Journal of Equine Veterinary Science 31 (2011) 640-644

Journal of Equine Veterinary Science

journal homepage: www.j-evs.com

Original Research

Nutritional Quality of Forages Consumed by Feral Horses: The Horses of Shackleford Banks

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ARTICLE INFO

Article history:
Received 03 January 2011
Received in revised form
18 April 2011
Accepted 02 May 2011
Available online 01 July 2011

Keywords:
Feral
Horse
Diet
Nutrient

ABSTRACT

This preliminary study describes the nutritional profiles of the horses of Shackleford Banks, NC. Nutrient composition of plants was analyzed during the four seasons over 2 years. Microhistological examination of the feces was used to determine the contribution of the various plant types to the horse's diet. Together, this information provided an estimate of the nutrient profile for these horses. There were significant differences in nutrient content between the main plant types analyzed, as well as differences between the seasons for several nutrients (such as crude protein [CP] and acid detergent fiber [ADF]). Grasses were the primary plant type found in the feces of the horses, although forbs were also found, particularly in the winter and spring. It is likely that plant availability and palatability affect selection because plant nutrient content did not have a significant relationship with consumption. The yearly diet had an average of 6.6% ± 1.4% CP, 0.5% ± 0.1% calcium, 0.1% ± 0.03% phosphorus, 8.3 ± 2.25 ppm copper, 23.2 ± 4.70 ppm zinc, and 1.9 ± 0.07 Mcal/kg digestive energy (DE). Thus, even at an intake of 3% of body weight, these horses are likely deficient in phosphorus, zinc, and copper several times throughout the year. Future studies should include expanded plant sampling, habitat information, additional fecal samples, and body condition scores of the horses.

1. Introduction

The feral horses of Shackleford Banks, NC, are protected by federal legislation within Cape Lookout National Seashore. They are co-managed by the National Park Service and the Foundation for Shackleford Horses, Inc. [1]. These small horses have freely roamed the 2,990-acre island for centuries; it is possible that they were introduced in the 1500s by early explorers. Visual assessment of the island's flora would suggest limited nutritive conditions for these horses, yet contraception and periodic removal of horses from the island are required to keep the population within the 110 to 130 head management range. This number limits the negative impact on the island ecology and ideally allows sufficient flora to be available for grazing. Anecdotally, however, horses have been observed with low body condition scores (3-4 on the Henneke Scale [2]) at different times of the year and occasionally foals have been born with developmental orthopedic diseases. It is therefore of interest for both wildlife managers and researchers to assess the quality of the available forage to determine the nutritional profiles of the animals.

Assessing nutritional status of wild herbivores is a challenging task [3] and care must be taken not to disturb the animals. Direct observation of grazing behavior can indicate forage selection, although accuracy largely depends on the plant knowledge of the observer and in some cases it is not possible to determine what has just been consumed [4]. However, substantial information can

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doi:10.1016/j.jevs.2011.05.012

be generated from forage analysis throughout the year because plants differ in their nutrient composition.

Microhistological fecal analysis has been used extensively to estimate the botanical composition of the diet in several feral species including horses [4-6]. This procedure identifies vegetative fragments of the feces as derived from specific plant species, generating data regarding the contribution of each plant species to the total diet. However, this method is not without its faults , because plants of higher quality are also more digestible and therefore fragments may be unidentifiable or lacking altogether [7-9]. Yet, microhistological analysis of feces continues to be regarded as an accurate method of identifying plant composition in the diet [7,10,11].

The combination of diet composition (plant selection) and nutrient content of each plant can help in estimating the nutritional profile for the animal [12]. This estimate is strengthened if dry matter intake of the forage is assessed. The National Research Council (NRC) estimates that horses at pasture consume between 1.5% and 3.1% of their body weight as dry matter intake [13]. Studies of dry matter intake in free-range animals are limited. Menard et al found daily food intakes of 144 $g_{\text{dry matter (DM)}}$/kg body weight$^{0.75}$[3], whereas Kuntz et al. reported intakes of up to 5.1% in the months of October and November in Przewalski horses (*Equus ferus przewalskii*) [14].

This preliminary study was therefore designed to determine (1) the nutrient profiles of plant types selected by the horses of Shackleford Banks across the four seasons, and (2) the contribution of different plant types to the total diet across four seasons based on limited analysis of feces using microhistological analysis. Taken together, the study aimed to obtain an estimate for the nutrient intake profile by these horses.

