FORAGE SELECTION STUDIES
1. THE BOTANICAL COMPOSITION OF FORAGE SELECTED BY SHEEP GRAZING *ASTREBLA* SPP. PASTURE IN NORTH-WEST QUEENSLAND

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ABSTRACT

Ten merino wethers with oesophageal fistulae grazed with fifteen normal wethers on 40 hectares of Mitchell grass (Astrebla *spp.*) *country, typical of that found in large areas of north-west Queensland. Oesophageal extrusa samples were collected and the plant species identified. The botanical composition and dry matter yield of the experimental area were determined prior to collecting samples of the forage selected by sheep. Body-weights were recorded each month.*

Mitchell grass (Astrebla *spp.*) *made an important contribution to the diet throughout the year with a minimum level occurring immediately after the wet season rains when a large number of plant species, more acceptable to sheep, were available. Flinders grass* (Iseilema *spp.*) *made a maximum contribution to the diet while in the green immature state immediately after the wet season rains. The quantity of Flinders grass consumed during the dry season was low. The large variety of other plant species which form a low proportion of the total pasture dry-matter available, particularly the native legumes were, because of their higher nutritional value, of great importance in the forage selected by sheep.*

INTRODUCTION

The Mitchell grass pasture association of north-west Queensland in the shires of Flinders, McKinlay, Richmond and parts of Cloncurry and Winton, covers an area of approximately 19.6 million ha and depastures approximately 2.4 million sheep and 900,000 head of cattle (Personal communication, Bureau of Census and Statistics). The rainfall is seasonal and variable; effective rain can only be expected during two summer months between December and March with 66% reliability (Farmer *et al.* 1947). The growing season varies from 5–6 weeks at Winton, 9 weeks at Cloncurry, to 15 weeks at Hughenden (Slayter 1964). This area is situated in the hottest part of the State, where the mean monthly maximum temperature is 35°C or greater for the six months, September to February inclusive each year. The soils range from a brown gravelly to a grey heavy-textured clay. In the dry season they crack to a depth of 0.5–0.8 metres (Davidson 1954) and have a high wilting point which limits the quantity of water available for plant growth.

Mitchell grasses have adapted to the harsh environment by developing an efficient root system described by Everist (1951). The basal area of a dense stand may cover only 4–5% of the ground surface, and annual species and many other plant species including native legumes grow prolifically, particularly after the wet season rains (Table 1). The annual species decrease in nutritional value within 2–3 months after germination.

The ability of sheep to select certain plant species has been adequately documented (Leigh and Mulham 1964, 1966a & b, 1967). Factors such as palatability (Heady 1964), sight, smell, touch and taste (Arnold 1966a, b) and the nutritional status of the pastures (Milford and Minson 1966) have also been shown to influence selectivity.

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TABLE 1

The botanical and common names of plant species available to sheep grazing Mitchell grass pastures

Monocotyledons:

Aristida pruinosa,* wire grass; *Aristida latifolia*, feathertop wire grass; *Astrebla elymoides*, hoop mitchell; *Astrebla lappacea*, curly mitchell; *Astrebla pectinata*, barley mitchell; *Astrebla squarrosa*, bull mitchell; *Bothriochloa ewartiana*, desert blue grass; *Brachyachne convergens*, native couch grass; *Chloris divaricata*, slender chloris; *Chloris pectinata*, windmill grass; *Chloris virgata*,* feathertop rhodes grass; *Chrysopogon fallax*, golden beard grass; *Cyperus pygmaeus*, sedge; *Chionachne hubbardiana*; *Dactyloctenium radulans*, button grass; *Dichanthium affine*,* (small) blue grass; *Dichanthium tenue*, blue grass; *Digitaria cterantha*, digitaria; *Echinochloa colonum*, awnless barnyard grass; *Enneapogon polyphyllus*, bottlewasher grass; *Eragrostis cilianensis**, stink grass; *Eragrostis japonica*,* delicate love grass; *Eriochloa crebra*, early spring grass; *Eulalia fulva*, brown top grass; *Isielema vaginiflorum*, (red) flinders grass; *Isielema membranacea*, flinders grass; *Panicum whitei*, pepper grass; *Sporobolus australasicus*, feather grass; *Sporobolus mitchellii*; *Sorghum australiense*,* annual sorghum; *Tragus australianus*, small burr grass.

