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THE EFFECTS OF SEASON, STAGE OF GROWTH, AND SOIL TYPE ON THE CHEMICAL COMPOSITION OF GRASSES IN THE QUEENSLAND "WET BELT."

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SUMMARY.

1. The chemical composition of the principal grasses—Para, molasses, Guinea, sour and Russell River grasses—growing on alluvial soils in the tropical "wet belt" of Queensland was investigated. Only the leafy parts of the grasses, such as are eaten by cattle, were selected for analysis.

2. The dry matter content of Para, molasses and Guinea grasses is higher in long than in short grass; and is higher in the dry season than at the end of the wet season for both long and short Para and molasses grasses.

3. The crude protein content rises with the progress of the wet season and falls sharply during the dry spring months. There is no marked seasonal influence on the phosphate content, but in most cases the calcium content rises markedly during the dry period.

4. Long Para grass has a higher crude protein than short grass. Short molasses grass contains more phosphate than long, but is no higher in crude protein and calcium. Soil type affects the composition of Para grass.

5. A relationship is shown to exist between protein and phosphate for Para grass during the greater part of the year.

6. Possible deficiencies in the pasture revealed by the analyses are discussed and means of overcoming them are considered.

INTRODUCTION.

The Queensland "wet belt" is a relatively narrow tract of coastal country extending approximately from the Herbert River (lat. 18° 32′ S.) to the Daintree River (lat. 16° 22′ S.), a distance of about 160 miles. The coastal ranges of the Main Divide, lying between 10 and 50 miles from the coast, form the western boundary of the area. The region has a high rainfall and is watered by numerous swiftly-flowing rivers and creeks running from the ranges to the sea. The topography varies, being flat in some districts and hilly and broken in others.

The distribution of the flora of the region is governed largely by soil factors and under natural conditions the dominant type of vegetation is tropical rain-forest, commonly termed "scrub." This occupies the most fertile, deep soils, which are well supplied with moisture. Where the soil is shallower, or where for some other reason soil moisture conditions are less satisfactory, eucalypt forest or open plain country carrying native grasses predominates. The open forest formation occurs mainly on the least fertile soils, and these areas remain largely undeveloped, whereas the more fertile, cultivable scrub and plain country is now devoted mainly to the production of sugar cane.

For some years prior to the outbreak of war in 1939 attempts were being made in Queensland to expand the export trade in chilled beef, and particularly to ensure a continuity of supply throughout the year. In 1935 the late Mr. Brice Henry, who for many years had been engaged in raising cattle in North Queensland for the local market, conceived the idea of utilizing pastures in the wet belt for the purpose of fattening young stock for killing as "chillers." At that time Mr. Henry already had paddocks of Para grass (*Brachiaria purpurascens*) on his "Riversdale" property at Tully, and further areas of this and other grasses were quickly planted at "Riversdale." Plantings by other pioneers followed on various properties throughout the north-eastern coastal region. The exploratory work of these landholders soon established the fact that certain species of grasses were outstanding in the region for fattening cattle under a system of intensive grazing. Particularly good results were obtained from Para grass and this was used more extensively than any other species. However, it soon became apparent that, in order to develop the industry along sound lines, the collection of fundamental data upon the pastures was required. Accordingly, in co-operation with Mr. Henry, experiments were carried out at "Riversdale" to ascertain the relative merits of Para grass and other species then being used and to detect any major deficiencies in the chemical composition of the grasses. A series of pasture experiments was conducted between 1937 and 1940. The investigations reported here were begun in 1939 and completed early in 1940. They deal with the chemical composition of the principal grass species in the Tully paddocks and the changes or differences in the composition of each species attributable to season, stage of growth, and soil type.

DESCRIPTION OF THE EXPERIMENTAL AREA.

Climate.

The climatic conditions of the Tully district are typical of those of the wet belt. The number of wet months in the year and the total precipitation are both sufficiently great to justify the use of the term "wet belt" in referring to the area, but there is a well-defined dry season of comparatively short duration. The average annual rainfall is about 150 inches, of which approximately 75 per cent. is recorded in the first six months of the year. The climate is, in short, a "monsoon climate," such as is typical of much of the humid tropics.

From January to July—the usual extent of the so-called wet season—the rainfall is high. Totals of over 30 inches are usual for each of the months of the "mid-wet" period—*i.e.*, February and March—and during this time the rainfall is characterized by intermittent torrential falls, when the surface run-off is considerable and flooding of rivers and creeks occurs. During April, May and June the rainfall is lower, though wet days are numerous; the surface run-off during this "late-wet" period is small, while the evaporation is low. As a consequence of these climatic conditions the soils are often waterlogged for several days. The cessation of the wet season is somewhat abrupt, July being usually a transition period heralding the approach of the dry season.

August, September and October are the dry months, when rainfall is light and sporadic and the skies are usually clear. Temperatures and evaporation during this period are moderate. The dry period is usually broken by storms in November, though the rainfall both in this month and in December is uncertain. Nevertheless, the rainfall usually is sufficient to promote new pasture growth, and these months mark the beginning of the period of increasing productivity.

The following meteorological data have been recorded at Innisfail, where climatic conditions are similar to those at Tully:—

Mean maximum and mean minimum temperatures for the year	83°F. and 65°F.
Mean maximum and mean minimum temperatures for the coldest month (July)	76°F. and 57°F.
Mean maximum and mean minimum temperatures for the hottest month (January)	88°F. and 72°F.
Relative humidity for the year (9 a.m. reading) ..	75% to 85%
Mean relative humidity for the year (9 a.m. reading)	81%

Soils.

The soils of the area on which the investigations were made are alluvial in character, and are of two distinct types, referred to here as the "scrub" soil and the "plain" soil. The scrub soil is so called because its native vegetation is a dense scrub or tropical rain-forest. The plain soil is the type belonging to a tract of flat country, between the Murray and the Tully Rivers, which is open and treeless and on which native grasses are practically the sole form of natural vegetation. These open areas are fairly extensive in places and seemingly are large flood plains. The scrub soil is a light-brown loam, friable and porous, and fairly deep. The plain soil is a dark-grey to black clay-loam, which is sticky when wet and hard and compact when dry. Drainage through this soil is impeded.

Mechanical analyses of samples of the scrub soil show that it consists mainly of fine sand (25 per cent.-30 per cent.), silt (22 per cent.-32 per cent.), and clay (26 per cent.-35 per cent.). It contains a moderate quantity of organic matter (4 per cent.-5 per cent.), fairly large quantities of nitrogen, and moderate amounts of lime and potash, but is deficient in phosphoric acid. The replaceable lime and available phosphate are both somewhat low, but the replaceable potash is apparently satisfactory. This type of soil is markedly acid. The range of values obtained from a number of analyses of the scrub soil, and an analysis of a sample of the plain soil, are set out in Table 1. It will be seen that the plain soil is apparently of lower average fertility than the scrub soil and is also more acid.

Table 1.

Some Analytical Data for the Scrub and Plain Soils.

——	Scrub Soil.	Plain Soil.
Nitrogen	0·26–0·32 per cent.	0·30 per cent.
CaO	0·20–0·30 per cent.	0·17 per cent.
K_2O	0·20–0·25 per cent.	0·19 per cent.
P_2O_5	0·12–0·14 per cent.	0·12 per cent.
Replaceable Ca	4·0–8·0 m.e. per cent.	4·0 m.e. per cent.
Replaceable K	0·5–1·0 m.e. per cent.	0·7 m.e. per cent.
Available P_2O_5 (Truog) ..	15–30 p.p.m.	30 p.p.m.
Fe_2O_3, Al_2O_3, MnO ..	22–28 per cent.	29 per cent.
SiO_2	58–65 per cent.	53 per cent.
pH	5·0–5·6	4·9

The plain country is flooded for a few days on at least one occasion each year. The scrub country is not so subject to flooding because of its slightly higher elevation, and only exceptionally high floods cover it to any extent; in any case the flood waters recede from it fairly quickly. Three of the experimental paddocks were situated on areas of scrub soil and the fourth on an area of plain soil.

Grasses.

The five species constituting practically the whole of the pasture complex on the experimental area comprised three cultivated perennials and two adventitious indigenous perennials. The exotics were *Brachiaria purpurascens* Raddi (Para grass), *Melinis minutiflora* Beauv. (molasses grass) and *Panicum maximum* Jacq. (Guinea grass), which occupied 80 per cent., 12 per cent., and 2 per cent. respectively of the experimental paddocks. The indigenous species were *Paspalum conjugatum* Berg. (sour grass) and *Paspalum paniculatum* L. (Russell River grass), occupying 3 per cent. and 2 per cent. respectively of the paddocks.