2. Methods

Field collections were conducted for a period of 2 years (2005 through 2007) during the four seasons: winter, spring, summer, and fall (December, March, July, and October).

2.1. Forage Nutrient Quality

Plant samples were collected from all over the island. Horses were observed to find out what they were eating and representative samples were collected using hand clippers. The project leader identified the plants being consumed and samples were grouped based on plant type. Two to nine samples of each plant type were collected and analyzed. Forage samples were submitted to a commercial forage laboratory (Cumberland Valley Analytical Services, Maugansville, MD) for analysis to determine DM, crude protein (CP), calcium (Ca), phosphorus (P), sodium, copper (Cu), zinc (Zn), acid detergent fiber (ADF), and digestive energy (DE) (DE by calculation). All values are reported as DM in the following text.

Mean (±SD) plant nutrient composition for each type and season was determined, combining both years of data. Plant types analyzed included sea oats (*Uniola paniculata*), centipede grass (*Eremochloa ophiuroides*), smooth cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*; analyzed only in summer, winter, and spring), and pennywort (*Hydrocotyle bonariensis*; analyzed only in winter). Data were analyzed to determine whether differences existed between mean nutrient composition of sea oats, centipede grass, smooth cordgrass, and saltmeadow cordgrass, and between the seasons (SAS 9.1; SAS Institute Inc., Cary, NC). Significance was accepted when P was $<.05$.

2.2. Dietary Composition

Fecal samples were collected during the second year of the study for microhistological analysis to estimate selection and proportions of plant species consumed and dietary composition. Fresh fecal samples were collected from several horses along the full length of the island. These samples were mixed to create a composite fecal sample per season to save on analysis costs. Laboratory personnel (Wildlife Habitat Nutrition Laboratory, Washington State University, Pullman, WA) prepared six representative slides from each season's sample and studied 25 views of each slide. Epidermal fragment analysis identified plant types present in the feces and representative percentages. Correlations were conducted between plant consumption proportion and nutrient composition to determine whether intake was related to plant quality (Graph Pad Prism, Graph Pad Software Inc., La Jolla, CA).

2.3. Nutritional Profiles

Data from microhistological analysis (percentage of plant type present in the feces during each of the four seasons) were weighted with nutrient data from plant types when available. When nutrient analysis was not available for a plant type present in the fecal samples, the total intake was scaled (eg, in summer, nutrient analysis was available for only approximately 74% of the total plants that were consumed). From this value, estimated nutrient intake for the total diet was determined for each of the four seasons. The nutrient intakes were compared with the NRC's Nutrient Requirements of Horses [13]. It has been estimated that the horses weigh approximately 300 kg (based on horses that have been removed from the island for adoption), and get a moderate workout (extensive daily walking on island). Dry matter intake was not assessed in the present study. Therefore, on the basis of previous work [3,14], intakes of 2%, 3%, and 5% of body weight were used to compare how the nutritional intake profile of the horses compared with nutrient requirements.

3. Results

3.1. Forage Nutritive Quality

Nutrient composition of the grasses analyzed is shown in Table 1. There were significant differences between plant types ($P < .05$) for all nutrients examined. Season significantly influenced CP ($P = .001$), ADF ($P = .01$), P ($P = .006$), and Zn ($P = .04$). There were season by plant type interactions for CP ($P = .04$) and P ($P = .005$).

Table 1
Average (±SD) nutrient composition of the five main plants analyzed across four seasons