Dicotyledons:

(Legumes)

Acacia farnesiana, mimosa; *Alysicarpus rugosa*; *Crotalaria dissitiflora*, grey rattlepod; *Crotalaria linifolia*, rattlepod; *Crotalaria trifoliastrum*, rattlepod; *Dicerma biarticulatum*, tick trefoil; *Glycine tomentosa*, woolly glycine; *Indigofera parviflora*, native indigo; *Neptunia monosperma*,* sensitive plant; *Psoralea cinerea*, psoralea; *Rhyncosia minima*, rhyncosia; *Sesbania brachycarpa*, pea bush.

Dicotyledons:

(Other species)

Abutilon malvifolium; *Alternanthera nana*,* hairy joyweed; *Alternanthera nodiflora*,* joyweed; *Amaranthus mitchellii*, roly poly (smooth); *Amaranthus viridis*, green amaranth; *Boerhavia diffusa*, tar vine; *Commelina undulata*, wandering jew; *Corchorus pascuorum*,* corchorus; *Corchorus trilocularis*, corchorus; *Daucus glochidatus*, Australian carrot; *Euphorbia drummondii*, caustic weed; *Euphorbia surrulata*; *Flaveria australasica*, speedy weed; *Glinus lotoides*; *Gnaphalium involucratum*; *Gomphrena conica*, gomphrena; *Goodenia strangfordii*, goodenia; *Goodenia subintegra*, goodenia; *Heliotropium pauciflorum*, heliotrope; *Heliotropium tenuifolium*, native heliotrope; *Heliotropium ventricosum*, heliotrope; *Hibiscus ficulneus*, native rosella; *Ipomoea aquatica*;* *Ipomoea lonchophylla*, cow vine; *Josephinia eugeniae*, josephina burr; *Justica procumbens*; *Malvastrum spicatum*, malvastrum; *Malvastrum trionum*,* bladder ketmia; *Melothria micrantha*; *Morgania glabra*; *Operculina terpethum*, potato vine; *Phyllanthus fuernrohrii*,* phyllanthus; *Phyllanthus maderaspatensis*;* *Polanisia viscosa*, tickweed; *Polygala gabrielae*, polygala; *Portulaca filifolia*, pig weed; *Ptilotus spicatus*,* bachelors button; *Pterigeron adscendens*, mint bush; *Salsola kali*, roly poly (soft); *Sida corrugata*, sida bush; *Sida fibulifera*, silver sida; *Sida rohlenae*, sida bush; *Solanum esuriale*, potato weed; *Teucrium integrifolium*; *Tribulus terrestris*, caltrop; *Wedelia asperrima*, *sunflower daisy

*Plant species common to the Mitchell grass association but not present on the Forage Selection Trial area.

For the semi-arid pastoral country of the Riverine plains, Leigh and Mulham (1964, 1966 and 1967) have discussed the possible effects grazing sheep can have on the composition, yield and quality of the pastures available to the animals and have presented information to show that plant species present in large quantities may contribute very little to the diet of the grazing animal, whereas some of the less significant pasture species may play an important role in the nutrition and therefore, final level of production by sheep. For other areas of Australia, Davies *et al.* (1938), Roe (1941) and Roe and Allen (1945) have made recommendations on pasture management based on animal experimentation. Everist (1935) has made recommendations based on observations collected from various sources rather than results of trials designed to answer specific questions.

In north-west Queensland, very little work has been done to determine which pasture species influence the level of animal production. From observations on sheep grazing under natural conditions, Weston and Moir (1969) suggested that a progressive selection of pasture species and plant portions occurred, beginning with herbs and annual grasses after the wet season rains. The seed heads of Mitchell grass

were next to be grazed followed by the leaf and finally towards the end of the dry season, the stem. This study was a first attempt to assess the grazing preferences of sheep in the Mitchell grass country but the lack of quantitative information has prevented any comparative evaluation of individual plant species. If the herbs and annual grasses are favoured more than the perennial Mitchell grass while the new seasons growth is available, as Weston and Moir have suggested, the risk of damaging Mitchell grass by increasing the stocking rate on a portion of a property while the pasture on another area is conserved, is low. Such speculation must be verified quantitatively if alternative forms of pasture management are to be considered.

