THE CHEMICAL COMPOSITION OF SOME ARID ZONE PASTURE SPECIES

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SUMMARY

The chemical composition of 38 species of grasses, shrubs and forbs found in the Alice Springs district of central Australia has been considered.

The nitrogen content of the forb and shrub material was greater than that of either perennial or annual grasses but the vegetation generally appeared to have a greater nitrogen content than that of native pastures, found in the more humid tropics of north Australia.

Although some grasses were low in nitrogen content when dry, animals on mature pasture may be able to maintain themselves by selectively grazing plant parts or particular species if vegetation is sufficiently dense.

INTRODUCTION

Aspects of the ecology of arid zone pasture species in Australia have been presented by Osborn and Wood (1931), Blake (1938), Beadle (1948), Jessup (1951), Williams (1960) and Perry (1962). Perry made a detailed study of pasture communities in the Alice Springs district of central Australia and noted that the native pasture species present were also widespread throughout the remainder of the Australian arid zone. He has classified the district into six major "pasture lands"; (i) Spinifex sand plains and dunes (58% of the total area), (ii) Short grass–forb pasture on young alluvia (4%), (iii) Short grass–forb pasture on flat or undulating country (15%), (iv) Saltbush and Bluebush country (2%), (v) Mitchell grass country (1%), (vi) Alternating hills and lowlands with short grass–forb pastures (20%).

Domestic herbivores are sustained on most of these pasture types, but the most intensively used areas are those dominated by short grasses and forbs. Because the vegetation is usually sparse the pastoral areas are only lightly stocked, but the large areas involved allow the raising of appreciable numbers of beef cattle. The Alice Springs district covers approximately 100,000 square miles and has maintained a cattle population of nearly 400,000.

The tropical and sub-tropical pastures of northern Australia have been shown to be poor nutritionally (Christian and Shaw, 1951; Milford, 1960; Norman, 1963), but such studies were generally carried out in the grassland regions of the tropics and have not included the vegetation found in the more arid regions.

This paper examines the results of chemical analyses of grasses, shrubs and forbs collected in the Alice Springs district and known to be grazed by cattle. Samples of vegetation were collected at different stages of growth following falls of light rain during drought years.

MATERIAL AND METHODS

Plant samples were collected within a 50 mile radius of Alice Springs over an 18 month period. The samples comprised 38 species of grasses, shrubs and forbs taken between early growth and complete dryness. Growth stage was arbitrarily divided into 5 categories; (i) Fresh, green, (ii) Early drying, (iii)

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TABLE 1

Chemical composition of 15 species of native grasses collected during growth in central Australia.

Species	Stage of growth	Constituents on a dry weight basis (%)					Remarks
		Crude Protein	Crude fibre	Mineral	Ether extract	Nitrogen -free extract	
Eragrostis eriopoda (Woollybutt)	Fresh, green	6.2	31.3	8.2	1.2	53.1	Perennial, palatable
	Partly dry	4.6	28.7	8.1	1.0	57.6	
	Almost dry	3.5	26.5	7.9	1.2	60.9	
Eragrostis setifolia (Neverfail)	Fresh, green	6.8	23.2	9.4	2.6	58.0	Perennial, palatable
	Early drying	7.6	28.9	8.3	1.4	53.8	
	Partly dry	4.3	29.9	12.7	1.5	51.6	
	Almost dry	3.6	32.2	10.3	1.4	52.5	
Eragrostis xerophila	Early drying	6.6	24.5	11.3	1.3	54.3	Perennial, palatable
	Partly dry	4.7	30.6	14.9	0.9	48.9	
Chloris acicularis (Curly windmill grass)	Fresh, green	9.5	19.8	11.7	1.3	57.7	Perennial, palatable
	Partly dry	12.2	22.1	12.5	1.4	51.8	
	Almost dry	7.9	29.6	9.2	1.5	51.8	
	Completely dry	5.0	30.1	9.4	2.0	53.5	
Astrebla pectinata (Barley mitchell grass)	Partly dry	6.8	28.5	12.0	1.4	51.3	Perennial, palatable
	Almost dry	5.3	26.2	8.8	1.4	58.3	
	Completely dry	4.5	26.1	10.6	2.0	56.8	
Digitaria ammophila	Fresh, green	11.4	20.4	19.9	1.9	46.4	Perennial, palatable
	Early drying	12.5	19.6	16.8	1.2	49.9	
	Partly dry	6.7	17.8	9.7	1.3	64.5	
	Completely dry	3.1	27.6	12.9	1.1	55.3	
Digitaria brownii (Cotton panic)	Early drying	5.1	27.1	12.0	1.4	54.4	Perennial, palatable
	Partly dry	5.0	23.2	12.5	2.1	57.2	
	Almost dry	7.3	43.8	9.1	1.4	38.4	
	Completely dry	4.3	45.2	16.8	1.2	32.5	