Grass	Season	CP	ADF	Ca	P	Na	Cu	Zn	DE
		%	%	%	%	%	ppm	ppm	Mcal/kg
Sea oats	Summer (n = 8)	6.7 ± 0.76	46.9 ± 4.4	0.24 ± 0.09	0.17 ± 0.03	0.36 ± 0.10	5.5 ± 2.07	17.7 ± 4.6	1.77 ± 0.03
	Fall (n = 2)	4.6 ± 0.23	46.3 ± 0.04	0.34 ± 0.04	0.11 ± 0.01	0.14 ± 0.05	2.2 ± 2.3	11.9 ± 2.9	1.68 ± 0.01
	Winter (n = 9)	4.72 ± 1.0	48.9 ± 1.9	0.34 ± 0.08	0.10 ± 0.03	0.16 ± 0.08	4.0 ± 1.6	8.8 ± 2.7	1.70 ± 0.03
	Spring (n = 7)	4.6 ± 1.4	49.2 ± 2.3	0.34 ± 0.07	0.10 ± 0.05	0.20 ± 0.13	5.4 ± 2.6	18.9 ± 10.2	1.71 ± 0.04
Centipede	Summer (n = 5)	4.91 ± 1.1	40.7 ± 6.5	0.57 ± 0.19	0.09 ± 0.03	0.30 ± 0.15	11.4 ± 4.3	25.2 ± 5.1	1.80 ± 0.11
	Fall (n = 4)	4.6 ± 1.7	36.1 ± 2.2	0.56 ± 0.15	0.07 ± 0.03	0.16 ± 0.11	5.1 ± 1.5	28.9 ± 6.2	1.87 ± 0.08
	Winter (n = 3)	5.1 ± 1.4	42.3 ± 3.6	0.59 ± 0.32	0.08 ± 0.005	0.19 ± 0.11	15.3 ± 18.8	32.7 ± 9.3	1.75 ± 0.05
	Spring (n = 5)	5.6 ± 1.7	42.1 ± 0.97	0.47 ± 0.22	0.10 ± 0.01	0.21 ± 0.09	14.4 ± 8.7	54.6 ± 50.6	1.76 ± 0.05
Smooth cordgrass	Summer (n = 9)	11.0 ± 2.4	33.4 ± 8.1	0.54 ± 0.40	0.16 ± 0.04	2.43 ± 0.95	9.0 ± 4.1	18.9 ± 7.1	2.22 ± 0.30
	Fall (n = 3)	9.5 ± 0.79	23.1 ± 1.8	1.1 ± 0.20	0.13 ± 0.03	2.75 ± 0.34	17.5 ± 12.4	32.2 ± 8.1	2.59 ± 0.13
	Winter (n = 2)	8.3 ± 0.27	28.4 ± 5.5	0.90 ± 0.04	0.11 ± 0.03	4.6 ± 0.91	15.0 ± 14.1	22.0 ± 8.5	2.29 ± 0.26
	Spring (n = 3)	13.5 ± 4.5	33.3 ± 10.3	0.63 ± 0.32	0.22 ± 0.08	3.00 ± 0.86	10.7 ± 4.16	38.0 ± 16.5	2.32 ± 0.45
Saltmeadow cordgrass	Summer (n = 7)	7.3 ± 1.16	41.3 ± 3.6	0.50 ± 0.41	0.09 ± 0.02	1.04 ± 0.74	9.3 ± 7.7	22.7 ± 10.6	1.84 ± 0.08
	Fall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Winter (n = 6)	4.5 ± 1.4	48.4 ± 2.6	0.39 ± 0.35	0.055 ± 0.025	0.27 ± 0.15	8.3 ± 8.2	22.5 ± 11.1	1.67 ± 0.05
	Spring (n = 5)	6.9 ± 2.4	44.8 ± 2.2	0.31 ± 0.06	0.14 ± 0.07	0.25 ± 0.21	8.0 ± 2.9	23.6 ± 10.5	1.77 ± 0.10
Pennywort	Summer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Winter (n = 1)	7.35	59.5	2.1	0.19	0.70	15.0	21.0	1.88
	Spring	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

CP, crude protein; ADF, acid detergent fiber; Ca, calcium; P, phosphorus; Na, sodium; Cu, copper; Zn, zinc; DE, digestive energy; N/A, nonapplicable.

3.2. Dietary Composition

In the fall, sea oats, centipede, and smooth cordgrass made up 78% of the horse's diet (Table 2). In the winter, consumption of sea oats decreased by half, whereas the variety of plants consumed increased. In the spring, centipede consumption dropped in favor of increased sea oats, smooth cordgrass, and pennywort. In the summer, sea oats, smooth cordgrass, and centipede made up 64.3% of the horse's diet, with other plants making up the difference. Grasses made up a majority of the forages consumed in all seasons, with increased amounts of forbs consumed in the winter and spring. There was no relationship, however, between plant nutrient content and plant selection ($P > .1$).

