Nutrient Composition and Selection Preferences of Forages by Feral Horses: The Horses of Shackleford Banks, North Carolina

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Bachelor feeding on sea oats tops. Except during the brief period in summer when the seeds are green, the leaves are the preferred part of the plant.

Introduction

The feral horses of Shackleford Banks, North Carolina, are protected by Cape Lookout National Seashore, a unit of the National Park Service, and the nonprofit Foundation for Shackleford Horses, Inc. Horses have freely roamed the 2990 acre island for centuries. No clear account of their arrival exists. In the past they shared the island with cattle and other domestic or feral farm animals. Locals and residents interacted with the horses in a number of ways including periodic roundups.

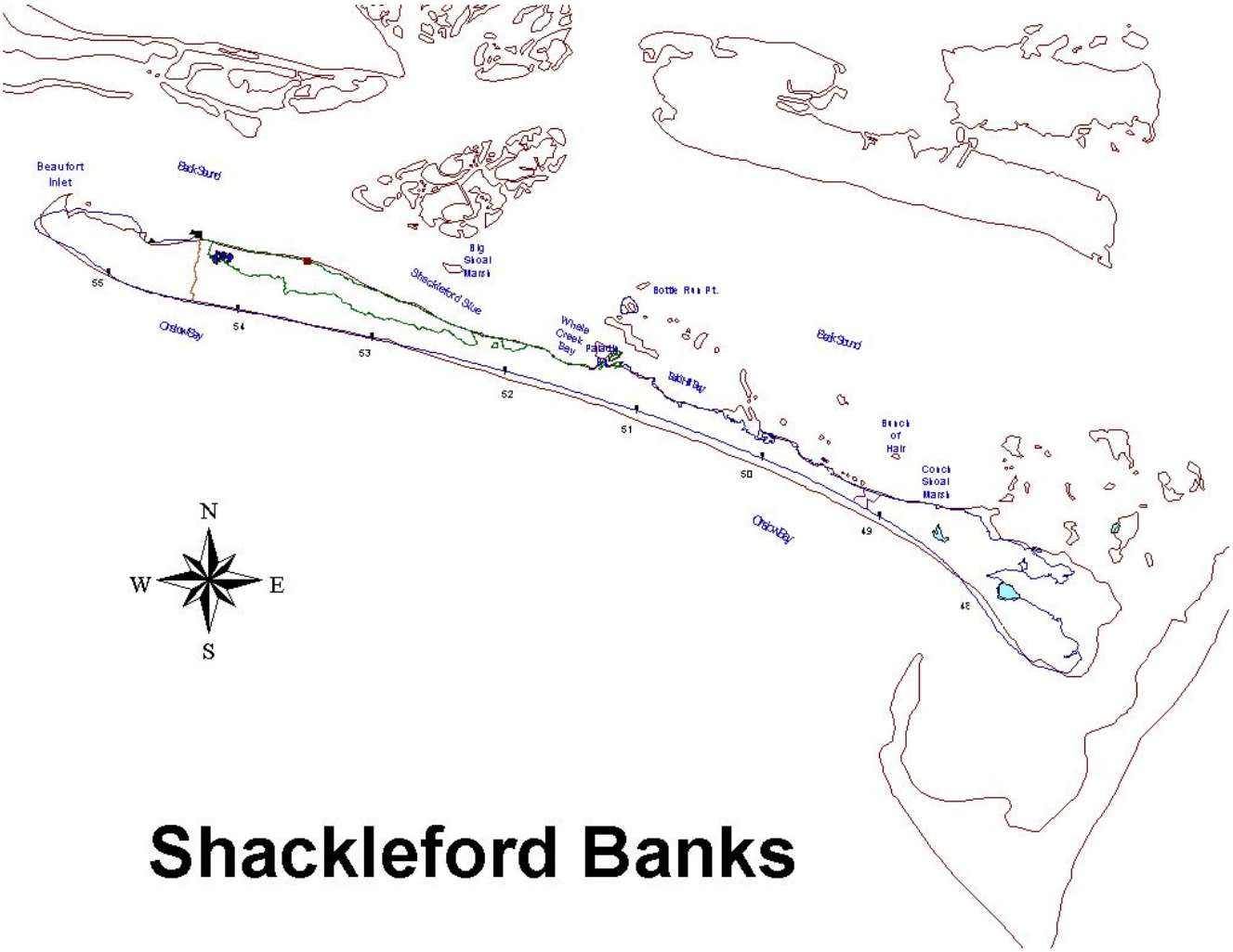
Today, the herd is managed at 110 to 130 horses; the numbers are set by legislation and maintained by agreement between the managing parties. Between 6 and 15 foals are born each year. Contraception and periodic removal of horses from the island are used as population management tools. Removed horses are available for adoption through the Foundation.