It might seem that, because of the marked predominance of Para grass, this species was planted most extensively on the area. An examination of the history of the paddocks, however, revealed that in most of them the original mixture consisted of equal amounts of Para grass and molasses grass. Apparently climatic conditions are primarily responsible for the increase in the percentage of Para grass, for it has been observed that, under semi-saturated or fully saturated soil conditions, Para grass is much more aggressive than is molasses grass. During 1937-38 data on the rate of growth of Para grass were colllected by A. F. Skinner and R. F. Langdon in the course of investigations into the most suitable management practice for this grass. From their unpublished results these workers estimated that the rate of growth was roughly ten times as rapid at the flush in May and June as in November, when it was slowest. The storm rains of November, December and January caused a gradual improvement in the rate of growth, which increased fairly rapidly in February, March and April, remained constant during May, June and July, and then declined very rapidly during August and slowly during September and October to the minimum level of November. These observations suggest that there is some correlation between rainfall and rate of growth. A high correlation, however, is not to be expected, since much of the rain which falls during the wet season is ineffective, being lost by run-off and percolation. The water which is retained by the soil and subsequently utilized by the plant in its development—i.e., the effective rainfall—is a more significant factor. Actually it is found that growth is most prolific during the late-wet period, when fairly continuous light rain maintains the soil moisture at about field capacity.

Molasses grass flourishes in warm weather when provided with liberal soil moisture, but observations indicate that it at no time grows very rapidly. It is intolerant of waterlogged soil conditions and perishes or receives a severe check in positions where drainage is poor. On the other hand, in the dry season molasses grass seems to exceed Para grass in growth rate, and it is green and succulent-looking when Para grass is dry and unpalatable.

Guinea grass has been planted for observation purposes in a few small, scattered patches within the area. It consistently provides green, succulent feed, being apparently tolerant of both wet and dry conditions. Its large and relatively deep root system seems to enable the plant to draw upon a comparatively large amount of soil moisture in dry weather, but its growth rate is highest during periods of wet weather.

The two indigenous grasses are to be found mostly on the edges of the road through the paddocks and along pathways and pads and in other places where the exotic grasses have been trampled out by the stock. Sour grass is eaten to some extent, but Russell River grass is avoided by cattle. Both of these grasses—and particularly sour grass—thrive best under wet conditions.

PURPOSE OF THE INVESTIGATIONS.

The purpose of the investigations discussed in this paper was to ascertain the nature and extent of any gross changes and differences which might occur in the chemical composition of each of the more important grass species growing on the alluvial soils at Tully. Information about each of the five grasses selected was sought along the following lines:—

1. Seasonal changes in chemical composition of "long" grass.
2. Seasonal changes in chemical composition of "short" grass.
3. Differences in chemical composition of "long" and "short" grass.
4. Differences in chemical composition of "long" and "short" grass between paddocks.

As Para grass was the most important species in the paddocks it was studied more intensively than the others.

TECHNIQUE.

Sampling Areas.

Four paddocks, each of approximately 60 acres, were set aside for the experiment. Paddocks 1, 2 and 3 were situated on scrub soil and Paddock 4 on plain soil. For the purpose of collecting Para grass samples, each paddock was marked off into four approximately equal areas, the subdivision being based mainly on obvious topographical differences where it was practicable to do so.

Time of Sampling.

The collection times were chosen so as to be representative of the four rainfall periods already discussed. They were usually as follows:—

1. Late December or early January ("pre-wet" period);
2. Late March or early April ("mid-wet" period);
3. Late June or early July ("late-wet" period);
4. Late September or early October ("mid-dry" period).

Type of Sample.

In order to get information concerning the composition of the grasses at different stages of growth, samples of long grass and short grass were collected at each period. The heights adopted to distinguish the two stages are given below for each of the five grasses:—

	"long." ins.	"short." ins.
Para grass	> 24	< 12
Molasses grass	> 18	< 10
Guinea grass	> 24	< 12
Sour grass	> 10	< 6
Russell River grass	> 15	< 8

The distinctions as to height were not rigid, but were decided upon as the appropriate limits to serve as a guide to the collector and to ensure that two quite different stages of growth would be represented by the samples collected.

Collection Technique.

A collection technique was adopted which aimed at procuring only those parts of the grasses which are normally chosen by grazing cattle, since the chemical composition of pasturage not selectively sampled is of little significance where the bulk of the pasture is made up of a "stemmy" grass such as Para grass.

Close observations of the grazing habits of the stock had revealed that only the young, succulent leaf is selected by the animals from grasses such as Para grass and molasses grass. Old leaf and stem of these grasses are not eaten and the seedhead and stem of Guinea grass are likewise avoided. In order therefore, to obtain samples of the grasses which would represent the part actually ingested by stock the young, succulent leaf at the tips of the runners—or, in the case of short grass, bud or seedling leaf—was hand-plucked from Para and molasses grasses. From Guinea grass the leafy parts without stems or seed-heads were selected. Similar judgement was used in sampling sour grass and Russell River grass.

Under grazing conditions Para grass may regenerate by various methods, viz., (*a*) by indeterminate elongation of its main stems or runners; (*b*) by the development of lateral buds on the stems; and (*c*) by the production of new tillers from the original crown. If the growing points at the ends of the main stems are not eaten off by stock the first method is dominant and may continue until checked by physiological limits. Where the stalks have been broken through below the growing point the development of lateral buds is stimulated. This occurs to the greatest extent under moist conditions, particularly where the nodes concerned make contact with the soil and take root. When rooting is well developed and the old stem begins to die the new leafy bud shoots elongate to form the main running stems of a new plant. The third method comes into prominence only where the main stems of a plant have been eaten or cut back severely to near the crown. This does not occur frequently with Para grass, except in the very young stages of growth. The samples of long material therefore consisted mainly of terminal leaf from old runners or from new runners developed from the crown or from lateral buds. Short material was derived mainly from newly developed lateral leaves.

Similar general conditions apply in the case of molasses grass, though here the growth is more erect, rooting at the nodes less common, and tillering from old crowns more prolific. In addition, seeding plays a more prominent part in the regeneration of this species. In the cases of Guinea grass, sour grass, and Russell River grass, long and short material would represent approximately semi-mature and young leaf respectively.

Number of Samples.

At each sampling, from each marked-off plot in each paddock a sample of long Para grass was collected by taking by hand over 100 pluckings throughout the area of each plot. Similarly, a sample of short Para grass was collected from each plot. Thus from each of the four paddocks four samples of young leaf of both long and short Para grass were collected. For the indicative tests of the other grasses a smaller number of samples of the leaf of each was plucked. The sampling aimed at for each collection period was as follows:—

1. Para grass—4 samples of long grass and 4 samples of short grass from each of the 4 paddocks.
2. Molasses grass—1 sample of long grass and 1 sample of short grass from each of the 4 paddocks.
3. Guinea grass—1 sample of long grass and 1 sample of short grass from each of 2 paddocks.
4. Sour grass and Russell River grass—1 sample of long grass and 1 sample of short grass from 1 padodck.

Because of the slow recovery of the grasses in the late-wet and mid-dry collection periods, it was not possible to obtain a complete series of samples at those times.

Treatment of Samples.

When practicable, the samples were weighed immediately after collection. Subsequently, they were sent to the Bureau of Tropical Agriculture at South Johnstone for drying and chemical analysis. A proximate analysis of the dried herbage of each sample was made, and, in addition, the calcium and phosphate contents were determined.

Grazing Practice.

Throughout the year the paddocks were grazed in rotation. The number of stock carried averaged 100 head. A three weeks' grazing period on each paddock was found to be satisfactory for most of the year. By such a routine each paddock was spelled for nine weeks, which, when rainfall was adequate, gave the grasses time to recover and produce a good stand of succulent leaf. An altered routine had to be adopted, however, in the latter part of the year, when the productivity of the grasses was low owing to particularly dry weather conditions and recovery of the paddocks was slow. To cope with the circumstances longer periods between grazings were allowed on some occasions, while eventually the number of head of stock was reduced.

RESULTS OF THE EXPERIMENTS.

Dry Matter Content of the Grasses.

Data were obtained on the dry matter content of two series of samples—one series taken at the late-wet period when productivity is high, and the other at the mid-dry period when productivity is low. Examination of the figures, which are shown in the appendix, reveals a considerable variation among samples taken during the same period. This is attributable largely to differences in topography, on account of which soil moisture variations were considerable; some samples were composed mostly of grass growing in depressions where drainage was not free. Such samples usually contained a high percentage of moisture in comparison with samples taken from more elevated sites. The data for the five grasses are summarized in Table 2.

Table 2.

DRY MATTER CONTENT OF THE GRASSES.

(Mean values ; percentages of Green Weights.)

Para Grass.

——	Paddock 1.			Paddock 2.		
	Late-wet.	Mid-dry.	Mean.	Late-wet.	Mid-dry.	Mean.
Long ..	23·4	26·3	24·9	20·0	27·8	23·9
Short ..	21·5	22·3	21·9	18·4	23·0	20·7
Mean ..	22·4	24·3	23·4	19·2	25·4	22·3

Paddock 1: Long minus Short highly significant. Mid-dry minus late-wet highly significant.

Paddock 2: Long minus Short significant. Mid-dry minus late-wet highly significant.

No significant interaction between season and stage of growth, though suggestion of this in Paddock 1.

Molasses Grass.

——	Late-wet.	Mid-dry.	Mean.
Long	26·4	31·3	28·9
Short	23·9	28·1	26·0
Mean	25·1	29·7	27·4

Long minus Short significant.
Mid-dry minus late-wet highly significant.
No interaction between season and stage of growth.

Guinea Grass.

