Seasonal Trends in the Chemical Composition of Ten Range Plants in South Texas

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Abstract

The chemical composition of 10 range plants of dietary importance to cattle and white-tailed deer *(Odocoileus virginianus)* was determined on the Texas A&I University Range and Wildlife Research Pastures from October 1980–September 1981. Samples were analyzed for crude protein (CP), neutral detergent fiber (NDF), lignin, organic matter (OM), in vitro dry matter digestibility (IVDMD), phosphorus (P), and calcium (Ca) concentration.

The grasses were lower ($P<.05$) in CP and Ca concentration than the non-grasses, while non-grasses had lower ($P<.05$) NDF content. On the basis of digestibility, fiber content, protein, and mineral concentration, forage quality was highest in the spring. Winter forage samples were of a higher quality than were late summer samples. Low phosphorus concentrations were common throughout the year.

Optimum economic return from the proper utilization of forages on rangeland is a common goal. Knowledge of range animal nutritional requirements and how well those needs are met by the forage provided is essential. Only after the relative seasonal availability of nutrients is known can livestock be managed to obtain a maximum return from the available resources (Raleigh 1970).

The nutritional quality of Texas range plants generally peaks in the spring, decreases in the summer and fall, and reaches its lowest levels in the winter (Huston et al. 1981). Recent studies investigating the nutritional quality of deer forages in South Texas have found a different pattern. Varner et al. (1977) and Everitt and Gonzales (1981) found the quality of winter forage to be high and the quality of summer forage to be the lowest. The subtropical climate with its mild winter temperatures allowed several browse and forb species to remain green and nutritious through the winter.

To further investigate the seasonal trends in forage quality in South Texas, we chose to analyze the chemical composition of 10 plant species of dietary importance to cattle and white-tailed deer in the region. The seasonal trends in the chemical composition of the species were used to identify periods of maximum and minimum nutritional quality.

Study Area

Forage samples were collected monthly on the Texas A&I University Range and Wildlife Research Pastures located 5 km south of Kingsville, in Kleberg County. The topography of the area is flat, with elevations ranging from sea level to 45 m. Five major soils are included in the 55-ha study area. They are Delfino, Edroy, Hidalgo, Orelia, and Willacy (Girdner, unpub. data). The majority of the area is fine sandy loam with inclusions of sandy clay loam, clay loam, and clay.

The climate is subtropical with hot, humid summers and mild, dry winters. July maxima average 36°C whereas January maxima average 21°C. The growing season averages 314 days with an average of only 5 nights below freezing in January, the coldest month. Precipitation averages 65 cm annually but is highly variable with periodic droughts. Peak rainfall occurs in May due to thunderstorm activity and in September as a result of the occasional tropical storms and hurricanes most common during that month (U.S. Dept. of Commerce 1971).

Lying within the transitional zone between the Coastal prairies and marshes and the South Texas plains (Gould 1975), the vegetation of the area is best described as a mesquite-mixed brush community. The main shrub species include one mesquite *(Prosopis glandulosa)*, spiny hackberry *(Celtis pallida)*, lime pricklyash *(Zanthoxylum fagara)*, and a semishrub *(Ericameria austrotexana)*. Dominant grasses consist of Texas bristlegrass *(Setaria texana)*, lovegrass tridens *(Tridens eragrostoides)*, Kleberg bluestem *(Dichanthium annulatum)*, silver bluestem *(Bothriochloa saccharoides)*, multiflowered false-rhodesgrass *(Chloris pluriflora)*, buffel sandbur *(Cenchrus ciliaris)*, tropic sprangletop *(Leptochloa virgata)*, and pink pappusgrass *(Pappophorum bicolor)*. Over 70 forb species are present. Christmasbush *(Eupatorium odoratum)*, *Ruellia* sp., false ragweed *(Parthenium hysterophorus)*, Texas virgin's bower *(Clematis drummondii)*, and crownbeard *(Verbesina microptera)* are common (Graham 1982).

Materials and Methods

The dietary importance of forage species within the study area was determined by directly observing grazing cattle and deer within separate enclosures and counting the number of bites taken of each forage species. Each animal species was observed twice monthly for 4 hours. The dietary percentage of each species was determined by dividing the number of bites for a particular forage by the total number of bites of all species (Graham 1982).