Visual assessment of the island's flora would suggest limited nutritive conditions for the horses. A few orthopedic problems (angular limb deformity and parrot mouth) have been observed in foals and young animals, though not enough to make this appear to be a widespread nutritional problem or even linked to nutrition. It is, however, of interest to assess the quality of

the available forage and the forage choices to determine the potential nutritive status of these horses.

Assessing nutritive status of wild herbivores is a challenging task as care must be taken not to disturb the animals. Direct observation of grazing behavior can indicate forage selection, though accuracy largely depends on the plant knowledge of the observer. Recent bite marks will show what has been consumed, though plant identification at that time can be very difficult. Conveniently, microscopic analysis of the plant epidermal fragments within feces shows the contribution of the different plant types to the total diet (1, 2). Forage analysis shows the nutrients available in the plants selected by the horses. The diet components, generated by the fecal exams, combined with the nutrient analyses of the forages, give an estimate of the nutrient intake.

Horses grazing dry grassland, predominantly centipede grass, in winter.



Map of study location.

Study Location

Shackleford Banks is one of the barrier islands comprising Cape Lookout National Seashore. This island is unique within the park as having the only expanse of maritime forest (defined as live oak trees more than 15 feet in height) which provides some shelter for the horses, and being the only island with an east to west orientation. The island is approximately 9 miles long and ranges from less than ½ mile to almost 2 miles in width (including marsh islands).

Materials and Methods

The initial plan was to sample each habitat to determine the habitat's nutritional value. This was done, and when the habitat sample was found to be entirely one species, that information was noted. The specific species analyses became important for comparison after the consumption data were received and the four significant species were determined. Were this study to be repeated, emphasis would be on the species rather than the habitats.

Horses were observed to see what they were eating and representative samples of identified plants were collected. Separate samples were taken as the observed horses moved from one habitat to another. Sampling occurred during four seasons over two years. For data purposes,

the island was divided into quarters from east to west and each quarter was sampled at each session.

During the second year of the study, dung samples were taken. Analysis showed which species were being consumed in what percentages, so the individual species identified in the collections became more important.

Forage samples were analyzed at a commercial laboratory using wet chemistry. They were analyzed for dry matter (DM,) crude protein (CP), acid detergent fiber (ADF), calcium (Ca), phosphorus (P), copper (Cu), zinc (Zn), and digestible energy (DE). (All values reported here are as dry matter, meaning the water has already been removed from the sample. This is a standard technique. It gives a more accurate comparison across forages and across seasons when forages may be more moist or more dry.)

Fresh fecal samples from at least three horses in each of the four quadrants of the island were collected and pooled each season during the second year of the study. This gave one composite sample per season from the island as a whole. Epidermal fragments of the plants found in the fecal samples were inspected by commercial lab personnel using microscopes to determine the genus, species, and percent of diet (Selected References 1, 2). The laboratory prepared for recognition of the forages found in this specific location one time, giving results only at the end of the second year. In the future, if each season's samples could be analyzed after collection, the collection could be certain to emphasize the species of interest. (Table 2 shows no results for Saltmeadow cordgrass in the fall.)

Statistical analysis of variants (ANOVA) was used to determine if nutritive content of the plants differed across the season and between plants. All data are presented as mean ± standard deviation (SD). Differences were deemed significant when $P<0.05$.

Mare grazing smooth cordgrass in the intertidal zone in summer

Four Major Diet Components and Some Species of Interest

Observation of the horses' grazing behavior and analysis of their dung showed four species that made up the majority of the horses' diets. These forages are pictured here. Pennywort and little bluestem are small components of the diet during limited seasons.

Spartina alterniflora (smooth cordgrass)

Spartina patens (saltmeadow cordgrass)

Spartina patens (saltmeadow cordgrass)

Uniola paniculata (sea oats)

Uniola paniculata (sea oats)

Eremochloa ophiuroides (centipede grass)

Hydrocotyl bonariensis (penny wort)

Schizachyrium (little bluestem)

Results and Discussion

Percent of Diet

Results of plant selection and consumption are shown in Table 1. In the fall, sea oats, centipede grass and smooth cordgrass made up 78.0% of the horse's diet as based on the fecal analysis. In the winter, centipede grass consumption increased slightly, consumption of sea oats

decreased by half, consumption of smooth cordgrass decreased by two-thirds, while the overall variety of plants consumed increased. The increased variety consumed in winter could be due to decreased growth and/or palatability among the plants chosen in other seasons.