The objective of this trial was to determine which pasture species were selected by sheep in relation to the botanical composition of the pastures available.

MATERIALS AND METHODS

The experimental area was a 40 ha paddock on the Toorak Sheep Field Research Station (21°S, 141° 45'E), 48 km south of Julia Creek. The paddock was stocked with 25 3-year old wethers (0.62 sheep ha^{-1}), 10 of which had been fitted with oesophageal fistulae (McManus *et al.* 1962). For three years prior to this experiment the stocking rate was maintained at 0.62 sheep ha^{-1}, this being the district average. The sheep were only removed from the area for crutching and shearing. The experiment commenced on 2/12/1970 and concluded on 14/5/1973.

The botanical composition and dry matter (D.M.) yield of the pasture available to the animals were determined by the Rank-Set Method (Halls and Dell 1966) every four weeks just prior to the collection of extrusa samples from the fistulated animals. The trial area was divided into four bays, each with three parallel transects. Two operators independently assessed three 0.7 × 1.4 m quadrats at 20 sites along one transect in each bay. As one quadrat at every site was harvested, the final estimate of pasture composition and D.M. yield per hectare was based on the assessment of 240 quadrats and the harvested material from 80 quadrats. All the harvested herbage was separated into species and placed in separate bags at the site, then dried later in a forced-draught oven at 60°C and weighed.

The botanical composition of the oesophageal extrusa samples were determined by a technique developed from the works of Storr (1961), Stewart (1967), Sparks and Malachek (1968), and Williams (1969), and modified by the author. (See Appendix 1). The epidermal patterns of the leaf and stem of all plant species available to the experimental sheep during the trial were drawn with the aid of camera lucida equipment and photographed to establish a library of reference patterns.

A standard analysis of variance was used to analyse the botanical composition of the diet and the correlations between the dietary components were estimated from the residual variation after the effect of a month of sampling and the effect of individual sheep had been removed (Table 2).

TABLE 2

The correlation coefficients for the pasture species found in the forage selected and their relationship to the body-weight of sheep

	Flinders grass	Mint bush	Other grasses	Other forbs	Body-weight
Mitchell grass	—0.2528	—0.7053**	0.0220	—0.4971**	—0.4757**
Flinders grass		0.0052	—0.0654	—0.2239	0.1144
Mint bush			—0.3168	0.0584	0.2845
Other grasses				—0.2784	—0.1917
Other forbs					0.4224**

(P* = 0.05; P** = 0.01)