——	Late-wet.	Mid-dry.	Mean.
Long	29·9	33·6	31·8
Short	26·5	26·1	26·3
Mean	28·2	29·9	29·05

Long minus Short highly significant.
Seasonal difference and interaction not significant.

Sour Grass.

——	Late-wet.	Mid-dry.
Long	22·2	..
Short	23·2	23·7

Russell River Grass.

——	Late-wet.	Mid-dry.
Long	26·5	26·9
Short	24·8	25·0

In the case of Para grass, an analysis of the data indicates that both season and stage of growth have a significant effect upon the amount of dry matter. In the dry season the dry matter content of the grass is greater than at the end of the wet season, while the long grass contains more dry matter than the short at both of these periods. For Paddocks 1 and 2 the seasonal effect is highly significant in each case, while the effect of stage of growth is highly significant for Paddock 1 and significant for Paddock 2. No significant interaction is shown between season and stage of growth, although there is a suggestion of interaction in Paddock 1. The data from Paddocks 3 and 4 are inadequate to show interactions. In Paddock 3 (see appendix) the increase in dry weight for the mid-dry period over the late-wet period is considerably greater for long grass (only two replicates) than for short (four replicates), which suggests interaction between seasons and stage of growth as in Paddock 1. While the interaction has not proved significant in Paddocks 1 and 2, and cannot be proved in Paddocks 3 and 4 on account of insufficient data, there is a definite tendency for the difference between long and short grass in dry matter content to be more marked during the dry season than at the late-wet period. This accords with expectations, since during the dry season the grass tends to mature early, so that the long sample represents fairly mature grass while the short sample is still relatively young. During the late-wet period the long and the short samples would approximate more closely to the same stage of maturity.

With molasses grass the increase in dry matter content during the dry season is highly significant and is of the same order for both long and short samples. Long grass is also significantly higher in dry matter content than short in both periods.

The difference between long Guinea grass and short Guinea grass is highly significant. Because of the paucity of data no significance can be attached to the differences between seasons nor to interaction.

No important differences are manifested in the meagre data available for sour grass and Russell River grass.

Chemical Composition of the Grasses.

Para Grass.

The composition of Para grass shows definite seasonal changes which are of considerable importance. The crude protein content of both long and short grass rises steadily in the wet season and drops sharply in the three months of dry weather following the late-wet period (Table 3). For long grass the decrease is 3.9 per cent. and for short grass 3.4 per cent., both decreases being highly significant. In long grass the crude protein is significantly higher in the pre-wet period than in the dry season, but in short grass the difference is not significant. The inferior quality of the leaf in respect of crude protein after periods of dry weather is definitely established by these investigations. Wet weather, which greatly increases productivity, also improves the quality of the grass.

Table 3.

Showing the Analytical Data for the Oven-dry Material of Long and Short Para Grass at the Four Collection Periods (Mean Values).

Period.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5
			Long.				
A. Pre-wet	13·3	45·7	1·7	30·3	9·0	·528	·618
B. Mid-wet	14·8	45·0	1·6	29·9	8·6	·475	·559
C. Late-wet	15·1	*	*	*	9·5	·627	·596
D. Mid-dry	11·2	*	*	*	14·3	1·283	·532
Standard Error ..	±·470 A, B, C > D B, C > A	±·357	±·0453	±·115	±·485 D > A, B, C	±·0534 D > A, B, C	±·0254 A > D
F value ..	14·47 Highly significant	1·73 Not significant	< 1 Not significant	8·33 Not significant	30·07 Highly significant	49·35 Highly significant	2·24 Not significant
			Short.				
A. Pre-wet	11·8	46·4	1·8	30·0	10·0	·566	·649
B. Mid-wet	13·5	45·6	1·6	30·3	8·9	·475	·555
C. Late-wet	15·5	*	*	*	10·5	·675	·652
D. Mid-dry	12·1	*	*	*	12·7	1·047	·562
Standard Error ..	±·450 B, C > A, D C > B	±·542	±·0318 A > B	±·310	±·343 (A > B) C > B D > A, B, C	±·0231 A > B C > A, B D > A, B, C	±·0273 A, C > B (C > D)
F value ..	13·92 Highly significant	1·19 Not significant	12·10 Significant	< 1 Not significant	21·65 Highly significant	117·9 Highly significant	3·78 Not significant

Brackets, *e.g.*, (A > B), indicate that the difference is approaching significance at the 5 per cent. level.

* Not determined.

In the pre-wet period long grass is distinctly higher in protein than short, the mean difference being 1.5 per cent. (Table 4). The superiority of the long grass is maintained up to the mid-wet period, when the difference between the two stages is still about the same, although both have increased in protein content. Thereafter, the increase continues in both stages, but at a greater rate in the short grass, so that at the end of the wet season and in the mid-dry period the protein is about the same in both stages. The interaction between season and stage of growth is shown to be highly significant. On the mean protein values for the year, however, there is a highly significant difference of 0.39 per cent. in favour of long grass.

Table 4.

SHOWING THE DIFFERENCES BETWEEN THE MEAN VALUES OF THE PERCENTAGES OF THE VARIOUS CONSTITUENTS IN LONG AND SHORT PARA GRASS AT THE FOUR COLLECTION PERIODS, AND THE MEAN DIFFERENCES FOR ALL ANALYSES FOR THE YEAR.

(VALUES FOR LONG MINUS SHORT.)

Period.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
A. Pre-wet	1·5	−0·8	−0·1	0·4	−0·9	−0·038	−0·031
B. Mid-wet	1·3	−0·6	0·0	−0·4	−0·3	−0·000	0·005
C. Late-wet	−0·4	*	*	*	−1·0	−0·048	−0·056
D. Mid-dry	−0·8	*	*	*	1·6	0·236	−0·030
Standard Error ..	±0·205	±0·348	±0·0402	±0·302	±0·298	±0·0447	±0·0292
	A, B > C, D				D > A, B, C	D > A, B, C	
F value ..	31·86	< 1	4·84	3·56	16·89	8·96	< 1
	Highly significant	Not significant	Not significant	Not significant	Highly significant	Highly significant	Not significant
Mean difference	0·39	−0·68	−0·07	−0·03	−0·13	0·038	−0·028
Standard Error ..	±0·102	±0·246	±0·0284	±0·214	±0·149	±0·0224	±0·015
	Highly significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant

* Not determined.

Grass from Paddock 4—i.e., from plain soil—contains in most cases significantly less protein than grass from the three scrub-soil paddocks (Table 5). There are no significant differences between samples from the scrub soils. A highly significant interaction between paddocks and stage of growth was found for crude protein. Thus the difference in protein content between long and short grass is high and positive in Paddocks 2 and 3, and low and negative in Paddock 1. Paddock 2, in which the highest difference was obtained, was regarded as the best grazing paddock of the four; nevertheless, the practical significance of this interaction is difficult to assess.

Table 5.

SHOWING THE COMPOSITION OF LONG AND SHORT PARA GRASS FROM EACH OF THE FOUR PADDOCKS. (MEAN VALUES.)

Paddock No.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
				LONG.			
1	13·2	44·4	1·6	30·2	10·5	·700	·526
2	14·7	45·0	1·6	29·9	10·4	·745	·635
3	14·3	45·2	1·9	29·1	10·4	·746	·622
4	12·3	46·7	1·6	31·2	10·2	·721	·523
Standard Error ..	$\pm$·470 2, 3 > 4	$\pm$·502 4 > 1	$\pm$·0640	$\pm$·162 1, 2 > 3 4 > 1, 2, 3	$\pm$·485	$\pm$·0534	$\pm$·0254 2, 3 > 1, 4
F value ..	5·35 Significant	3·70 Not significant	4·28 Not significant	28·24 Highly significant	< 1 Not significant	< 1 Not significant	5·64 Significant
				SHORT.			
1	13·5	45·5	1·6	29·8	10·5	·653	·601
2	13·5	46·4	1·8	30·0	10·7	·708	·593
3	13·9	45·5	1·8	29·1	10·6	·685	·669
4	12·0	46·8	1·7	31·6	10·2	·716	·555
Standard Error ..	$\pm$·450 (1, 2 > 4) 3 > 4	$\pm$·767	$\pm$·0449 (2 > 1)	$\pm$·438 4 > 1, 2, 3	$\pm$·343	$\pm$·0231	$\pm$·0273 3 > 4
F value ..	3·46 Not significant	< 1 Not significant	3·68 Not significant	5·72 Not significant	< 1 Not significant	1·50 Not significant	3·03 Not significant
				LONG MINUS SHORT.			
1	−0·3	−1·0	−·01	0·4	0·0	·047	−·075
2	1·2	−1·3	−·25	−0·1	−0·3	·038	·042
3	0·4	−0·3	−·09	−0·0	−0·2	·061	−·047
4	0·3	−0·1	−·10	−0·4	−0·1	·005	−·032
Standard Error ..	$\pm$·205 2 > 1, 3, 4 3 > 1	$\pm$·493	$\pm$·0568 3 > 2	$\pm$·427	$\pm$·298	$\pm$·0447	$\pm$·0292 2 > 1
F value ..	9·14 Highly significant	1·53 Not significant	6·34 Not significant	< 1 Not significant	< 1 Not significant	< 1 Not significant	2·94 Not significant

Brackets, *e.g.* (1 > 2), indicate that the difference is approaching significance at the 5 per cent. level.