Themeda australis (Kangaroo grass)	Fresh, green	6.3	28.1	11.3	1.4	52.9	Perennial, palatable
	Partly dry	4.1	24.8	10.5	1.4	59.2	
	Almost dry	3.8	26.6	12.1	1.3	56.2	
	Completely dry	2.5	27.4	13.4	1.6	55.1	
Triodia basedowii (Spinifex-hard)	Fresh, green	5.4	28.3	6.4	1.3	58.6	Perennial, unpalatable
	Partly dry	4.5	25.6	8.4	17.3	44.2	
	Almost dry	2.3	31.6	7.2	10.8	48.1	
	Completely dry	3.6	30.8	9.4	0.8	55.4	
Triodia pungens (Spinifex-soft)	Partly dry	4.3	27.6	6.3	13.7	48.1	Perennial, slightly palatable
	Almost dry	2.8	35.8	9.8	1.0	50.6	
Tripogon loliiformis (Five-minute grass)	Fresh, green	8.9	21.7	25.8	1.5	42.1	Perennial, palatable
	Early drying	10.5	20.3	14.1	2.7	52.4	
	Almost dry	11.8	20.0	19.7	1.4	47.1	
	Completely dry	9.1	19.0	11.0	1.5	59.4	
Aristida contorta (Mulga grass)	Fresh, green	11.4	27.0	13.9	2.0	45.7	Annual, palatable
	Early drying	7.6	26.6	14.7	1.5	49.6	
	Partly dry	7.0	23.8	29.5	2.0	38.7	
	Completely dry	4.8	26.9	13.3	1.3	53.7	
Dactyloctenium radulans (Button grass)	Fresh, green	14.0	23.3	16.4	1.5	44.8	Annual, palatable
	Early drying	10.9	22.0	23.5	1.4	42.2	
	Completely dry	5.7	17.8	39.3	1.1	36.1	
Enneapogon polyphyllus (White-top)	Fresh, green	10.3	23.3	10.8	1.9	53.7	Annual, palatable
	Early drying	7.5	28.6	12.3	1.8	49.8	
	Completely dry	5.0	22.9	17.5	1.7	52.9	
Tragus australianus (Small burr grass)	Fresh, green	13.2	13.7	34.0	1.2	37.9	Annual, palatable
	Early drying	8.6	17.1	33.0	1.3	40.0	
	Almost dry	5.6	21.7	20.0	1.9	50.8	
	Completely dry	11.3	25.1	19.4	0.6	43.6	

Partly dry, (iv) Almost dry and (v) Completely dry. After positive identification in the herbarium these samples were oven dried at 60°C. to constant weight.

The dried samples were hammermilled through a 0.7 m.m. screen then stored in sealed containers for analysis. Nitrogen was determined by Kjeldahl digestion using a mercury catalyst according to the method of McKenzie and Wallace (1956). Crude protein was considered as N × 6.25. Crude fibre, ether extract and mineral content were determined according to the methods of the A.O.A.C. (1960). Nitrogen-free extract was calculated by difference.

RESULTS

The chemical composition of the plant samples is shown in Tables 1, 2 and 3. Not all the plant species were available at all growth stages, but most species were analysed at three different stages of development.

Shown in Table 1 are the results of analyses of 15 species of perennial and annual grasses. The range of crude protein content at different growth stages was as follows:

(i) Fresh, green .... 5.4 to 14.0%
(ii) Early drying .... 5.1 to 12.5%
(iii) Party dry .... 4.1 to 12.2%
(iv) Almost dry .... 2.3 to 11.8%
(v) Completely dry .... 2.5 to 11.3%

The highest value determined was 14.0% in fresh green *Dactyloctenium radulans.* Almost dry, *Triodia basedowii,* had a very low value of 2.3%. The crude fibre content ranged from 20 to 30% in most cases, although the concentration in completely dry *Digitaria brownii,* reached 45.2%. Minerals usually made up less than 15% of the dry matter, but some annual grasses, notably *Tragus australianus* and *Dactyloctenium radulans,* had values in excess of 20%. Ether extract in almost all cases contributed less than 2%, except in dry *Triodia basedowii* and partly dry *Triodia pungens* when values were in excess of 10%.