Table 2
Percentages of plant types present in feces over four seasons, estimating consumption of the different plants

Plant	Summer	Fall	Winter	Spring
Grasses				
Broomsedge	4.7	7.3	6.5	5.3
Saltgrass	0.2	0.6	0.8	4.1
Centipede	14.8	23.9	28.2	7.4
Little bluestem	2.8	0.6	9.2	2.9
Smooth cordgrass	19.5	12.5	4.5	22.2
Saltmeadow cordgrass	8.8	5.6	6.3	5.7
Sea oats	30.15	41.6	20.6	28.2
Unknown	1.5	1.9	2.3	2.6
Total grasses	82.3	94	78.4	78.4
Sedge/rush				
Spikerush	4.5	1.3	2.5	1.4
Needle rush	1.3	0	0.8	0
White topped sedge	3.6	0.8	2	1.9
Unknown	6.2	3.1	5.3	1.2
Total sedge/rush	15.6	5.2	10.6	4.5
Shrubs				
Groundsel bush	0.4	0	1	1.2
Unknown shrub	0.2	0	0	0
Total shrubs	0.6	0	1	1.2
Forbs				
Pennywort	0.7	0	5.9	10.8
Glasswort	0	0	2.7	1.7
Unknown forb	0.8	0.8	1.4	3.4
Total forbs	1.5	0.8	10	15.9

3.3. Nutritional Profile

Table 3 shows the estimated nutrient intake profiles over the four seasons. These data were calculated using percentage of plant cells present in the feces weighted against the nutrient in the plant. The mean yearly diet consisted of 6.6% ± 1.4% CP, 0.5% ± 0.1% Ca, 0.1% ± 0.03% P, and 1.9 ± 0.07 Mcal/kg DE. NRC requirements for these nutrients are 461 g CP, 21 g Ca, 13 g P, and 14 Mcal of DE [13]. Figure 1 shows how nutrients are met as a percentage of NRC requirements when horses consume 2% (Fig. 1A), 3% (Fig. 1B), or 5% (Fig. 1C) of their body weight in DM forage per day.

4. Discussion

The results from this preliminary study, which were determined by using plant nutritive analysis combined with botanical composition of the feces, describe the estimated nutrient intakes by the horses of Shackleford Banks during the four seasons. More accurate

Table 3
Approximate mean nutrient intake over four seasons (calculated using consumption data and plant nutrient profiles)

Season	CP	ADF	Ca	P	Na	Cu	Zn	DE
	%	%	%	%	%	ppm	ppm	Mcal/kg
Summer	7.6	41.4	0.42	0.14	0.98	8.1	20.1	1.91
Fall	5.4	39.4	0.53	0.10	0.57	5.5	20.4	1.88
Winter	5.3	45.5	0.65	0.10	0.53	11.0	22.3	1.77
Spring	8.0	42.4	0.46	0.15	1.19	8.5	30.1	1.92

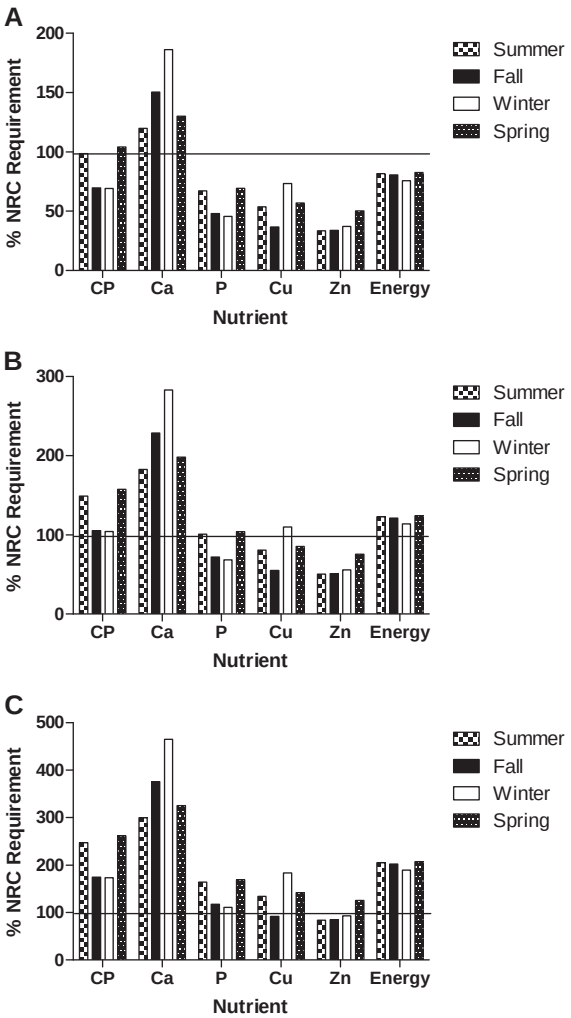

Fig. 1. Estimated nutrient intake as a percentage of National Research Council (NRC) requirements when consuming either 2% (**A**) or 3% (**B**) or 5% (**C**) of their body weight.

determination of nutritive profiles would require plant analysis of a higher percentage of the plant species consumed, additional fecal samples to better represent the horse population, and total dry matter intake data. Because of logistical, financial, and managerial constraints associated with working with this population of feral horses, the present data represent estimates and therefore the results should be interpreted with caution. However, this information is useful as a pilot project and to better understand the challenges facing this unique equine population.