Five grasses [Kleberg bluestem, buffel sandbur, purple threeawn *(Aristida purpurea)*, multiflowered false-rhodesgrass, and silver bluestem]; 2 forb species (Christmasbush and false ragweed); 2 browse species [spiny hackberry and bluewood condalia *(Condalia obovata)*]; and prickly pear cactus *(Opuntia lindheimeri)* were sampled and analyzed for crude protein (CP), neutral detergent fiber (NDF), lignin, organic matter (OM), in vitro dry matter digestibility (IVDMD), phosphorus (P), and calcium (Ca concentration). On a monthly basis, the 5 grasses comprised >50% of the cattle diets during the study (Smith, pers. comm.) and 1–26% of the deer diets, while the non-grasses made up 15–30% of the deer diets and trace amounts of the cattle diets (Graham 1982).

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Grab samples of the forages were collected during bite count observations taking care to sample only plant parts actually consumed by the animals. Samples were handplucked, dried for 72 hours at 55°C, ground in a Wiley mill to pass a 1-mm screen, and stored in air-tight containers until analysis. Crude protein (% N × 6.25) and organic matter (100 - % ash) were determined using standard techniques (A.O.A.C. 1970). Neutral detergent fiber and permanganate lignin were determined as described by Goering and Van Soest (1970). In vitro dry matter digestibility was determined using the procedure of Tilley and Terry (1963). Rumen inocula was obtained from a jersey cow on a roughage diet, and forages with known in vivo values were included with each digestion run to standardize results. Phosphorus analyses were performed as described by Harris (1970). Calcium concentration was determined by atomic absorption spectrophotometry. All assays were run in duplicate.

A nested two-way analysis of variance model (Ostel 1975) was used to determine whether a significant difference in chemical composition existed between months and between type of species (grasses vs. non-grasses). In this model, type of species and months were considered to be fixed effects. Species were nested inside type.

Results and Discussion

Crude Protein

Monthly differences ($P<.01$) occurred in the mean CP concentration of the forages with the mean CP concentration of March samples higher than that of other months. Protein concentration closely followed the growing season. Grasses, browse, and forbs initiated growth during late February and March, at which time CP concentration was high (Fig. 1). As the plants matured, their CP concentration declined, reaching lowest levels in late summer. Rain and cooler temperatures initiated a second growth period in September, at which time CP concentration increased. Only one hard freeze occurred during the winter of 1980-81 and little reduction in CP concentration was observed.

The mean CP concentration of the 5 grasses was significantly lower ($P<.01$) than the CP concentration of the non-grasses. Verme and Ullrey (1974) found 13–20% dietary CP provided deer with sufficient protein for growth and reproduction. The non-grasses with the exception of prickly pear cactus, provided optimum CP throughout the year (Fig. 1). Cattle require 8–9% CP for maintenance and reproduction, and 9–15% CP for growth and lactation (NAS-NRC 1963). Multiflower false-rhodegrass maintained optimum CP concentration during all seasons except