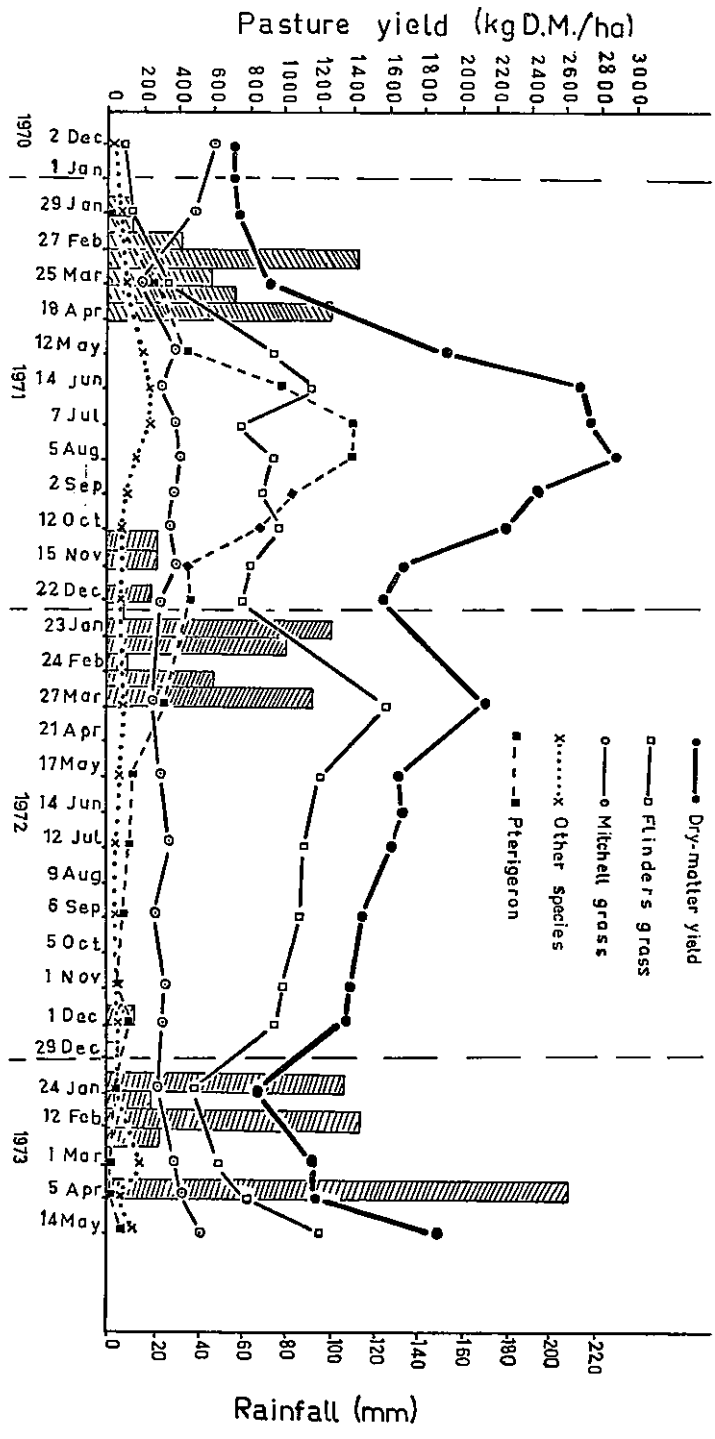

FIGURE 1
Rainfall, dry-matter yield and botanical composition of pastures in N.W. Queensland.

RESULTS

Rainfall distribution

The quantity and distribution of rainfall falling on the experimental area for the 2½ year trial period are shown in Figure 1 and the average monthly and yearly rainfall for Toorak S.F.R.S., Julia Creek and other towns in the Mitchell grass area of north-west Queensland are shown in Table 3. The wettest March (212 mm) and April (105 mm) in the 83-year old Toorak Station rainfall records occurred in 1971. If the wet season is taken as the period between October and April, two wet seasons recorded during the experiment were very similar and slightly below average, *viz.* 1970/71—385 mm, 1971/72—398 mm, whereas the 1972/73 wet season was above average with 454 mm.

Botanical composition of pasture

The dry matter yield and botanical composition of the pastures are summarized for the trial period in Figure 1. The main feature of these results is the variation in botanical composition over the trial period. 1971 was dominated by *Pterigeron* and Flinders grass with a large number of other species contributing to the collective term "other species". In 1972, and to a lesser extent, 1973, Flinders grass alone was the dominant species.

Botanical composition of selected forage

The botanical composition of the forage selected by sheep is shown in Figure 2. The main points of interest in these results are:

(i) the lowest intake of Mitchell grass occurs during the wet season;
(ii) the proportion of Mitchell grass in the diet increased during each year to become the dominant species by the end of the dry season;
(iii) the large contribution of "other species" in the diet during and immediately after the wet season rains. During these peak contributions the proportion of forbs to grasses was approximately 3:2, but during the dry seasons of 1971 and 1972 when the total contribution was less than 20%, the ratio was 1:1 and 1:2 respectively (see Table 4);
(iv) the low overall contribution of Flinders grass to the diet of sheep;
(v) the high contribution of *Pterigeron* to the diet of sheep in 1971 compared with the very low contribution in 1972.