The results of similar analyses carried out on 13 species of perennial shrubs are shown in Table 2. Crude protein content of the shrub material was higher than that of the grasses in the early stages of maturity:

(i) Fresh, green .... 8.3 to 17.8%
(ii) Early drying .... 6.9 to 19.4%
(iii) Partly dry .... 5.1 to 13.6%
(iv) Almost dry .... 3.8 to 9.9%
(v) Completely dry 8.6%

Early drying *Atriplex nummularia* had a crude protein content of 19.4%. Crude fibre values in chenopod material were similar to those of grasses in the green state, but tended to be higher when dry. Mineral content ranged from 3.6% in *Spartothamnella teucriiflora* to 29.6% in *Atriplex nummularia.*

The chemical composition of 20 annual forbs (shown in Table 3) was similar in some respects to that of the shrub material. The crude protein content at different growth stages was as follows:

(i) Fresh, green .... 9.8 to 24.8%
(ii) Early drying .... 6.5 to 19.9%
(iii) Partly dry .... 6.5 to 16.3%
(iv) Almost dry 10.5%
(v) Completely dry .... 5.1 to 10.6%

TABLE 2.
Chemical composition of 13 species of native shrubs collected during growth in central Australia.

Species	Stage of growth	Constituents on a dry weight basis (%)					Remarks
		Crude protein	Crude fibre	Mineral	Ether extract	Nitrogen -free extract	
Atriplex nummularia (Old-man saltbush)	Fresh, green	17.7	8.1	24.0	2.0	48.2	Perennial, palatable
	Early drying	19.4	17.1	29.6	2.1	31.8	
Atriplex vesicaria (Bladder saltbush)	Fresh, green	11.7	18.2	23.3	2.1	44.7	Perennial, palatable
	Early drying	10.4	23.5	14.8	2.4	48.9	
	Partly dry	7.6	30.1	16.9	1.2	44.2	
Chenopodium auricomum (Northern bluebush)	Fresh, green	16.3	19.7	18.0	3.0	43.0	Perennial, palatable
	Early drying	15.4	14.9	16.9	2.4	50.4	
	Partly dry	11.9	25.3	13.3	3.6	45.9	
Kochia aphylla (Cottonbush)	Fresh, green	17.8	26.2	9.7	1.6	44.8	Perennial, slightly palatable
	Partly dry	10.5	31.5	6.7	3.5	47.8	
Enchylaena tomentosa (Ruby saltbush)	Fresh, green	15.6	25.4	17.2	1.5	40.3	Perennial, palatable
	Early drying	10.7	29.0	12.0	2.0	46.3	
Kochia tomentosa	Fresh, green	16.1	18.9	16.5	1.9	46.6	Perennial, palatable
	Early drying	10.4	24.4	22.8	1.6	40.8	
Rhagodia nutans (Climbing saltbush)	Fresh, green	14.9	18.8	16.5	1.8	48.0	Perennial, palatable
	Early drying	10.8	29.7	9.0	1.3	49.2	
	Partly dry	6.0	40.7	7.0	1.6	44.7	
Ptilotus atriplicifolius	Fresh, green	14.5	17.2	20.3	2.0	46.0	Perennial, palatable
	Early drying	13.1	28.4	14.1	2.2	42.2	
	Partly dry	9.5	33.3	8.2	3.1	45.9	
	Almost dry	8.1	32.8	9.5	2.3	47.3	
Ptilotus obovatus	Fresh, green	11.1	23.5	11.9	2.4	51.1	Perennial, palatable
	Early drying	10.8	30.2	10.9	2.1	46.0	
	Almost dry	6.9	30.4	12.9	2.2	47.6	
Hybanthus enneaspermus	Early drying	6.9	36.2	7.0	2.3	47.6	Perennial, palatable
	Partly dry	8.4	28.9	8.0	1.4	53.3	
	Almost dry	9.9	28.7	10.4	2.5	48.5	
	Completely dry	8.6	25.6	9.3	2.1	54.4	
Spartothamnella teucriiflora	Early drying	13.0	46.9	3.6	1.4	35.1	Perennial, palatable
	Partly dry	7.5	38.3	4.9	3.2	46.1	
	Almost dry	7.6	35.5	5.7	2.8	48.4	
Psoralea patens (Perennial Verbine)	Fresh, green	14.7	30.7	7.2	4.6	42.8	Perennial, palatable
	Early drying	12.1	40.5	10.3	0.9	36.2	
	Partly dry	5.1	51.6	5.8	2.0	35.5	
	Almost dry	3.8	50.3	4.9	1.4	39.6	
Teucrium racemosum	Fresh, green	8.3	16.2	10.4	4.1	61.0	Perennial, palatable
	Early drying	11.6	18.4	5.9	4.1	60.0	
	Partly dry	13.6	23.4	6.5	4.8	51.7	

TABLE 3

Chemical composition of 20 species of native forbs collected during growth in central Australia.