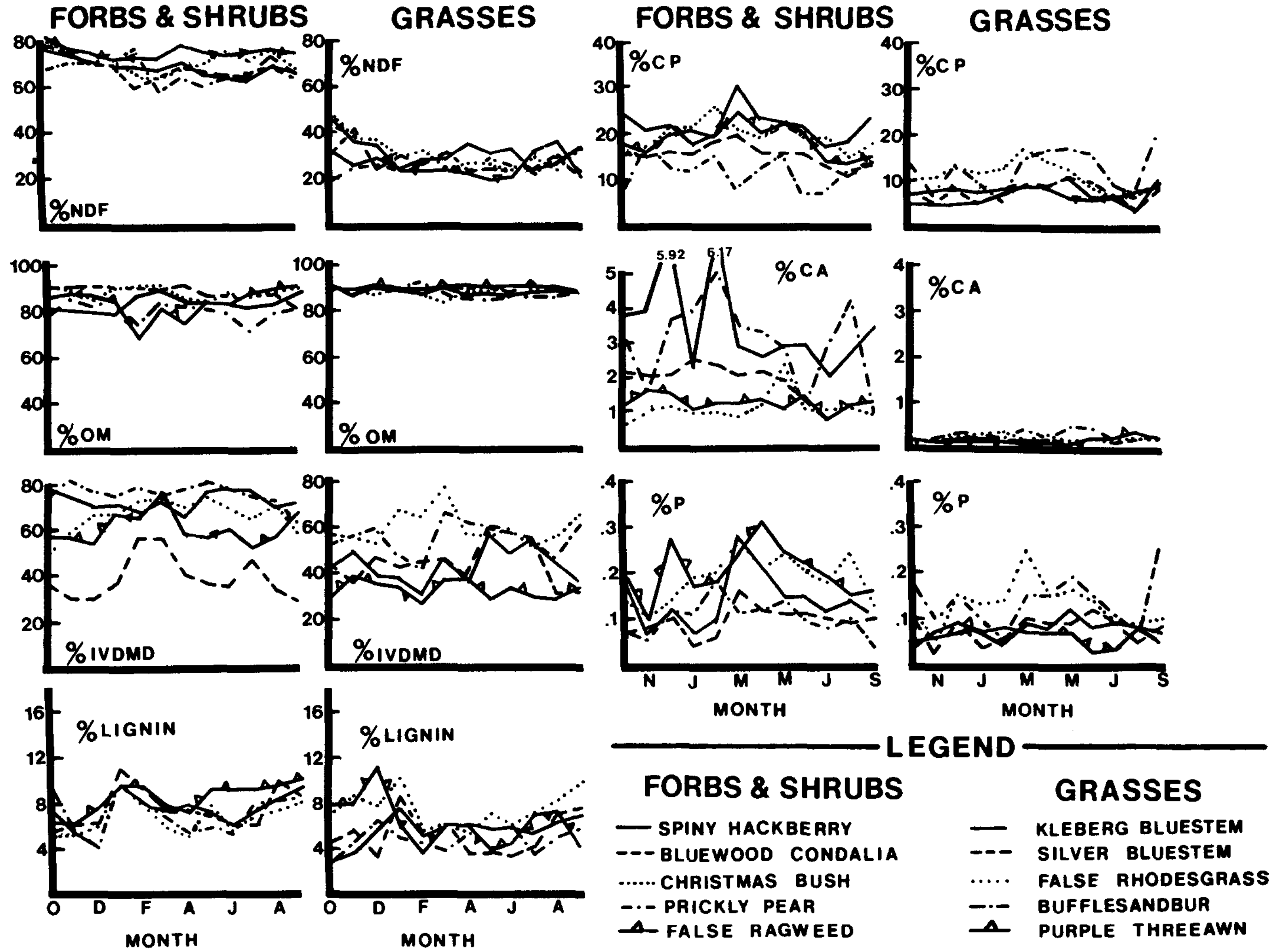

Fig. 1. *Monthly crude protein, neutral detergent fiber, lignin, in-vitro dry matter digestibility, organic matter, calcium and phosphorus concentration of purple threeawn* (Aristida purpurea), *silver bluestem* (Bothriocloa saccharoides), *spiny hackberry* (Celtis pallida), *buffle sandbur* (Cenchrus cilliaris), *multifloweredfalse-rhodesgrass* (Chloris pluriflora), *bluewood condalia* (Condalia obovata), *Kleberg bluestem* (Dichanthium annulatum), *Christmas bush* (Eupatorium odoratum), *prickly pear cactus* (Opuntia lindheimeri), *a false ragweed* (Parthenium hysterophorus).

summer, and buffel sandbur was optimal during spring and early summer. Only during spring and autumn did Kleberg bluestem, silver bluestem, or purple threeawn provide CP at maintenance levels.

Neutral Detergent Fiber

NDF concentration is comprised of cellulose, hemicellulose, and lignin which are cell wall components that require microbial fermentation for digestion. The remaining cell contents are up to 98% digestible and readily available to the animal (Goering and Van Soest 1970). NDF is a more accurate measure of forage quality than is the more frequently reported acid detergent fiber (ADF) because ADF places hemicellulose in the completely digested fraction. This may be erroneous as hemicellulose is actually less digestible then cellulose in some plant species (Van Soest 1982).

Seasonal trends in the NDF concentration of the grasses and non-grasses were not distinct during this study although bluewood condalia, Christmasbush, prickly pear, and false rhodegrass did show a reduction of fiber concentration during spring and early summer (Fig. 1), typical of new growth. The NDF concentration of many winter forage samples was lower than that of the fall samples. A drought occurred during the summer of 1980, and many plants became dormant. The autumn rains broke the drought, and less fibrous forages became available as the season progressed. Lack of frost allowed plant growth to continue through the winter, and little increase in fiber concentration occurred in the forages selected.