Sheep liveweight

The average fasted liveweights of the trial sheep are shown in Figure 2. Each year liveweight was lowest at the end of each dry season and highest during the middle of the year (July-August).

Forage selection

The ability of sheep to select forage differing in composition from that of the available pastures is shown in Table 4.

DISCUSSION

Rainfall distribution and pasture composition

Pasture growth in north-west Queensland is very rapid when moisture is available and a dramatic change in botanical composition and D.M. yield occurs after the onset of the wet season. Approximately the same quantity of rain fell in the wet seasons of 1970/71 and 1971/72 but the main falls occurred in March-April and January-February respectively. The botanical composition and maximum D.M. yield of the resulting pastures for those two years were quite different (see Figure 1). By comparison, the 1972/73 wet season had a two-peak distribution; approximately 225 mm between January and mid-February, which stimulated Mitchell grass and

TABLE 3

Average monthly and yearly rainfall (mm)

Location	Av. Yearly Rain mm	No. of Years Records	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Hughenden	479.0	86	20.3	31.2	68.1	112.3	97.3	59.2	24.4	17.0	20.3	12.2	7.1	9.7
Julia Creek	439.2	58	14.5	25.9	66.3	106.2	112.7	56.9	18.0	17.5	11.2	7.9	2.3	4.1
Toorak S.F.R.S.	438.9	83	14.2	22.4	56.4	106.4	94.7	61.2	18.3	15.5	14.0	7.9	3.3	6.1
Winton	395.0	87	17.3	27.9	47.5	77.7	80.0	55.1	20.3	19.8	19.3	14.7	5.6	9.7