Seasonal changes in the mineral content of Para grass are pronounced in the case of calcium, which is highest in the mid-dry period for both long and short grass. The increase in the dry season is large and highly significant. The phosphate, on the other hand, does not vary to any significant extent. The variations in the crude ash are strikingly parallel with those of calcium. At the mid-dry period the values for crude ash and calcium are higher for long grass than for short grass, while at the other periods they are higher for short grass. These seasonal variations are highly significant; i.e., a highly significant interaction exists between seasons and stage of growth for crude ash and calcium. There is no significant difference in the mean values for the year of crude ash and calcium.

There is a similarity in the protein and phosphate variations between paddocks, mean phosphate being lowest in grass from Paddock 4. For long grass the phosphate is shown to be significantly higher in two of the scrub-soil paddocks—Paddocks 2 and 3—than in Paddock 4. A difference in crude fibre attributable to soil type is also indicated.

Molasses Grass.

A characteristic feature of the chemical composition of both long and short molasses grass is the significantly higher protein content at the end of the wet season than at any other period. The crude fibre increases significantly in the long grass from the pre-wet to the mid-wet period. For the pre-wet period the data indicate a higher crude fibre percentage in short grass, while for the mid-wet period they show a higher percentage in long grass. The seasonal variation in the differences is shown to be highly significant; i.e., a highly significant interaction exists between season and stage of growth for crude fibre. There is no significant difference in crude fibre content between long and short grass on the mean values for all analyses. The crude fat decreases in both long and short grass from the pre-wet to the mid-wet period and is of the same order for the two stages. The crude ash is significantly higher in the long grass on the mean values. The calcium and phosphate show no significant seasonal variations, except that in short grass the calcium is lower at the pre-wet period than at any other time. There is no significant difference between long and short grass in calcium content. In short grass phosphate is significantly greater than in long grass in the late-wet period as compared with the pre-wet and mid-wet, and also is greater on the mean values. A significant interaction between period and stage of growth exists for phosphate.

Table 6.

Showing the Analytical Data for the Oven-dry Material of Long and Short Molasses Grass at the Four Collection Periods (Mean Values).

Period.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
			Long.				
A. Pre-wet	9·6	49·2	2·2	30·5	8·6	·399	·559
B. Mid-wet	9·7	47·5	1·6	33·7	7·6	·403	·614
C. Late-wet	13·1	*	*	*	7·3	·443	·575
D. Mid-dry	9·9	*	*	*	8·6	·424	·526
Standard Error ..	±·289 C > A, B, D	±·840	±·0354 A > B	±·643 B > A	±·631	±·0144	±·0548
F value ..	34·78 Highly significant	1·87 Not significant	169·0 Highly significant	12·21 Significant	1·06 Not significant	2·03 Not significant	< 1 Not significant

Table 6—continued.

Showing the Analytical Data for the Oven-dry Material of Long and Short Molasses Grass at the Four Collection Periods (Mean Values)—*continued*.

Period.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
			Short.				
A. Pre-wet	8·7	49·3	2·1	31·6	8·3	·360	·570
B. Mid-wet	9·9	49·6	1·6	32·0	7·1	·403	·608
C. Late-wet	13·1	*	*	*	7·6	·439	·746
D. Mid-dry	10·7	*	*	*	8·3	·443	·583
Standard Error ..	±·640 C > A, B (C > D)	±1·131	±·110 (A > B)	±·347	±·407	±·0118 B, C, D > A (D > B)	±·0561
F value ..	8·43 Highly significant	< 1 Not significant	12·52 Significant	< 1 Not Significant	2·32 Not significant	10·67 Highly significant	2·09 Not significant

Brackets, *e.g.* (A > B), indicate that the difference is approaching significance at the 5 per cent. level.

* Not determined.

Table 7.

Showing the Differences between the Mean Values of the Percentages of the Various Constituents in Long and Short Molasses Grass at the Four Collection Periods, and the Mean Differences for all Analyses for the Year. (Values for Long minus Short.)

Period.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
A. Pre-wet	1·0	−0·1	0·1	−1·2	0·23	0·039	−0·011
B. Mid-wet	−0·2	−2·0	0·0	1·7	0·53	−0·001	0·006
C. Late-wet	0·1	*	*	*	−0·28	0·005	−0·171
D. Mid-dry	−0·8	*	*	*	0·25	−0·019	−0·057
Standard Error ..	±0·707	±0·561	±0·126	±0·564 B > A	±0·297	±0·0134 A > D	±0·0357 A, B > C
F. Value ..	1·00 Not significant	5·73 Not significant	< 1 Not significant	12·56 Highly significant	1·26 Not significant	3·26 Not significant	5·00 Significant
Mean Difference	0·03	−1·08	0·05	0·26	0·53	0·001	−0·058
Standard Error ..	±0·354 Not significant	±0·397 Not significant	±0·089 Not significant	±0·399 Not significant	±0·149 Significant	±0·0067 Not significant	±0·0178 Significant

* Not determined.

Table 8.

SHOWING THE COMPOSITION OF LONG AND SHORT MOLASSES GRASS FROM EACH OF THE FOUR PADDOCKS. (MEAN VALUES.)

Paddock No.	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
				LONG.			
1	10·3	48·2	2·2	31·9	8·2	·452	·523
2	10·4	48·8	1·9	33·2	7·4	·417	·516
3	10·7	47·5	1·7	32·3	8·3	·385	·674
4	11·0	49·0	1·8	31·0	8·2	·415	·562
Standard Error ..	±·289	±1·188	±·050 $1 > 2, 3, 4$	±·909	±·631	±·0483 $1 > 3$	±·0548
F value ..	1·05 Not significant	< 1 Not significant	18·6 Significant	1·05 Not significant	< 1 Not significant	3·63 Not significant	1·78 Not significant
				SHORT.			
1	10·1	49·1	2·0	32·6	8·0	·456	·509
2	10·8	48·9	2·2	32·7	7·8	·407	·569
3	11·4	48·7	1·6	31·3	7·6	·371	·791
4	9·9	51·1	1·7	30·7	8·0	·411	·639
Standard Error ..	±·640	±1·599	±·156	±·496	±·407	±·0118 $1 > 2, 3, 4$ $(4 > 3)$	±·0561 $3 > 1, 2$
F value ..	1·13 Not significant	< 1 Not significant	2·55 Not significant	3·98 Not significant	< 1 Not significant	8·67 Highly significant	4·69 Significant
				LONG MINUS SHORT.			
1	0·2	−0·9	·25	−0·8	·23	−·003	·014
2	−0·5	−0·1	−·25	0·6	−·40	·010	−·053
3	−0·7	−1·2	·1	1·0	·65	·014	−·117
4	1·1	−2·1	·1	0·3	·25	·004	−·077
Standard Error ..	±·707	±·794	±·178	±·797	±·297 $3 > 2$	±·0134	±·0357 $1 > 3$
F value ..	1·27 Not significant	1·08 Not significant	1·42 Not significant	< 1 Not significant	2·13 Not significant	< 1 Not significant	2·35 Not significant

Brackets, *e.g.* $(1 > 2)$, indicate that the difference is approaching significance at the 5 per cent. level.

No significant differences in composition due to soil type are shown, though there is a difference as between paddocks on the scrub soil, the short grass from Paddock 3 being significantly higher in phosphate and lower in calcium than grass from Paddock 1. There is no significant interaction between paddocks and stage of growth.

The analytical data for molasses grass are summarized in Tables 6, 7 and 8.

Guinea Grass.

The data available for Guinea grass, which are summarized in Table 9, are not adequate for statistical analysis, but the indications are that the protein is low, particularly in the long grass, during the dry season, after which it rises fairly rapidly and is high in both long and short grass at the end of the

Table 9.

SHOWING THE ANALYTICAL DATA FOR THE OVEN-DRY MATERIAL OF LONG AND SHORT GUINEA GRASS AT THE FOUR COLLECTION PERIODS. (MEAN VALUES.)

—	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
				LONG.			
A. Pre-wet	8·5	46·2	1·2	34·2	10·0	·523	·450
B. Mid-wet	11·5	42·8	1·6	35·0	9·2	·575	·387
C. Late-wet	14·1	*	*	*	11·7	·863	·488
D. Mid-dry	8·5	*	*	*	14·0	·990	·382
				SHORT.			
A. Pre-wet	9·8	45·1	1·3	34·7	9·2	·573	·439
B. Mid-wet	10·8	44·1	1·3	35·3	8·6	·584	·405
C. Late-wet	14·5	*	*	*	10·3	·688	·553
D. Mid-dry	11·3	*	*	*	11·1	·959	·526

* Not determined.

Table 10.

SHOWING THE ANALYTICAL DATA FOR THE OVEN-DRY MATERIAL OF LONG AND SHORT SOUR GRASS AT THE FOUR COLLECTION PERIODS.