Species	Stage of growth	Constituents on a dry weight basis (%)					Remarks
		Crude protein	Crude fibre	Mineral	Ether extract	Nitrogen -free extract	
Atriplex elachophylla	Fresh, green	15.5	18.4	16.9	2.0	47.2	Annual, palatable
	Early drying	14.1	15.0	22.2	1.9	46.8	
	Partly dry	12.3	21.5	11.0	1.8	53.4	
	Almost dry	10.5	29.5	11.1	1.5	47.4	
Atriplex lindleyi	Fresh, green	14.0	16.3	29.9	2.3	37.5	Annual, palatable
	Early drying	6.5	20.0	23.9	2.1	47.5	
Atriplex holocarpa (Pop saltbush)	Fresh, green	16.3	8.4	42.0	2.1	31.2	Annual, palatable
	Early drying	11.0	13.2	35.5	2.5	37.8	
	Almost dry	10.6	21.3	20.1	1.5	46.5	
	Completely dry	8.9	23.2	16.8	1.7	49.4	
Bassia convexula	Fresh, green	17.0	18.5	26.2	1.3	47.0	Annual, palatable
	Early drying	10.6	25.6	16.8	2.0	45.0	
Bassia costata	Fresh, green	16.0	12.9	25.5	2.0	43.6	Annual, palatable
	Early drying	11.5	20.4	14.4	1.7	52.0	
	Partly dry	10.4	19.1	15.8	1.8	52.9	
Bassia divaricata	Fresh, green	18.8	6.2	35.6	1.9	37.5	Annual, palatable
	Early drying	15.4	15.5	31.8	2.1	35.2	
	Partly dry	13.9	21.0	16.6	2.0	46.5	
Bassia lanicuspis	Fresh, green	17.8	22.0	21.5	1.8	36.9	Annual, palatable
	Early drying	13.0	17.2	23.6	2.6	43.6	
	Completely dry	10.5	29.8	11.9	1.5	46.3	
Bassia diacantha	Fresh, green	14.6	9.8	20.9	0.7	54.0	Annual, palatable
	Partly dry	6.5	22.3	24.3	1.7	45.2	
Kochia scleroptera	Fresh, green	10.8	21.2	32.4	1.5	34.1	Annual, palatable
	Early drying	11.3	19.9	28.4	1.7	38.7	
	Partly dry	11.9	21.4	21.4	2.3	43.0	

Salsola kali (Buckbush)	Fresh, green	19.9	12.4	27.2	1.2	39.3	Annual, palatable
	Early drying	14.4	13.1	24.6	1.7	46.2	
	Completely dry	10.6	24.2	11.2	1.8	52.2	
Ptilotus polystachyus (Pussytail)	Fresh, green	13.9	22.4	15.8	1.2	46.7	Annual, palatable
	Early drying	12.6	21.7	16.0	3.3	46.4	
	Partly dry	7.6	28.0	12.3	3.8	48.3	
	Completely dry	7.4	33.3	6.6	1.3	51.4	
Boerhavia diffusa (Tar vine)	Fresh, green	14.0	11.9	35.9	2.1	36.1	Annual, palatable
	Early drying	9.9	22.1	17.0	2.5	48.5	
Calandrinia balonensis (Parakeelya)	Fresh, green	20.5	6.2	23.8	3.2	46.3	Annual, palatable High in oxalate
	Early drying	19.9	8.5	19.9	3.3	49.4	
	Partly dry	16.3	13.1	26.8	3.5	40.3	
Portulaca oleracea (Pigweed, Munyeroo)	Fresh, green	14.1	22.8	14.4	2.6	46.1	Annual, palatable High in oxalate
	Early drying	10.4	15.1	24.9	3.5	46.1	
Lepidium rotundum	Fresh, green	23.4	15.6	11.6	2.8	46.6	Annual, palatable
	Partly dry	13.4	22.3	10.0	4.3	50.0	
Crotalaria strehlowii (Rattlepod)	Fresh, green	21.4	18.1	8.0	3.9	48.6	Annual, palatable
	Early drying	10.6	36.9	6.5	4.8	41.2	
	Partly dry	8.6	38.3	4.4	2.8	45.9	
Indigofera dominii (Birdsville indigo)	Fresh, green	9.8	23.7	14.8	1.5	50.2	Perennial, legume toxic to horses
	Early drying	17.3	19.3	14.3	2.5	46.6	
Psoralea cinerea (Annual verbine)	Fresh, green	24.8	13.4	11.7	6.1	44.0	Annual, palatable
	Early drying	7.5	36.6	7.9	1.4	46.6	
	Completely dry	5.1	42.3	4.6	0.6	47.4	
Tribulus terrestris (Caltrop)	Fresh, green	15.2	14.6	19.2	1.7	49.3	Annual, palatable
	Partly dry	10.4	29.8	14.2	1.8	43.8	
Fimbristylis aff. *dichotoma* (Eight-day 'grass')	Fresh, green	16.8	17.0	12.3	2.4	51.5	Perennial, palatable
	Early drying	11.4	20.5	14.7	2.0	51.4	
	Completely dry	5.9	25.8	12.6	1.9	53.8	