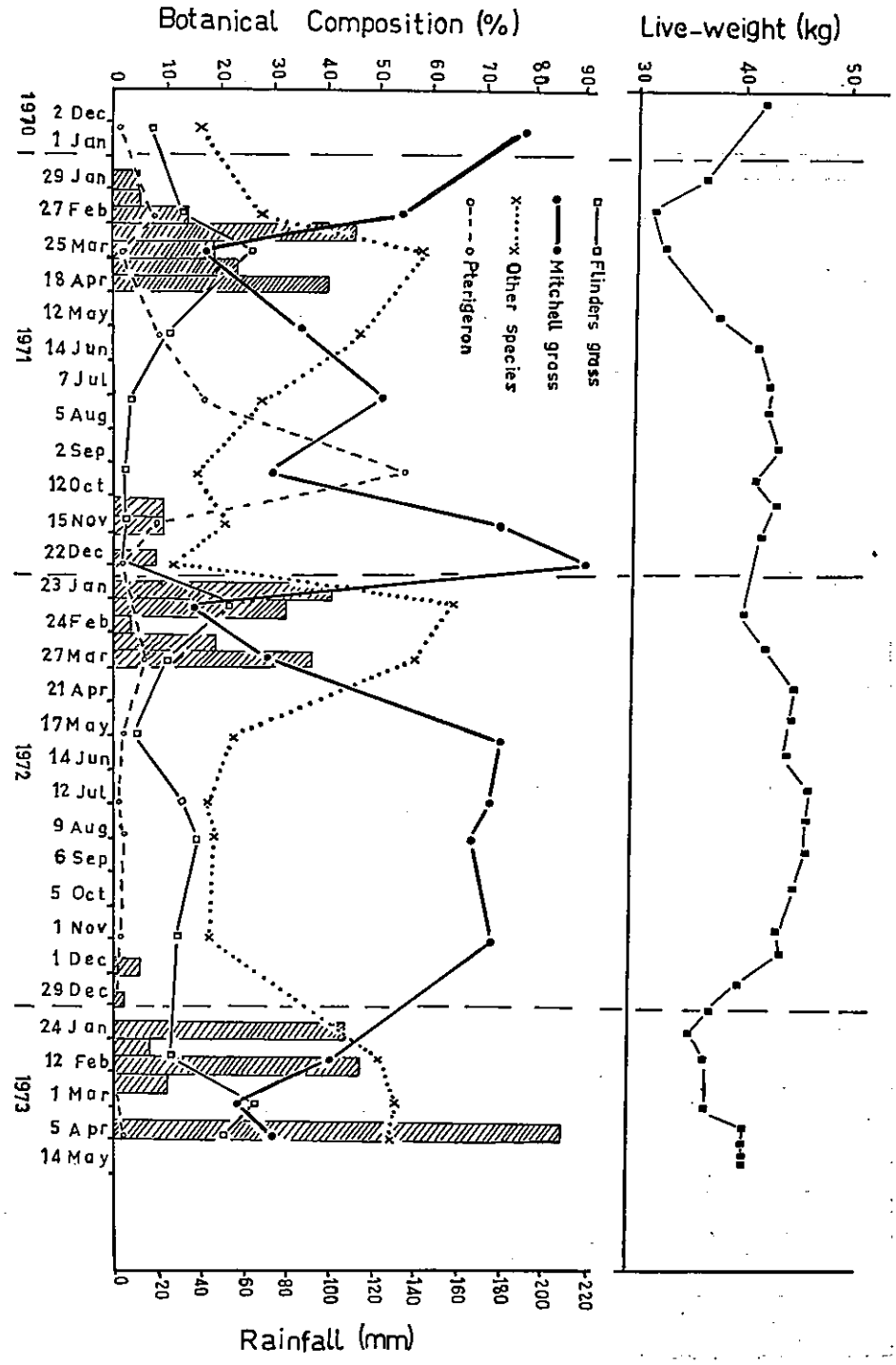

FIGURE 2
Rainfall, botanical composition of forage selected by, and live-weight of sheep in N.W. Queensland.

TABLE 4

Forage selection by sheep compared to pasture composition

Date	Composition	Mitchell grass %	Flinders grass %	Pterigeron %	Other species %
January, 1971	Pasture on offer	70	21	9	0
	Forage selected	61	9	5	25 (9 forbs, 16 grass)
March, 1971	Pasture on offer	17	36	37	10
	Forage selected	16	26	1	57 (35 forbs, 22 grass)
July, 1971	Pasture on offer	14	31	50	6
	Forage selected	50	3	18	29 (13 forbs, 16 grass)
December, 1971	Pasture on offer	19	50	29	2
	Forage selected	87	1	2	10 (5 forbs, 5 grass)
March, 1972	Pasture on offer	11	76	11	2
	Forage selected	29	10	6	55 (38 forbs, 17 grass)
July, 1972	Pasture on offer	21	69	8	2
	Forage selected	70	12	1	17 (6 forbs, 11 grass)
November, 1972	Pasture on offer	21	69	7	3
	Forage selected	71	10	1	18 (2 forbs, 16 grass)
March, 1973	Pasture on offer	29	53	3	15
	Forage selected	22	25	1	52 (32 forbs, 20 grass)

the annual grasses, particularly Flinders grass, and a further 200 mm four weeks later which caused very little change to either botanical composition or D.M. yield. It may be assumed that competition by the well established Flinders grass for the moisture in the top 2–3 cm of soil prevented those plant species which develop late in the season, from becoming established. Pasture sampling in April, 1973 revealed large numbers of small *Pterigeron* plants, which had died before the primary root could extend below the 2–3 cm of surface soil containing Flinders grass roots. As water runoff after the second fall of rain in 1973 was low and the ground had developed large cracks since the first fall, most of the water percolated down to the subsoil to become a valuable source of moisture for Mitchell grass and other deep-rooted species for many months into the dry season.

Sheep continued to graze the area during all pasture measurements, however their influence on the botanical composition and D.M. yield of the pasture is likely to be minimal at least in the short term, viz.

(i) 27th February, 1971 - 14th June, 1971—available pasture increased from 700 kg D.M. ha^{-1} to 2 700 kg D.M. ha^{-1}; i.e. an increase of 2 000 kg D.M. ha^{-1} or 3 200 kg D.M. 1.6 ha^{-1} where 1.6 ha = 1 sheep area.