—	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
				LONG.			
A. Pre-wet	8·4	46·9	0·6	34·9	9·2	·411	·469
B. Mid-wet	12·5	45·7	1·7	31·1	9·0	·440	·606
C. Late-wet	11·3	*	*	*	11·1	·536	·585
D. Mid-dry			Not	sampled			
				SHORT.			
A. Pre-wet	8·7	46·6	0·8	34·4	9·5	·363	·478
B. Mid-wet	13·0	45·6	1·5	29·0	10·9	·449	·527
C. Late-wet	11·1	*	*	*	12·1	·554	·566
D. Mid-dry	8·8	*	*	*	13·7	·804	·427

* Not determined.

wet season. The calcium content also appears to vary greatly, being particularly high in the mid-dry period but much lower in the pre-wet, with little difference between long and short grass at these periods. The phosphate content, on the other hand, probably decreases in dry weather and is mostly higher in the short grass. If significant, these changes in the mineral content of Guinea grass resemble those of Para grass.

Sour Grass and Russell River Grass.

The meagre data obtained for sour grass and Russell River grass are summarized in Tables 10 and 11. They are suggestive only, but indicate that the protein contents of the grasses are highest at the mid-wet period, and that the calcium content tends to rise in the dry period and the phosphate content to fall.

Table 11.

SHOWING THE ANALYTICAL DATA FOR THE OVEN-DRY MATERIAL OF LONG AND SHORT RUSSELL RIVER GRASS AT THE FOUR COLLECTION PERIODS.

—	Crude Protein.	N-free Extract.	Crude Fat.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
			LONG.				
A. Pre-wet	7·9	45·5	1·4	36·1	9·1	·474	·341
B. Mid-wet	11·5	46·4	1·6	33·1	7·4	·387	·425
C. Late-wet	11·4	*	*	*	9·1	·392	·410
D. Mid-dry	7·6	*	*	*	11·8	·665	·239
			SHORT.				
A. Pre-wet	7·6	45·1	1·1	37·9	8·3	·378	·334
B. Mid-wet	13·4	46·4	2·0	29·5	8·7	·436	·449
C. Late-wet	12·5	*	*	*	10·7	·360	·460
D. Mid-dry	11·5	*	*	*	10·8	·635	·310

* Not determined.

GENERAL DISCUSSION OF RESULTS.

Effect of Season.

The protein content in most cases rises with the advance of the wet season and falls sharply upon its cessation. Except for a sharp rise in the calcium content in the dry season, there is no very marked seasonal influence upon the mineral content of the various grasses. Examination of the appropriate figures in the several tables of chemical composition shows that there is a general tendency towards a high calcium content in dry weather and a low calcium content during the wet season for all the grasses except molasses grass, in which the calcium content shows no relationship to rainfall.

Effect of Stage of Growth.

The data show that, for the greater part of the year, long Para grass contains more crude protein than does short grass. The difference assumes importance during the summer and autumn, which are the periods when rate of growth is high. There are no important differences between the two stages of growth in Para grass in respect to other constituents. The analytical data support the observation of Seddon and Mulhearn (1938) that stock grazing on the Para grass pastures at Tully gained weight more rapidly when depastured on paddocks carrying a stand of tall grass (18-24 inches) than when on paddocks of short grass (6-8 inches). A graphical representation of the relationships between rainfall and protein and mineral composition of long and short Para grass is given in Figure 1.

In the other species it was found that the short grass is usually of higher protein content than the long grass, except in the case of molasses grass, in which no important difference in chemical composition between the two stages of growth was found. With these grasses, maturity factors were probably responsible for the difference in composition; whereas with Para grass the maturity factor operated only in the dry season, when the long grass represented mature grass which probably was not grazed by the stock because of its dry, unpalatable condition, due perhaps to lignification, as is suggested by the relatively high content of dry matter and the low protein content.

Effect of Soil Type.

Soil type has a significant effect upon the composition of Para grass, but not upon that of molasses grass. The scrub soil has been shown to produce a better quality Para grass than the plain soil. A significantly higher quantity of protein, a lesser quantity of fibre, and a slightly higher content of mineral matter are present in the leaf from the scrub soil. The indications from field observations are that the grass on the scrub soil has greater recuperative powers.

Nutritive Value of the Grasses.

The following discussion of the feeding value of the grasses is based upon the data recorded. Whilst chemical analysis is inadequate to express precisely the nutritive value of a grass, it is considered a sufficiently sound basis upon which the relative feeding values of grasses grown under the same conditions of soil and climate may be assessed.

Of the five grasses, Para grass contains the highest average percentage of crude protein at all periods of the year. The figures are about 14 for the scrub soil and 12 for the plain soil, with a general average during the wet season of 15 and during the dry season of 11.5. The coefficient of digestibility of the crude protein in the material eaten by the cattle is hardly likely to be lower than 60 (Harrison (1942) has reported it to be 67 in 8-weeks old Para grass), so that the digestible crude protein should not fall lower than about 7 per cent. Para grass pasture, then, may be regarded as having an adequate protein content throughout the year. Similarly, molasses grass, which has a crude protein content of between 10 per cent. and 11 per cent. throughout the year, may be accepted as satisfactory as a supplier of protein. Moreover, the fibre content of these two grasses is not high, so that, provided the stock always have access

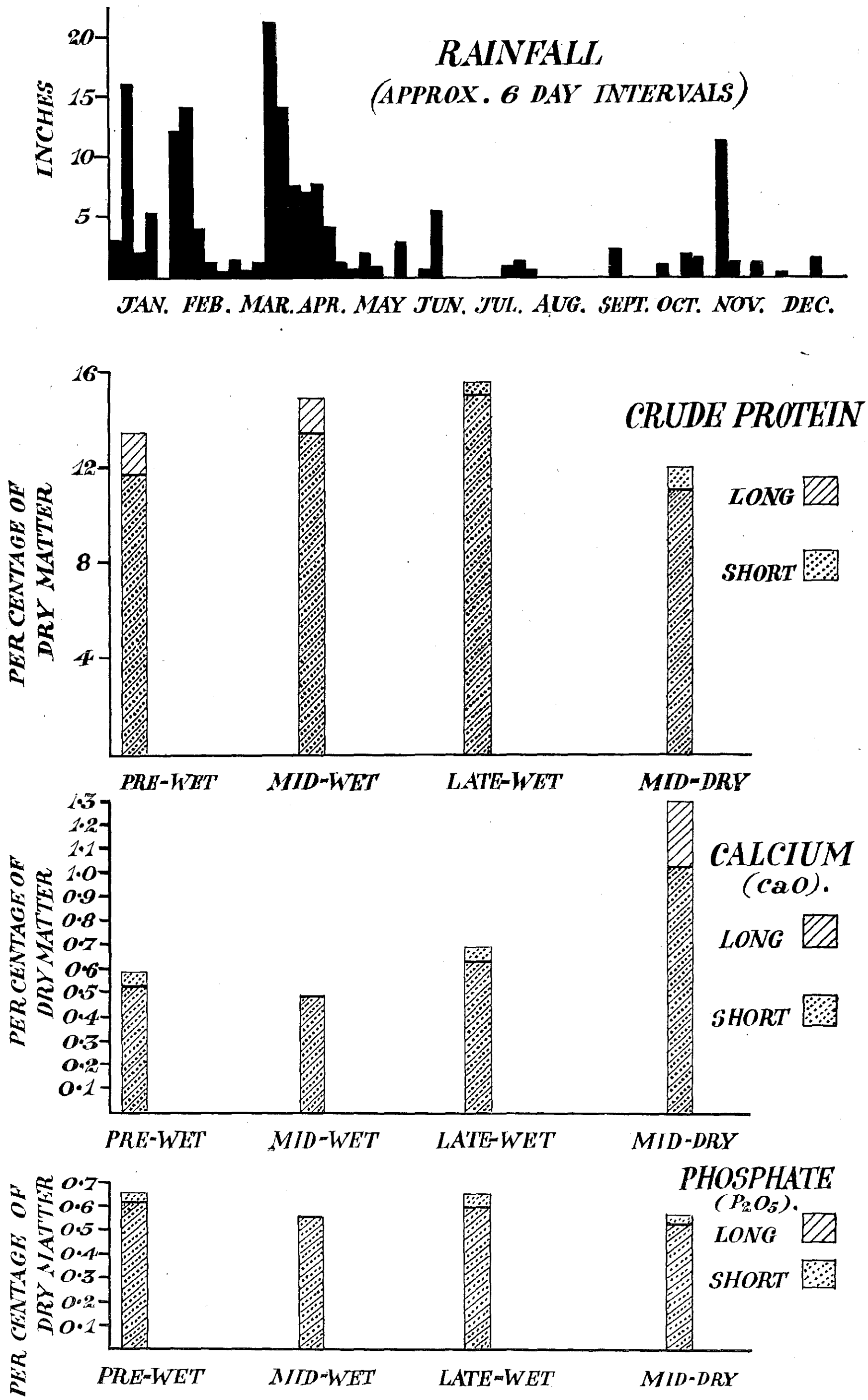

Fig. 1.

SHOWING THE SEASONAL FLUCTUATIONS IN THE PERCENTAGES OF CRUDE PROTEIN, CALCIUM, AND PHOSPHATE IN LONG AND SHORT PARA GRASS, AND THEIR RELATIONSHIP TO THE RAINFALL.

to succulent leaf, the intake of the growth and energy-producing constituents should be adequate.