One limitation to this study is the use of microhistological analysis of the feces to determine botanical composition of the diet. Although this procedure is an accurate method of identifying plant composition of the diet [7,10,11], plants that are highly digestible may not be represented in the feces [7-9]. Therefore, these highly digestible and likely highly nutritious plants may not be included in the dietary analysis, thus underestimating nutrient intake. However, the plants on the island that were identified and analyzed were also identified in the feces (ie, there were no plants analyzed that were not found in the feces). Further, the results are to be interpreted with caution because only one fecal sample (albeit a composite of several piles of feces from different horses ranging over the full length of the island) was analyzed each season. Increased numbers of individual fecal samples analyzed would have increased the reliability of these data.

The seasonal and plant variations in nutrient content are expected [15]. Typically, plants are more nutritious in the spring and are of lowest nutritive content in the winter. The crude protein and ADF values are similar to those reported by McInnis and Vavra [12]. A larger variety of forages may have been selected throughout the year based on plant availability and nutrient composition. However, correlation analysis found that there was no relationship between plant selection and nutrient level in the plants. Putnam et al also reported a lack of relationship between nutritional value and dietary composition, and suggested that feed selection may be more likely because of forage availability and habitat [6]. Such a shift toward increased intake of forbs in the winter has been reported previously [6,12], and may also reflect availability and habitat preference during this season. Future work should include extensive habitat and plant identification to further explore this trend.

A limitation to the plant data is that not every plant consumed (as identified in the feces) was analyzed, because only between 65% and 84% of the plants found in the feces were analyzed for nutrient content. The use of skilled researchers who could identify the less common plants and select them for analysis would have improved the information regarding the horse's nutritional profile.

Intake rates of free-ranging horses have been published previously [3,16]. Menard et al reported intakes of 101 $\pm$ 20 to 215 $\pm$ 11 g DM kg $W^{-0.75}$ per day. For the horses of Shackleford Banks (estimated body weight of 300 kg), this equates to approximately 7.3 to 15.5 kg DM per day, or 2.4% to 5.1% of body weight per day. The NRC reports voluntary DM intake of pasture to be between 1.5% and 3.1% of body weight [13], and it is likely that the higher rates are observed in lactating mares [3,13]. As shown in Figure 1B, even at a 3% of body weight intake, the horses in the present study were likely deficient in P, Cu, and Zn several times in the year. Kuntz et al showed that forage intake of wild horses varied throughout the year, in preparation for changes in nutritional quality of the forages and environmental conditions [14]. It is possible the horses of Shackleford Banks use similar mechanisms in adjusting intake to account for seasonal differences in nutrient quality. However, even at high (5% body weight) intakes, the plants analyzed were low in key nutrients such as Cu and Zn. It is possible that growth problems observed in some horses may be attributed to such deficiencies [17], but further research is required to confirm and quantify the occurrence of such problems. It is also possible that plants with higher concentrations of these nutrients were consumed, but neither analyzed nor identified in the feces. The reports of thin horses also suggest that digestible energy intake may be limited, indicating the horses may be consuming the forages at the lower intake rates. It would be of interest to couple data between body condition scores across the season with intake rates and nutrient content, particularly digestible energy.

Despite the limitations of this study, a greater knowledge of the nutritional profile of this group of feral horses has been achieved. However, several questions remain, particularly with respect to the overall nutritional health of the herd (documented body condition scores and incidence of developmental conditions). Future studies can build on these results and should include additional plant sampling, extensive habitat information, horse seasonal behavior information, additional fecal samples, and horse herd health.

Acknowledgments

The researchers thank Eastern National, Fort Washington, PA, for funding this study. Thanks to Regional Equine Information Network System volunteers, North Carolina State University Cooperative Extension Agents, and National Park Service Volunteers in Parks for assistance in sample collection. Appreciation goes to the North Carolina Horse Council for supporting the research.

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