1 sheep during that same period (100 days) consuming 1.5 kg D.M. day^{-1} (over-estimate) would account for 150 kg D.M.;

i.e.

$$\frac{150}{(3200 + 150)} \times 100 = 4.8\%$$

(ii) 24th February, 1972 - 27th March, 1972—available pasture increased from 1 550 kg D.M. ha^{-1} to 2 100 kg D.M. ha^{-1}; i.e. nett increase of 550 kg D.M. ha^{-1} or 880 kg D.M. 1.6 ha^{-1}.

1 sheep during that same period (32 days) would account for $32 \times 1.5 = 48$ kg D.M.;

i.e.

$$\frac{48}{(880 + 48)} \times 100 = 5.2\%$$

Therefore as the grazing animal has only a minor influence on the quantity of pasture D.M. available during this period of rapid pasture growth, the main influence on the total D.M. yield and botanical composition, must be the quantity and distribution of rainfall during the wet season.

Winter rain is very erratic and cannot be relied on to stimulate further pasture growth. In general, only light showers occur and the dry standing herbage is knocked to the ground and leached of its remaining nutrient content. Winter rain has been reported to turn pastures black, rendering them useless as food for sheep (Blake 1938), however no winter rain fell during the trial period.

Forage selected by sheep

Weston and Moir (1969) believed that after the wet season rains, sheep grazed only the succulent forbs while they were available, but in this trial the epidermal patterns of Mitchell grass were also found in the extrusa samples collected from O.F. sheep. Mitchell grass was the main component in the diet selected by sheep throughout the year, however for approximately eight weeks following the onset of the wet season, it was grazed less intensively and its proportion in the diet decreased to approximately 15%.

Flinders grass has long been regarded as a very important fodder grass. In a survey by Everist (1935) on the acceptability of pasture species by stock in south-west Queensland, only two graziers had doubts about its nutritional value. The same general opinion occurs in north-west Queensland. In the forage selection trial it was found that sheep ingested maximum quantities of Flinders grass only when it was in a green immature state. Once it matured and became dry, intake decreased to less than 10% of the total D.M. intake. Once the small seeds of Flinders grass have matured and fallen from the plant, the remaining vegetative parts constitute a low quality fodder (Lorimer, unpublished) which, because of its brittle nature, is very susceptible to mechanical damage by wind and stock. It has been calculated that of the quantity of Flinders grass actually disappearing from the pasture during the dry season, less than 5% was consumed by sheep (Lorimer, unpublished).

The "other species" component of the pasture increased rapidly after the wet season rains but rarely exceeded 10% of the total pasture D.M. During the same period, their contribution to the diet of sheep was approximately 60% of the D.M. ingested. The native legumes are important for their contribution to animal production. The foliage and seedpods are a nutritious fodder, eagerly sought by sheep and those species with a deep root system provide valuable green material during the dry season, long after the annual grasses and many forbs have dried off and lost their

nutritional value. A significant correlation was established between the bodyweight of sheep and the proportion of forbs in their diet ($r = 0.4$, $P < 0.01$) indicating the importance of these plant species in the overall nutrition and associated animal production of sheep on Mitchell grass pastures.

The rapid increase in the quantity of *Pterigeron* following the 1970/71 wet season typifies the variation that can be expected in botanical composition from the Mitchell grass association. A late wet season of about average rainfall, and cool ambient temperatures following the last rains in April presumably suited the growth requirements of *Pterigeron*. From the similar patterns of increase and decrease in the proportions of *Pterigeron* in the pasture D.M. and the D.M. intake shown in Figure 1 and Figure 2 it is reasonable to assume that sheep do not actively select this plant species, but merely graze the bushes as they are confronted.

Table 4 provides a comparison between the plant species available and those actually selected by sheep during the trial period (values have been taken from Figures 1 and 2). During March of each year approximately half the forage selected by sheep consisted of "other species" which formed between 2 and 15% of the available pasture. It can also be seen that the "other forbs" were selected in preference to "other grasses" in the ratio of 2:1 whereas during the dry season the ratio was approximately 1:1.

The major contribution to the diet by Mitchell grass occurred during the dry season whereas the major and quite low contribution by Flinders grass occurred during the wet season while the pastures were still green. *Pterigeron* varied considerably in its availability with only one period when it formed a major component of the diet, from July to October, 1971.

