and our review of the literature suggested that the accuracy of bite-count technique basically depends on accurately selecting the correct species and particular plant part in the correct proportions. This requires docile animals that can be observed at close distances with a keen power of observation by the observer that only comes through experience of the observer with the ecosystem being observed. In addition, investigators should calibrate bite-count technique against fistula technique to solve any accuracy problem in their specific experimental conditions whenever possible.

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