In the spring, centipede consumption dropped by three-quarters in favor of increased sea oats, smooth cordgrass, and pennywort. In the summer, sea oats, centipede and smooth cordgrass made up 64.3% of the horse's diet with other plants making up the difference. Saltmeadow cordgrass consumption was fairly consistent across the four seasons.

When we look at species beside the four predominant species, additional patterns emerge. Broomsedge consumption remained low and fairly consistent across all four seasons. Saltgrass is a very low percent of the horses' diet except in the spring when consumption increases four-fold. Little bluestem is also a low percent of the diet, but consumption increases almost ten-fold in the winter. Not surprisingly, needle rush makes up a very low percentage of the diet. In the winter, groundsel bush has been observed to be a browsing choice; in winter and spring it makes up only a very low percentage of the diet. Pennywort is a significant component (10%) of the diet in the spring; winter consumption is about half of spring consumption, while summer and fall consumption is very low. Interestingly, glasswort is eaten along with alterniflora, but at a low percentage and only in winter and spring.

The reasoning behind horse selection of forages is not entirely clear. We can speculate that individual forage species' growth patterns and availability may interplay with horse preferences to create the patterns seen in Table 1. We know from domestic horse behavior that new growth is preferred over old, stemmy, relatively dry, mature plants, so we expect that palatability is a factor.

Plant	**common name**	**Fall**	**Winter**	**Spring**	**Summer**
Andropogon virginicus	broomsedge	7.3	6.5	5.3	4.7
Distichlis spicata	saltgrass	0.6	0.8	4.1	0.2
Eremochloa ophiuroides	centipede grass	23.9	28.2	7.4	14.8
Schizachyrium littorale	little bluestem	0.6	9.2	2.9	2.8
Spartina alterniflora	smooth cordgrass	12.5	4.5	22.2	19.5
Spartina patens	saltmeadow cordgrass	5.6	6.3	5.7	8.8
Uniola paniculata	sea oats	41.6	20.6	28.2	30.0
Unknown Grasses		1.9	2.3	2.6	1.5
Total Grasses:		**94.0 %**	**78.4 %**	**78.4 %**	**82.3 %**
Eleocharis	common spikerush	1.3	2.5		4.5
Juncus roemerianus	needle rush		0.8	1.4	1.3
Rhynchospora colorata	white topped sedge	0.8	2.0	1.9	3.6
Sedge/Rush		3.1	5.3	1.2	6.2
Total Sedge/Rush		**5.2 %**	**10.6 %**	**4.5 %**	**15.6 %**
Baccharis	groundsel bush		1.0	1.2	0.4
Unknown Shrub					0.2
Total Shrubs:		**0.0 %**	**1.0 %**	**1.2 %**	**0.6 %**

Hydrocotyl bonariensis	penny wort		5.9	10.8	0.7
Salicornia depressa (virginica)	glasswort		2.7	1.7	
Unknown Forb		0.8	1.4	3.4	0.8
Total Forbs:		**0.8 %**	**10.0 %**	**15.9 %**	**1.5 %**
TOTAL		**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

Table 1. Plants consumed and plant selection preferences from fecal analysis

Plant Species

There were significant differences in nutrient composition across plant species ($P<0.001$ for all nutrients examined). (Table 2)

Nutrients of the four main consumed species will be discussed here. Smooth cordgrass had the highest nutrient density with respect to digestible energy, crude protein and calcium for all four seasons.

The following are trends but statistical significance has not been determined. Sea oats, centipede grass, and saltmeadow cordgrass were similar in digestible energy to each other. Centipede grass was generally a better source of calcium than sea oats or saltmeadow cordgrass. The crude protein among sea oats, centipede grass, and saltmeadow cordgrass showed enough of a range to make clear trend conclusions impractical.

Season

Season significantly affected crude protein ($P=0.0014$), ADF ($P=0.018$), P ($P<0.001$) and Zn ($P=0.04$). Crude protein was higher in either the spring or summer compared to the fall and winter, depending on the plant species (species x season $P=0.043$). Plant crude protein does not appear to correlate with consumption by season.