The mean NDF concentration of the grasses was higher ($P<.01$) than the non-grasses during all months. Because of their higher fiber concentration, grasses require considerable microbial cellulose digestion and have a slow rate of volatile fatty acid (VFA) production, which is high in acetic acid (Short 1971). The non-grasses had a larger proportion of rapidly digested cell contents, which have a rapid rate of VFA production, which is higher in propionic acid concentration than is the case with grasses. This increase in propionic acid production results in more calories available to an animal because propionic acid has a heat of combustion nearly twice that of acetic acid (Short 1981). White-tailed deer consistently selected these high energy forages on our study site (Graham 1982), likely in compensation for their small ruminoreticular volumes. Cattle, with much larger rumen volumes, likley obtained sufficient energy from the grasses which have a lower energy concentration but are more easily obtained.

Lignin Content

True lignin comprises a class of non-carbohydrate compounds which give structural support to plant cell walls. Its concentration increases steadily as the growing plant matures, and its chemical linkage, especially with hemicellulose and cellulose, markedly reduces the latter (Maynard et al. 1979). There was a significant difference ($P<.01$) in the monthly levels of lignin found in the forages tested. January lignin concentration was higher ($P<.05$) than the other months, with a smaller peak occurring in September, coinciding with the conclusion of the spring and fall growing seasons. Prickly pear peaked in December, May, and September, perhaps indicative of a different growing pattern. Of the species tested, purple threeawn had the highest annual lignin content.

The mean lignin concentration of the non-grasses was not significantly different from the grasses even though it was consistently lower. A goal of range management should be to provide deer with foods of high cell concentration proportions and low lignocellulose levels (Short 1981). Using this criteria, the non-grasses we have tested make good candidates for propagation.

Digestibiity

Monthly in vitro dry matter digestibility differed significantly ($P<.01$) during the study, with March IVDMD highest. The mean IVDMD of grasses was not significantly different ($P<.05$) than the non-grasses, even though it was consistently lower. There was no difference in monthly trends between the 2 groups.

Digestibility of prickly pear and spiny hackberry remained high throughout the study (Fig. 1) and exceeded 75% during 6 months. Organic matter values have been included along with IVDMD values as Everitt and Gonzales (1981) found prickly pear's IVDMD to be inflated due to the large amount of soluble ash present in the samples. Spiny hackberry and prickly pear cactus also have a low OM concentration (thus high ash concentration) (Fig. 1), and the possibility exists that their IVDMD was inflated due to soluble ash. In vitro organic matter digestibility is a better measure of forage quality in species having a high ash content. When comparing mixed forage classes, however, NDF has been found to be the best measure of forage quality (Holechek and Varra, 1983).

Mineral Concentration

The calcium concentration of grasses was lower ($P<.01$) than the non-grasses. However, differences in phosphorus content did not occur. Mean Ca concentration of the grasses was highest in winter and spring while peak concentration of the non-grasses occurred in the winter. P concentration in both groups was highest in the spring.

Cattle require .21% Ca and .16% P in their diets for normal growth and maintenance (NAS-NRC 1963). The grasses analyzed provided maintenance levels of Ca through the study, but with the exception of multiflowered false-rhodegrass and buffel sandbur, they were deficient in P concentration (Fig. 1). White-tailed deer require .30% Ca and .25% P for maintenance and growth (Magruder et al. 1957). Ca concentrations of the non-grass species were exceptionally high and more than met nutritional requirements at all times. P requirements were met by spiny hackberry, Christmasbush, and false ragweed in the spring, but their P concentrations declined as they matured. Prickly pear cactus and bluewood condalia were below maintenance levels at all times.