Guinea, sour and Russell River grasses probably have an adequate crude protein content during the wet season, but the analyses indicate that in dry periods the fibre content of these grasses is fairly high and the protein content correspondingly low, so that at these times the protein intake from them may not be sufficient for fattening purposes.

It is of interest to consider the mineral analyses of the Tully grasses on the basis of the conventional standard of chemical analyses of good European pastures. The conventional standard for phosphate for maintenance requirements is approximately 0.50 per cent. P_2O_5 in the dry matter content. Maynard (1937) considers that a P_2O_5 content of at least 0.70 per cent. is required during periods of maximum demand, e.g. the growth period. The conventional standard for calcium is similarly about 0.50 per cent. CaO for maintenance purposes.

Judged on these standards, Para grass contains an adequate quantity of the two minerals for maintenance requirements. The calcium content is roughly 0.5 per cent., and the phosphate content 0.6 per cent., except in the dry season, when the percentage of calcium is more than doubled. Though satisfactory for maintenance purposes, it is questionable whether the quantities are adequate for growth requirements, particularly in regard to phosphate. However, provided the animals eat enough grass, adequate sunshine—by virtue of which ample Vitamin D is supplied—would ensure an efficient utilization of the minerals, and the requirements for growth might be met.

Molasses grass appears to be somewhat deficient in calcium, with an average content of approximately 0·4 per cent. The phosphate content is satisfactory at approximately 0·6 per cent. Guinea grass is deficient in phosphate, which averages approximately 0·4 per cent. for the year. The calcium content is comparatively high at about 0·6 per cent. Sour grass is deficient in calcium, but its phosphate content is fairly satisfactory. Russell River grass is deficient in both minerals.

The ratio of protein to phosphate in an intensively grazed pasture is held by some workers to be of nutritional significance. It has been stated that in a good pasture the ratio of N to P_2O_5 is most frequently found to be between 3 : 1 and 5 : 1. The analyses of the Tully grasses show that the ratios for the several species vary. For example, for Para grass the ratio is generally between 3 : 1 and 4 : 1; for molasses grass 2·5 : 1 and 3 : 1; and for Guinea grass 3 : 1 and 4·8 : 1. For Para grass and Guinea grass the ratio is widest in the wet season, due mainly to an increased crude protein content, and narrowest in the dry season, when the crude protein percentage is not so high. No clear seasonal effect on the ratio for molasses grass was found.

Many workers have found that a positive and significant correlation exists between the nitrogen and the phosphate in an intensively grazed pasture.

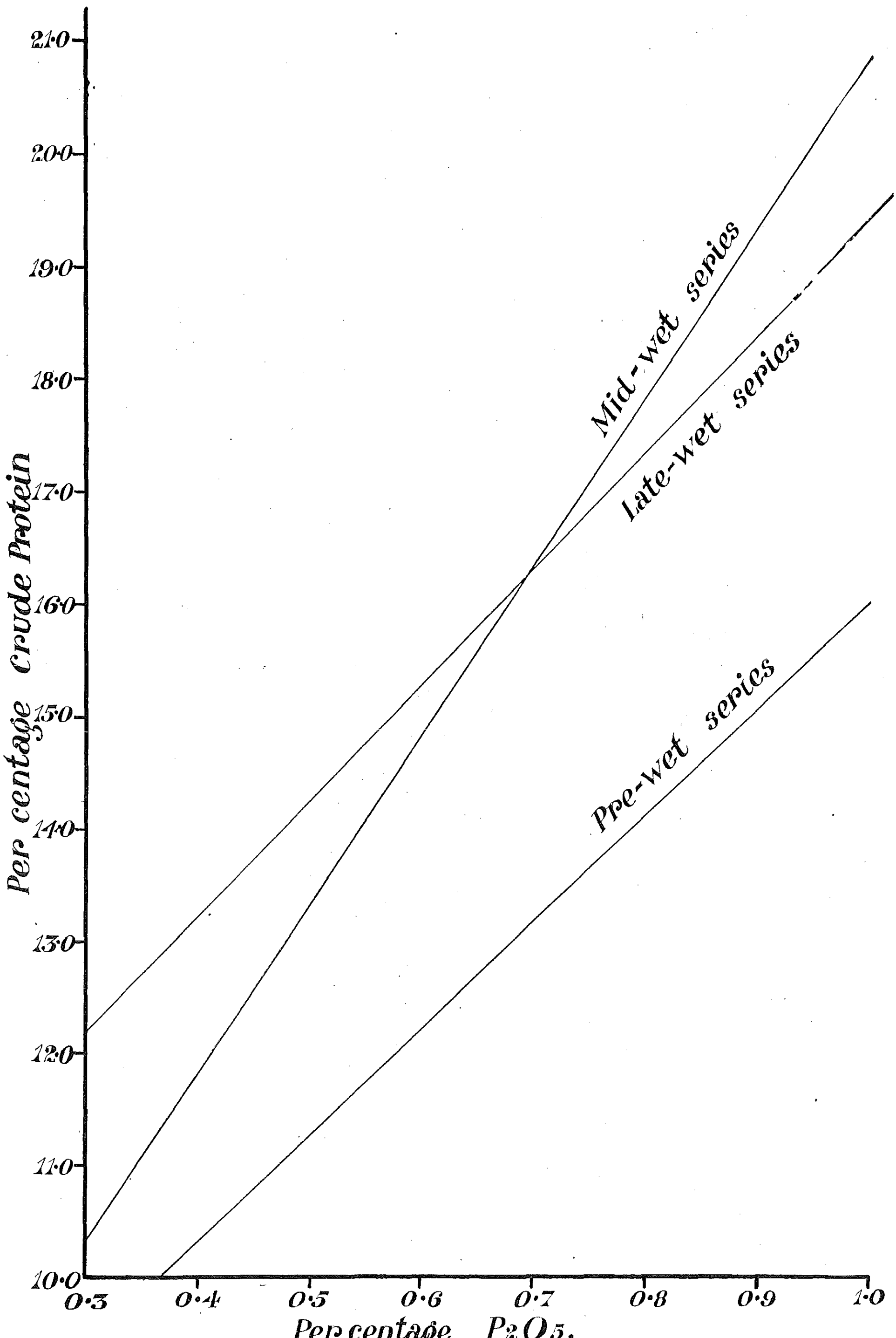

Fig. 2.

SHOWING THE REGRESSION LINES FOR PROTEIN ON PHOSPHATE FOR THE PRE-WET, MID-WET, AND LATE-WET SERIES OF SAMPLES.

An analysis of the data for Para grass confirms the existence of such a correlation in all but the dry season. For each of the pre-wet, mid-wet, and late-wet series of samples the correlation is shown to be positive and highly significant. The absence of a correlation in the dry season can probably be explained by the fact that much of the grass composing the samples for that period had reached a mature state and therefore could not be placed in the category of an intensively grazed pasture.

Table 12 summarizes the correlation coefficients and the regression coefficients for protein on phosphate for each series of samples of Para grass, and Figure 1 shows the regression lines for protein on phosphate for the pre-wet, mid-wet, and late-wet series of samples.

Table 12.

SHOWING THE CORRELATION AND REGRESSION COEFFICIENTS OF PROTEIN (y) and PHOSPHATE (x) FOR EACH SERIES OF SAMPLES OF PARA GRASS.

—	Pre-wet Series.	Mid-wet Series.	Late-wet Series.	Mid-dry Series.
Correlation Coefficient (r_{xy})	0·637	0·717	0·658	0·178
Regression Coefficient (b_{yx})	9·5	14·96	10·34	..
Degrees of Freedom	30	30	22	26
	Highly significant	Highly significant	Highly significant	Not significant

Practical Considerations.

Considered from the aspect of chemical composition, the general superiority of Para grass over its associates in the Tully pastures is outstanding. Its protein content is uniformly high, its crude fibre content is at no time high, and its mineral content, so far as calcium and phosphate are concerned, appears satisfactory for maintenance purposes. As this grass is agronomically satisfactory for pasture purposes its use in preference to the other grasses in localities similar to those of the experimental area is indicated.

There is a suggestion in the data obtained that the phosphate content of the pasturage may be inadequate at times, especially during drought periods; for the requirements of growing stock both now and, more particularly, in future years it would be desirable to increase it. The risk of phosphate becoming a limiting factor can be avoided either by fertilizing the soil with phosphatic fertilizers or by administering phosphate directly to the stock in the form of phosphatic licks. The latter method would correct any deficiency at a relatively low cost. Furthermore, because only a small proportion of the phosphate ingested in this way is retained and utilized by the animal, there must be an appreciable quantity of the mineral voided in the excreta. Most of this unabsorbed phosphate would eventually enter the soil complex and by enhancing fertility would enrich the pastures. The cumulative effect of the phosphates thus added to the soil would gradually effect much the same result on soil fertility as would the direct application of phosphatic fertilizers to the soil.