Crude fibre values were frequently less than 20% in the early stages of maturity, although values for some species (e.g. *Ptilotus polystachyus*) increased to over 30% when dry. Mineral content ranged from 4.4 to 42.0%, reaching very high values in *Atriplex* and *Bassia. s*pp.

DISCUSSION

Vegetative growth in central Australia is mainly dependent on summer rain, as is that of the humid tropics and sub-tropics of northern Australia. Results of chemical analyses of grasses, shrubs and forbs from the Alice Springs district however, indicate that the nitrogen content of this vegetation is frequently higher than that of native vegetation of the more humid regions, where pastures grow rapidly and become highly fibrous and low in nitrogen content as they mature (Milford, 1960; Norman, 1963).

TABLE 4

The average chemical composition of grasses, shrubs and forbs at green and dry stages of growth.

		Constituents on a dry weight basis (%)					
Type	Stage of growth	Crude protein	Crude fibre	Mineral	Ether extract	Nitrogen -free extract	No. of specimens
Perennial grasses	Green	8.1	24.4	12.9	1.6	53.0	12
	Dry	5.0	29.9	11.1	2.0	52.0	16
Annual grasses	Green	10.4	22.7	19.8	1.6	45.5	8
	Dry	6.5	22.9	21.9	1.3	47.4	5
Shrubs	Green	13.2	24.4	14.4	2.3	45.7	23
	Dry	7.5	33.9	8.8	2.2	47.6	6
Forbs	Green	14.6	17.6	21.3	2.3	44.2	37
	Dry	8.7	28.7	11.9	1.5	49.2	8

The results of analyses of the central Australian vegetation are summarized in Table 4 which shows the average content of the various constituents at green ('Fresh, green' and 'Early drying') and dry ('Almost' or 'Completely dry') stages of growth. Although the number of specimens in each category varied, there were distinct differences in composition of perennial grasses, annual grasses, shrubs and forbs. Crude protein values rose from perennial grasses through to forbs while annual grasses were the least fibrous in the dry state. The most useful in terms of energy (nitrogen-free extract) were the perennial grasses.

Overall the crude protein content of these native pasture species appears adequate for ruminant nutrition. Wool growth has been shown to be independent of dietary protein level in the range 7.5 to 29% crude protein (Ferguson, 1959) and with sub-tropical pastures, Milford and Haydock (1965) considered that crude protein content needed to be 7.2% to ensure a zero nitrogen balance. In the humid tropics, cattle grazing native pastures achieve maximum liveweight gains early in the wet season, when crude protein levels in the whole plant are in excess of 7.5% (Norman, 1965). As grasses mature however, liveweight gains decrease until about the middle of the dry season after which crude protein levels fall below 2.5% and weight losses occur.

In central Australia however, cattle grazing dry grass-forb pastures continue to gain weight into early summer (Siebert, unpublished data). The average crude protein of dry grasses in the Alice Springs district falls below 7.0%, but by selective grazing of some grasses with small quantities of shrubs and forbs, cattle can apparently meet their protein requirements when sufficient pasture is available. They are probably assisted by the protein available from fodder trees which

have been shown to have crude protein values ranging from 4.2 to 26.7% (Chippendale and Jephcott, 1963; Everist and Young, 1967).

In a series of dry years, pasture availability is the major factor limiting animal production. Pastures of low density and low in grass content are incapable of meeting the animals' requirements although they may have a chemical composition indicating a high nutritive value. In addition, as pastures are thinned out, the animal must use more energy in seeking feed.

Investigations are currently being carried out on the digestibility of some grass, shrub and forb species and it is envisaged that further studies will include assessing the selective grazing habits of stock on these pastures.

ACKNOWLEDGEMENTS

The technical assistance with chemical analyses by Mrs. T. Ellis and Mr. H. Granits is gratefully acknowledged. Thanks is also due to Mr. G. Chippendale for arranging the collection of the plant material.

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