Table 1. Mean annual organic matter, crude protein, neutral detergent fiber, lignin, in vitro dry matter digestibility, and phosphorus concentration of ten forages collected from Texas A&I University Research Pastures, Kingsville, Texas. October 1980 - September 1981 (% ± S.E.).[1]

Species	OM	CP	NDF	Lignin	IVDMD	Ca	P
Kleberg bluestem	87.5 ± .4	6.7 ± .7	68.7 ± 1.1	7.2 ± .5	43.5 ± 2.3	.22 ± .01	.08 ± .01
Buffelgrass	87.6 ± .6	12.3 ± 1.3	66.0 ± 1.5	6.9 ± .5	55.6 ± 2.1	.28 ± .03	.14 ± .02
Purple threeawn	90.2 ± .3	7.5 ± .3	75.1 ± .8	8.3 ± .4	32.3 ± 1.2	.18 ± .02	.06 ± .01
Trichloris	88.2 ± .5	11.0 ± .9	70.9 ± 1.4	6.5 ± .4	59.8 ± 2.1	.22 ± .02	.13 ± .01
Silver bluestem	89.4 ± .3	7.5 ± .6	67.9 ± 1.5	7.3 ± .5	44.6 ± 2.7	.18 ± .01	.08 ± .01
Spiny hackberry	82.5 ± 1.0	21.6 ± 1.0	29.0 ± 1.2	5.4 ± .4	72.1 ± 1.2	3.53 ± .40	.14 ± .02
Bluewood	88.2 ± .7	15.2 ± .7	27.5 ± 1.6	5.2 ± .5	38.4 ± 2.8	1.77 ± .17	.10 ± .01
Mistflower	82.7 ± .7	19.3 ± .9	30.5 ± 2.0	7.3 ± .5	65.4 ± 2.3	1.10 ± .12	.19 ± .01
False ragweed	83.0 ± 1.9	18.4 ± 1.0	28.1 ± 2.5	6.1 ± .6	59.8 ± 2.1	1.24 ± .06	.20 ± .02
Prickly pear cactus	79.8 ± 1.2	11.3 ± 1.0		4.8 ± .4	75.7 ± 1.4	3.02 ± .36	.10 ± .01

[1]Means are average of 12 monthly samples analyzed in duplicate.

A Ca:P ratio of between 2:1 and 1:1 is desirable in forages (Maynard et al. 1979). A wider range may not allow for optimum metabolism, dependent upon Vitamin D availability. While the grasses were within the desirable range, the non-grasses ranged from 10:1 to 20:1. This may further reduce the availability of the already marginal P concentrations found in these species.

Forage Quality

The nutritional quality of the grasses was high in the spring and declined through the summer, most notably in P and CP concentration (Fig. 1). Quality improved with the rains and cooler temperatures of fall. Of the grasses studied, buffel sandbur was the most nutritious (Table 1). On the basis of nutrients provided to our study animals, it was the most valuable graminoid on the study site. It is susceptible to frost (Mora 1981) and will provide considerably less quality forage during a hard winter. Multiflowered false-rhodegrass was also nutritious and common on the study site, but was less preferred than buffel sandbur (Smith, pers. comm.). These 2 species should be considered high quality cattle forage. Despite the poor nutritional quality of Kleberg bluestem, cattle consistently selected it, indicating its palatability. It was especially important in the late summer when other grasses became dormant. Silver bluestem and purple threeawn had low quality and limited dietary importance.

While seasonal trends in the nutritional quality of the non-grasses was similar to the grasses, the non-grasses were consistently more nutritious. Spiny hackberry, Christmasbush, and false ragweed were preferred (Graham 1982) high quality deer forage. Prickly pear cactus was highly digestible but low in CP and P. Cactus has been shown to be a valuable deer forage in arid ranges and during droughts (Arnold and Drawe 1974). Bluewood condalia was high in CP but deficient in P and poorly digested. It was not a preferred deer forage on our study pasture (Graham 1982).

Conclusions

The low quality of the late summer forage samples indicate that this period was nutritionally more critical than winter during this study. Programs of supplementation, adjustment of livestock numbers, or development of permanent pasturage should be considered for late summer to compensate for the reduced forage quality.

The 10 range plants studied were uniformly low in P concentration. Should this trend be widespread in South Texas, P deficiency is a definite possibility. Reynolds et al. (1953) found that supplementing cattle with phosphorus in South Texas increased the average calf-crop from 76.4% to well over 90%. Best results were obtained through range fertilization, while feeding bone meal and adding disodium phosphate to water supplies were also effective.

Three of the five grasses analyzed were also deficient in protein concentration, emphasizing the importance of propagating high quality grasses such as multiflowered false-rhodegrass and buffel sandbur.

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