However, direct fertilizing with the object of facilitating the establishment and promoting the development of leguminous plants should be given every consideration. Furthermore, the effect of the application of phosphatic fertilizers in lessening transpiration rate of pasture plants might be capable of useful application at Tully, for Para grass has been observed to wilt and decline seriously during spells of dry weather in September, October, and November.

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Grateful acknowledgment is made of the public-spiritedness of the late Mr. Brice Henry, who set aside for use by the Department of Agriculture and Stock the grassland paddocks on which the experiments were conducted and who actively and enthusiastically co-operated in the work.

Mr. P. B. McGovern, of the Department's biometrical staff, is responsible for the statistical analysis of the chemical data. Dr. L. G. Miles, who was formerly on the staff of the Bureau of Tropical Agriculture, advised on matters concerning correlation coefficients. Mr. J. Hart helped to collect the samples and assisted in the laboratory during the course of the experiment. The collaboration of the Director of the Animal Health Station, Oonoonba (Mr. C. R. Mulhearn) was appreciated.

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APPENDIX.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES.

1. Para Grass.

(a) Pre-wet Series.

Stage of Growth.	Paddock No.	Division No.	Analysis of Water-free Material.						
			Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
Long ..	1	1	11·2	1·4	45·4	32·7	9·3	·498	·388
,, ..	1	2	14·7	1·5	43·3	30·0	10·5	·638	·500
,, ..	1	3	12·1	1·5	46·3	29·1	11·0	·674	·533
,, ..	1	4	12·0	1·8	46·0	29·3	10·9	·758	·620
Short ..	1	1	11·5	1·7	43·6	29·7	13·5	·619	·580
,, ..	1	2	11·2	1·6	47·2	29·6	10·4	·527	·637
,, ..	1	3	10·9	1·5	49·0	29·6	9·0	·556	·581
,, ..	1	4	14·4	2·0	44·2	28·2	11·2	·497	·917
Long ..	2	1	13·3	1·5	48·3	29·3	7·6	·385	·597
,, ..	2	2	15·2	1·4	46·4	29·8	7·2	·341	·618
,, ..	2	3	13·0	1·5	45·1	32·2	8·2	·522	·684
,, ..	2	4	15·7	1·8	41·7	29·9	10·9	·525	·787
Short ..	2	1	12·0	1·8	49·1	28·6	8·5	·464	·552
,, ..	2	2	13·4	1·8	45·6	30·9	8·3	·482	·614
,, ..	2	3	10·3	1·8	47·8	29·0	11·1	·680	·671
,, ..	2	4	10·9	1·9	47·2	29·4	10·6	·642	·708
Long ..	3	1	11·7	2·0	49·6	29·3	7·4	·416	·547
,, ..	3	2	12·9	1·9	48·4	28·0	8·8	·478	·575
,, ..	3	3	16·1	1·9	43·8	29·7	8·5	·540	·849
,, ..	3	4	16·8	2·0	41·2	30·7	9·3	·596	·842
Short ..	3	1	12·1	1·8	48·9	29·4	7·8	·429	·648
,, ..	3	2	12·0	2·0	47·1	29·7	9·2	·500	·606
,, ..	3	3	12·0	1·6	46·8	29·7	9·9	·587	·733
,, ..	3	4	15·2	2·1	42·2	29·0	11·5	·656	·908
Long ..	4	1	12·2	1·6	45·9	33·0	7·3	·385	·564
,, ..	4	2	13·0	1·7	45·0	30·6	9·7	·511	·675
,, ..	4	3	11·3	1·6	47·3	30·8	9·0	·603	·586
,, ..	4	4	11·3	1·6	47·2	30·9	9·0	·580	·520
Short ..	4	1	10·2	1·8	47·0	32·0	9·0	·520	·582
,, ..	4	2	12·5	1·7	45·5	31·1	9·2	·530	·619
,, ..	4	3	9·9	1·9	46·3	31·6	10·3	·680	·485
,, ..	4	4	10·6	1·8	45·6	31·8	10·2	·693	·537

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

1. Para Grass—*continued.*

(*b*) *Mid-wet Series.*

Stage of Growth.	Paddock No.	Division No.	Analysis of Water-free Material.						
			Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.
Long ..	1	1	14·7	1·8	40·5	32·8	10·2	·432	·498
,, ..	1	2	15·0	1·6	44·5	28·9	10·0	·513	·569
,, ..	1	3	16·4	1·7	42·7	29·5	9·7	·399	·593
,, ..	1	4	15·5	1·5	46·7	29·5	6·8	·351	·545
Short ..	1	1	13·1	1·2	47·3	30·9	7·5	·394	·441
,, ..	1	2	14·7	1·5	45·0	30·8	8·0	·429	·531
,, ..	1	3	16·6	1·8	41·7	29·6	10·3	·487	·689
,, ..	1	4	12·5	1·6	45·7	30·3	9·9	·432	·567
Long ..	2	1	12·0	1·6	46·7	29·9	9·8	·576	·570
,, ..	2	2	16·7	1·5	43·9	30·2	7·7	·478	·696
,, ..	2	3	13·3	1·7	45·7	29·4	9·9	·691	·600
,, ..	2	4	17·3	1·5	42·5	28·5	10·2	·565	·703
Short ..	2	1	11·9	1·9	46·7	31·1	8·4	·461	·452
,, ..	2	2	13·9	1·6	44·5	31·0	9·0	·431	·607
,, ..	2	3	13·0	1·9	46·3	29·7	9·1	·572	·469
,, ..	2	4	14·4	1·8	43·8	30·1	9·8	·466	·591
Long ..	3	1	15·0	1·9	47·3	28·3	7·4	·471	·459
,, ..	3	2	16·0	1·9	46·0	28·2	7·9	·473	·587
,, ..	3	3	17·6	1·6	42·7	28·8	9·3	·506	·691
,, ..	3	4	16·6	1·6	42·8	29·7	9·3	·480	·637
Short ..	3	1	15·2	1·6	45·2	28·7	9·3	·474	·617
,, ..	3	2	13·3	1·4	46·3	29·6	9·4	·485	·624
,, ..	3	3	15·3	1·6	43·3	29·9	9·9	·561	·760
,, ..	3	4	17·5	2·0	44·0	26·8	9·7	·506	·680
Long ..	4	1	12·3	1·6	46·7	32·1	7·3	·368	·498
,, ..	4	2	12·3	1·5	48·1	30·4	7·7	·422	·438
,, ..	4	3	14·1	1·6	46·3	30·1	7·9	·429	·407
,, ..	4	4	12·6	1·6	47·2	31·5	7·1	·441	·458
Short ..	4	1	13·5	1·8	45·7	30·8	8·2	·403	·473
,, ..	4	2	10·0	1·5	49·2	31·4	7·9	·480	·393
,, ..	4	3	10·9	1·5	46·7	32·3	8·6	·531	·543
,, ..	4	4	10·9	1·6	48·3	31·7	7·5	·482	·436

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

1. PARA GRASS—*continued.*

*(c) Late-wet Series.**

Stage of Growth.	Paddock No.	Division No.	Analysis of Water-free Material.† Crude Protein.	Crude Ash.	CaO.	P_2O_5.	Dry Material Per Cent. of Green Weight.
Long	1	1	14·4	8·8	·638	·568	23·4
,, ...	1	2	15·1	9·7	·619	·555	23·1
,, ...	1	3	13·9	9·3	·666	·548	23·1
,, ...	1	4	14·3	8·8	·528	·530	24·0
Short	1	1	13·9	10·2	·649	·593	22·2
,, ...	1	2	18·6	11·8	1·020	·773	20·0
,, ...	1	3	14·9	9·9	·694	·617	21·7
,, ...	1	4	14·9	9·4	·413	·513	22·2
Long	2	1	17·3	10·2	·706	·632	21·3
,, ...	2	2	15·8	8·3	·628	·584	22·0
,, ...	2	3	17·4	10·3	·803	·747	20·6
,, ...	2	4	19·6	11·6	·687	·823	16·2
Short	2	1	17·9	11·1	·705	·745	16·9
,, ...	2	2	14·6	9·1	·562	·672	17·1
,, ...	2	3	17·3	11·5	·750	·688	18·8
,, ...	2	4	17·9	12·3	·710	·695	20·8
Long	3	1	14·4	9·2	·604	·466	23·3
,, ...	3	2	15·3	9·3	·486	·570	24·5
,, ...	3	3	14·8	9·7	·568	·738	22·8
,, ...	3	4	14·4	9·8	·618	·600	20·1
Short	3	1	14·4	9·9	·613	·652	23·0
,, ...	3	2	15·1	9·6	·497	·517	22·0
,, ...	3	3	15·5	10·6	·664	·855	20·6
,, ...	3	4	15·5	11·4	·715	·698	22·4

* No samples were obtained from Paddock 4.

† Crude fat, N-free extract and crude fibre were not determined in this series of samples.