Animal condition

As all the liveweight results have been corrected for wool growth, the 12 kg variation in 1971 and the 6 kg variation in 1972 indicate the real fluctuation in the body condition of an average 35–40 kg animal. Having sheep in very poor condition at the end of the dry season is a dangerous but common situation. Floods and extremely boggy conditions often isolate stock from food for days and many sheep die because their energy reserves are insufficient to cope with such extreme conditions.

CONCLUSION

It is unlikely that any two consecutive wet seasons in north-west Queensland would have the same quantity or distribution of rainfall, but the results of this trial indicate that rainfall plays a major role in determining the botanical composition and D.M. yield of the resulting pasture. When the main rains of the wet season occurred during December or January, the pastures were dominated by annual grasses, particularly Flinders grass. Such a pasture is not very productive and quality deteriorates rapidly as the dry season progresses. Conversely, when the main wet season rains occurred in March or April, the pasture contained a high proportion of winter growing dicotyledonous species. A longer growing season with an additional period of growth in the spring improves the quantity and quality of herbage available and is therefore, more likely to maintain sheep in good condition until the following wet season.

Sheep in north-west Queensland are selective in the pasture species they graze. Flinders grass, despite its relatively large dry matter yield in certain seasons, is not an important component of sheep intake, especially after it has matured and nutritional quality has deteriorated. Mitchell grass is always present in the ingested material although intake decreases when the new season's pasture is available. *Pterigeron* can be an important component in a sheep's diet, however its presence in the pasture and its dry matter production is dependent on particular seasonal conditions. The forb component of the pasture is very important in sheep nutrition, since these highly

nutritious plant species are selected in preference to the more common pasture species and are mainly responsible for the improved body condition of the sheep following the wet season rains.

Since a number of native legumes are included in this forb component there is a need to determine if a natural limitation to the legume dry matter production exists or if pasture management can increase the yield. The species of *Crotalaria, Glycine, Psoralea* and *Rhyncosia* offer a great potential for improving the nutritional quality of the herbage available to sheep.

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APPENDIX I

The standard reference material was cut into 0.5 cm pieces and washed gently, whereas the extrusa samples for each sampling period were bulked on an individual animal basis, chopped finely with a sharp knife and sub-sampled by quartering until

approximately 15 g was available. The technique for preparing a standard reference slide, and a slide of extrusa material after this initial preparation, and is described in detail below. Approximately 6–7 g of material was placed in an erlenmeyer flask containing 20–25 ml 45% HNO_3 and allowed to stand in a water bath set at 60°C for 24 hours. The flasks were shaken every 6–8 hours. The macerated material was then washed (Storr 1961) and transferred into a small flask containing absolute alcohol for 5 minutes, filtered (Whatman paper No. 4) and eluted off the filter paper into another flask containing fresh absolute alcohol. After a second filtering, small quantities of material selected at random were placed on each of three microscope slides, mixed thoroughly with Euparal (G.B.I. Ltd.) mountant, covered with a cover slip and dried in an oven at 45°C for two days.

Fifty fields located on a grid pattern of each slide containing extrusa material were observed under a magnification of × 128 using a Standard R. A. Carl Ziess Microscope with a Normarski differential interference-contrast attachment. A density of 2–3 epidermal particles per field was considered optimal and identification was made by comparing the epidermal patterns with those in the standard reference library. The frequency of species occurrence was on a presence only basis, that is, if the species was identified, it was marked as being present regardless of the number of epidermal pieces visible. Staining of the plant material was not necessary with the special microscope attachment available. The formulae used to convert the frequency of species occurrence to a percentage D.M. composition can be found in Cavender and Hausen (1970) *viz.*

(i) Converting frequency (F) to density (D)

$$F = 100\ (1 - e^{-D})$$

(ii) Relative density of a species

$$\text{R.D.} = \frac{\text{Density of particles of Species A}}{\text{Total density of particles of all species}} \times 100$$

(iii) The relative density of the particles of Species A is then equivalent to the percent dry matter of Species A in the unknown sample.