The following are trends but statistical significance has not been determined. Digestible energy for centipede grass and smooth cordgrass was highest in the fall, and for sea oats and saltmeadow cordgrass was highest in the summer. Interestingly, the consumption of centipede grass was higher in the fall than the spring or summer (but not the winter), corresponding with the high DE in the fall. However, the high DE of smooth cordgrass in the fall did not correspond to a higher consumption. From this, it appears that high digestible energy is not the only criteria for choice of a forage.

		Presence in fecal matter (% of total plant material in feces)	**DE (Mcal/Kg)**	**CP (%)**	**Ca (%)**	**P (%)**	**Cu (mg/kg)**	**Zn (mg/kg)**	**ADF (%)**
SEA OATS (*Uniola paniculata)*	**Fall**	41.6%	1.68±0.008	4.58±0.22	0.34±0.04	0.11±0.01	2.2±2.2	11.9±2.9	46.3±0.04
	Winter	20.6%	1.68±0.03	4.72±0.99	0.33±0.08	0.10±0.03	4.0±1.6	8.78±2.7	48.9±1.9
	Spring	28.2%	1.68±0.05	4.60±1.36	0.34±0.07	0.10±0.05	5.4±2.6	18.8±10.2	49.2±2.3
	Summer	30.0%	1.76±0.03	6.78±0.76	0.24±0.10	0.16±0.03	5.5±2.1	17.8±4.6	46.9±4.4
CENTIPEDE	**Fall**	23.9%	1.86±0.08	4.60±1.68	0.57±0.19	0.07±0.03	5.07±1.5	28.9±6.2	36.1±2.2

GRASS *(Eremochloa ophiuroides)*	**Winter**	28.2%	1.75±0.05	5.07±1.38	0.59±0.32	0.08±0.005	15.3±18.8	32.7±9.3	42.3±3.67
	Spring	7.4%	1.76±0.05	5.61±1.66	0.47±0.22	0.10±0.01	14.4±8.7	54.6±50.7	42.13±0.97
	Summer	14.8%	1.80±0.11	4.91±1.06	0.57±0.19	0.09±0.03	11.4±4.3	36.0±28.7	40.7±6.5
SMOOTH CORDGRASS (*Spartina alterniflora*)	**Fall**	12.5%	2.59±0.13	9.53±0.79	1.08±0.20	0.13±0.03	17.5±12.5	32.2±8.1	23.1±1.8
	Winter	4.5%	2.30±0.26	8.31±0.27	0.90±0.03	0.11±0.04	15.0±14.1	22.0±835	28.4±5.5
	Spring	22.2%	2.32±0.45	13.50±4.48	0.63±0.32	0.22±0.08	10.7±4.16	38.0±16.5	33.2±10.3
	Summer	19.5%	2.22±0.31	11.01±2.36	0.54±0.41	0.15±0.04	9.0±4.2	18.9±7.1	33.4±8.1
SALTMEADOW CORDGRASS (*Spartina patens)*	**Fall**	5.6%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Winter	6.3%	1.67±0.05	4.51±1.41	0.39±0.35	0.055±0.02	8.3±8.2	22.5±11.1	48.4±2.6
	Spring	5.7%	1.78±0.1	6.96±2.40	0.31±0.06	0.14±0.07	8.0±2.9	23.6±10.5	44.8±2.2
	Summer	8.8%	1.84±0.08	7.30±1.16	0.50±0.41	0.095±0.02	9.3±7.8	22.7±10.6	41.3±3.6

Table 2. Plant selection preferences from fecal analysis and nutrient composition of four major plants consumed by the horses.

Nutrition Requirements of Horses Compared to Available Nutrients

With each season, plant nutritive content was available for 78.0, 70.4, 63.5 and 73.3% of the horses' diet (based on fecal data) for fall, winter, spring, and summer respectively. Within these totals, the portions represented by the major forage components are also known. Given the percent of species consumed and the nutrients contained in the consumed species, an estimate of total diet nutrients was calculated. These values were compared to the 1989 NRC requirements (4) which likely are based on the standard horse consumption of 2% of the body weight per day. The horizontal red line represents 100% of the NRC values.[1]