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

1. PARA GRASS—*continued.*

(*d*) *Mid-dry Series.*

Stage of Growth.	Paddock No.	Division No.	Analysis of Water-free Material.*				Dry Material Per Cent. of Green Weight.
			Crude Protein.	Crude Ash.	CaO.	P_2O_5.	
Long	1	1	11·2	11·8	1·334	·422	26·8
,, ...	1	2	9·9	14·1	1·048	·539	25·2
,, ...	1	3	..	No	sample	procured	
,, ...	1	4	10·6	14·4	·978	·512	28·1
Short	1	1	12·0	10·4	·895	·576	20·5
,, ...	1	2	12·5	11·5	·992	·486	22·4
,, ...	1	3	13·1	12·1	1·020	·533	22·0
,, ...	1	4	11·6	13·1	·822	·584	24·3
Long	2	1	11·2	12·4	1·238	·455	26·6
,, ...	2	2	11·5	14·1	1·290	·536	24·4
,, ...	2	3	10·8	15·2	1·265	·536	31·9
,, ...	2	4	15·1	13·1	1·226	·584	28·3
Short	2	1	11·4	12·8	1·040	·467	24·6
,, ...	2	2	11·3	12·6	1·136	·388	23·5
,, ...	2	3	11·7	11·8	1·190	·644	23·2
,, ...	2	4	14·1	15·0	1·035	·519	20·8
Long	3	1 }	..	No	sample	procured	
,, ...	3	2 }					
,, ...	3	3	11·6	15·2	1·460	·707	31·5
,, ...	3	4	11·7	14·8	1·390	·488	26·9
Short	3	1	12·7	11·7	·790	·505	23·8
,, ...	3	2	11·7	11·6	1·070	·640	24·9
,, ...	3	3	11·7	14·4	1·276	·660	24·8
,, ...	3	4	12·5	13·9	1·140	·597	23·9
Long	4	1	..	No	sample	procured	
,, ...	4	2	10·4	12·9	1·349	·470	33·6
,, ...	4	3	9·9	14·0	1·154	·529	30·4
,, ...	4	4	11·3	18·8	1·488	·538	27·5
Short	4	1	13·4	13·7	1·072	·635	21·7
,, ...	4	2	10·6	11·7	1·130	·541	24·5
,, ...	4	3	11·0	12·0	1·178	·591	24·1
,, ...	4	4	11·5	14·9	·960	·630	24·3

* Crude fat, N-free extract and crude fibre were not determined in this series of samples.

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

2. MOLASSES GRASS.

Stage of Growth.	Paddock No.	Analysis of Water-free Material.*							Dry Material Per Cent. of Green Weight.
		Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.	
				(a) Pre-wet Series.					
Long ..	1	9·0	2·5	49·7	30·9	7·9	·426	·560	Not determined
Short ..	1	9·0	2·3	48·8	32·1	7·8	·407	·570	
Long ..	2	9·2	2·2	48·9	32·3	7·4	·423	·597	
Short ..	2	8·5	2·6	47·8	33·2	7·9	·376	·556	
Long ..	3	10·1	2·1	49·5	29·4	8·9	·343	·517	
Short ..	3	8·4	1·8	50·8	30·8	8·2	·315	·599	
Long ..	4	10·1	2·1	48·5	29·3	10·0	·404	·562	
Short ..	4	8·7	1·8	49·7	30·4	9·4	·342	·556	
				(b) Mid-wet Series.					
Long ..	1	10·1	1·9	46·6	32·8	8·6	·410	·536	Not determined
Short ..	1	8·7	1·6	49·3	33·1	7·3	·410	·475	
Long ..	2	8·9	1·6	48·6	34·1	6·8	·404	·440	
Short ..	2	9·4	1·7	49·9	32·1	6·9	·402	·435	
Long ..	3	9·8	1·3	45·4	35·1	8·4	·403	·884	
Short ..	3	12·7	1·4	46·5	31·7	7·7	·383	·940	
Long ..	4	9·9	1·5	49·5	32·6	6·5	·393	·597	
Short ..	4	8·6	1·6	52·5	31·0	6·3	·417	·582	
				(c) Late-wet Series.					
Long ..	1	13·2	..	..	..	6·2	·501	·574	27·3
Short ..	1	12·5	..	..	..	7·3	·513	·585	25·8
Long ..	2	13·2	..	..	..	7·9	·407	·518	24·0
Short ..	2	14·9	..	..	..	8·1	·425	·785	20·8
Long ..	3	12·6	..	..	..	7·7	·424	·640	28·0
Short ..	3	12·4	..	..	..	7·3	·378	·856	25·0
Long ..	4	No sample procured							
Short ..	4	No sample procured							

* Crude fat, N-free extract and crude fibre were not determined for the late-wet and mid-dry series of samples.

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

2. MOLASSES GRASS—*continued.*

Stage of Growth.	Paddock No.	Analysis of Water-free Material.							Dry Material Per Cent. of Green Weight.
		Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.	
				(d) Mid-dry Series.					
Long ..	1	9·0	..	..	..	10·1	·472	·421	32·6
Short ..	1	10·3	..	..	..	9·5	·492	·405	30·7
Long ..	2	10·1	..	..	..	7·3	·432	·509	32·0
Short ..	2	10·5	..	..	..	8·1	·425	·500	27·0
Long ..	3	10·2	..	..	..	8·1	·370	·656	29·4
Short ..	3	12·0	..	..	..	7·3	·408	·768	26·5
Long ..	4	No	sample p	rocured					
Short ..	4	9·8	..	..	..	8·4	·446	·658	33·3

3. GUINEA GRASS.

Stage of Growth.	Paddock No.	Analysis of Water-free Material.*							Dry Material Per Cent. of Green Weight.
		Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.	
				(a) Pre-wet Series.					
Long ..	1	8·5	1·4	46·7	32·0	11·4	·533	·429	Not determined
Short ..	1	11·6	1·6	43·2	34·1	9·5	·609	·425	
Long ..	2	8·4	1·0	45·7	36·4	8·5	·413	·470	
Short ..	2	7·9	1·0	46·9	35·3	8·9	·537	·452	
				(b) Mid-wet Series.					
Long ..	1	13·6	1·4	41·9	34·0	9·1	·574	·407	Not determined
Short ..	1	13·0	1·2	41·7	34·3	9·8	·624	·467	
Long ..	2	9·4	1·7	43·7	35·9	9·3	·576	·366	
Short ..	2	8·5	1·4	46·4	36·3	7·4	·544	·342	
				(c) Late-wet Series.					
Long ..	1	11·9	..	..	..	11·2	1·000	·374	32·0
Short ..	1	13·0	..	..	..	9·6	·714	·462	28·0
Long ..	2	16·2	..	..	..	12·2	·725	·602	27·8
Short ..	2	15·9	..	..	..	10·9	·662	·644	25·0
				(d) Mid-dry Series.					
Long ..	1	6·8	..	..	..	15·6	1·095	·276	35·1
Short ..	1	12·0	..	..	..	10·3	1·012	·543	26·2
Long ..	2	10·1	..	..	..	12·3	·884	·488	32·2
Short ..	2	10·6	..	..	..	11·8	·905	·508	26·1

* Crude fat, N-free extract and crude fibre were not determined for the late-wet and mid-dry series of samples.

APPENDIX—continued.

ANALYSIS OF INDIVIDUAL GRASS SAMPLES—*continued.*

4. Sour Grass.

Stage of Growth.	Paddock No.	Analysis of Water-free Material.*							Dry Material Per Cent. of Green Weight.
		Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.	
				(a) Pre-wet Series.					
Long ..	3	8·4	0·6	46·9	34·9	9·2	·411	·469	Not determined
Short ..	3	8·7	0·8	46·6	34·4	9·5	·363	·478	
				(b) Mid-wet Series.					
Long ..	3	12·5	1·7	45·7	31·1	9·0	·440	·606	Not determined
Short ..	3	13·0	1·5	45·6	29·0	10·9	·449	·527	
				(c) Late-wet Series.					
Long ..	3	11·3	..	..	..	11·1	·536	·585	22·2
Short ..	3	11·1	..	..	..	12·1	·554	·566	23·2
				(d) Mid-dry Series.					
Long ..	3	No	sample p	rocured					
Short ..	3	8·8	..	..	..	13·7	·804	·427	23·7

* Crude fat, N-free extract and crude fibre were not determined for the late-wet and mid-dry series of samples.

5. Russell River Grass.

Stage of Growth.	Paddock No.	Analysis of Water-free Material.*							Dry Material Per Cent. of Green Weight.
		Crude Protein.	Crude Fat.	N-free Extract.	Crude Fibre.	Crude Ash.	CaO.	P_2O_5.	
				(a) Pre-wet Series.					
Long ..	1	7·9	1·4	45·5	36·1	9·1	·474	·341	Not determined
Short ..	1	7·6	1·1	45·1	37·9	8·3	·378	·334	
				(b) Mid-wet Series.					
Long ..	1	11·5	1·6	46·4	33·1	7·4	·387	·425	Not determined
Short ..	1	13·4	2·0	46·4	29·5	8·7	·436	·449	
				(c) Late-wet Series.					
Long ..	1	11·4	..	..	..	9·1	·392	·410	26·5
Short ..	1	12·5	..	..	..	10·7	·360	·460	24·8
				(d) Mid-dry Series.					
Long ..	1	7·6	..	..	..	11·8	·665	·239	26·9
Short ..	1	11·7	..	..	..	10·8	·635	·310	25·0

* Crude fat, N-free extract and crude fibre were not determined for the late-wet and mid-dry series of samples.