The National Research Council's Nutrient Requirements of Horses (3), (4), is considered to err on the low side of actual requirements by many horse nutrition experts. However, it provides a good baseline for comparison of wild horse diets. It appears that the horses' crude protein requirements are being met in the spring and summer. This corresponds with the level of crude protein content in the four significant forage species (Table 2). Digestible energy needs appear to be met year-round. Calcium needs are exceed year-round, while phosphorus needs are not. The calcium to phosphorus ratio is within the recommended range. Calcium and phosphorus are essential in bone building, and figure significantly in other body functions (3). Copper and zinc are marginal to low in the diets of these horses. These trace minerals are reported here because of their relative importance in equine diets, although there is much that researchers still do not now know about their requirements and effects. Copper is essential in synthesis and maintenance of elastic connective tissue; it effects healthy bone growth. Zinc deficiencies have been shown to be detrimental to growth rate and linked to metabolic bone disease. Zinc deficiency has been linked to decreased alkaline phosphatase (ALP). This enzyme has been elevated consistently in young horses removed from the island, likely for other reasons.

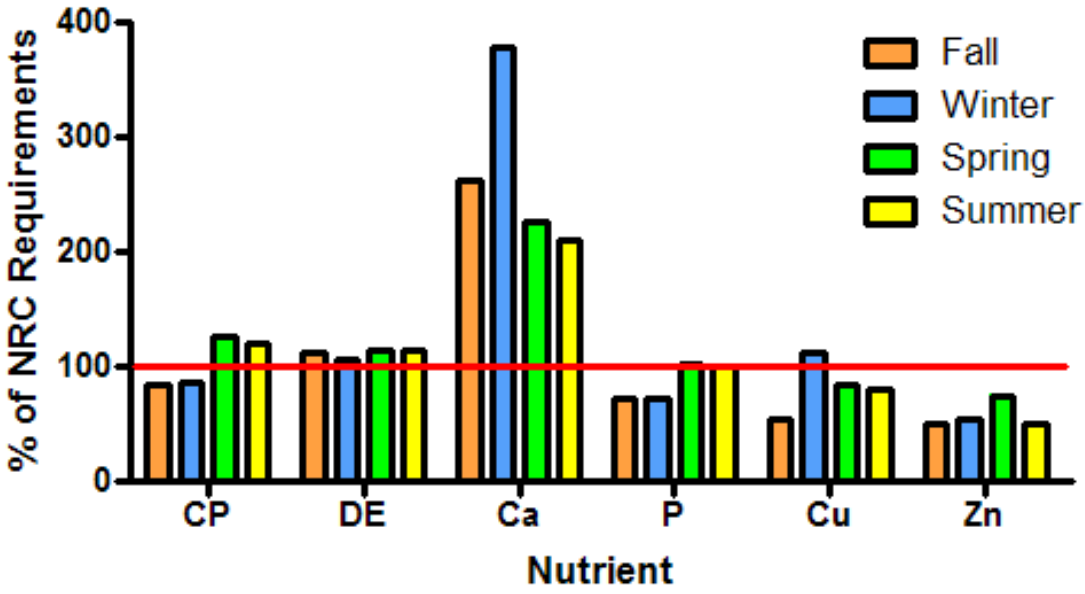


Figure 1. Comparison of estimated nutrient composition in the diet and the National Research Councils's Nutrient Requirements of Horses (3).

The above is based on the horses' eating 2% of their body weight per day. As seen in Figure 1, for some seasons and some nutrients, there is a deficit. And, to reiterate, the NRC requirements are generally thought to be minimums.

If forage with high enough levels of nutrients is available, if it is palatable enough for the horses to choose, if time allows within the daily budget for this grazing, and if the horses' digestive system is not already full, and, for some digestively challenged individuals, if the tooth condition and metabolism allow, the horses may be able to make up this deficit.

Stallion grazing smooth cordgrass in the intertidal zone in winter.

Brief Summary and Conclusions

The data presented here report the nutrient composition of plants consumed by the horses of Shackleford Banks. Fecal analysis provides plant selection preferences. While daily consumption could not be assessed, given body weight estimates, an estimate of the nutrient density of the diet was determined.

The nutrient content of the forages varies across the seasons and does not always correlate with consumption. It is probable that forage availability and palatability are also selection factors.

More research can further assess the nutrient status of the horses on Shackleford Banks. The results of this study will make a good basis for future work. A study of the plant fragments in the dung, analyzed on a quarterly basis, associated with quarterly collection and analysis of all the species found to be consumed in significant quantity here is recommended.

Acknowledgements

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[1] The 1989 NRC was used because it gives values in percentages, versus the 2007 edition that gives requirements in grams and requires the body weight of the horse. It appears that the NRC used a 2% intake rate to calculate the percentages from the grams.