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A Study of the Mineral Content and Feeding Value of Natural Pastures in the Union of South Africa.

(SECOND REPORT.)

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CONTENTS.

INTRODUCTION.

MENTION is made under "outline of investigation" in the first report (1932) on the problem stated above, of experimental grass plots forming a part of the experimental plan of the investigation. It is proposed to deal with the results of the first twelve months' work upon the experimental plots in this publication. Eleven species of grasses were subjected to the treatment according to the experimental plan, for the full period, as the analyses indicate.

The objects of the plot experiments may be restated here briefly:—

(1) A study of the effect of growth on the chemical composition of pasture. Monthly, two-monthly, three-monthly, etc., cuttings of each variety of grass were made and analysed.

(2) A study of the variation in chemical composition of different species of grasses at the same period of growth.

(3) The effect of seasonal variation in growth on the chemical composition and on the yield of grass.

(4) A study of the chemical composition of successive cuttings of the same variety of grass. This means that, if the work began in January, the analysis of the monthly growth during each month of the year would be available. The analyses of the two-monthly growth of the same portion of the plot would be made every alternate month, for three months' growth every three months and so on, so that the 12 months' growth would be ready for analysis at the end of the year.

(5) The determination of the chemical composition of different parts of the same plant at different stages of growth. For this purpose leaves, stalks, haulms, were analysed separately at the different periods of growth.

DETAILS OF PLOT EXPERIMENT.

In August, 1931, this aspect of the work was begun by planting eleven species of grasses in separate plots, 30 by 14 feet, mapped out in an area where indefinite extension was possible and where the soil was apparently uniform in composition over the whole area. The latter point was confirmed subsequently by chemical analyses of soil samples from each plot. Other plots have been planted from time to time, so that at present more than three times the original number of grass species are included in the work. However, this report deals only with the eleven species already referred to which were planted at the outset, and of which the analyses have been carried out for the first 12 months of the experimental period, i.e. from February, 1932, until January, 1933. The same method of establishing the plots has been followed throughout and will be described in detail.

The soil was dug up once, all vegetable matter removed, the ground harrowed, the plots mapped out so that each was surrounded by a path 3½ feet wide, and after the first good rain in August the grasses planted in rows 10 inches apart. After that the plots were watered until the grasses had established themselves, when they were given no further attention except being weeded when necessary. Some grasses did not grow as easily as others, and portions of the plots had to be replanted. However, all eleven plots were established successfully before the end of 1931. They were then left to grow freely until the end of January, 1932, when the investigations into their chemical composition was begun, and the grasses received no further attention, except occasional weeding, as already stated.

The grasses on all the plots were cut short—about half an inch from the ground—on the 27th January, and the following plan of experiment followed. On the 27th of each month from February, 1932, until January, 1933, samples were taken from each plot. The first row of grass on each plot was cut monthly and therefore yielded 12 samples of monthly growth of the grass in question. The second row was cut every two months, i.e. on the 27th of March, May, July, etc., and therefore yielded six samples of two months' growth each. The third row was cut every three months, the fourth every four, and so on, until the last or twelfth row was cut on the 27th January, 1933, after twelve months' growth. Each of the samples so obtained was analysed for phosphorus, calcium, magnesium, potassium, sodium, chlorine, protein and fibre.

It is realized, of course, that the plots are much too small to study yield, nor was it our intention to do so, although the differences in the weights of the grasses cut in the various rows uniformly planted would serve as an index of the amount of growth of that particular grass during the period in question. In other words, the samples were weighed, merely to derive at a figure suggesting growth during the period, and not to compare carefully the production of grass of one species with that of another species for the same period.

Other observations in regard to rate of growth, effect of cutting at different times, method of growth at different seasons, resistance against drought, response to climatic conditions, were made from time to time on the plots studied, and will be considered in the discussion of the results at a later stage in this article.

As the prevailing climatic conditions were undoubtedly the determining factors in regard to the growth of the grasses, these are given as fully as possible in Table I, to which reference will be made frequently.

TABLE I.

1932.		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
February....	Rainfall.....	—	0·66	0·10	1·05	0·30	—	—	—	—	—	—	—	—
	R. humidity.....	64	65	75	76	88	67	77	68	69	67	66	72	65
	Sunshine (hrs.).....	9·3	11·0	10·3	8·3	8·0	7·3	6·0	7·0	10·3	11·0	5·4	8·0	9·3
	Max. Temp.....	93·0	89·0	85·0	85·0	82·6	85·0	82·0	83·4	84·0	88·0	84·4	86·4	81·6
	Min. Temp.....	57·0	60·0	60·0	63·8	58·0	60·0	65·0	63·0	57·0	58·4	66·0	63·0	64·0
March.....	Rainfall.....	—	—	—	—	—	—	—	0·07	1·58	—	—	0·05	—
	R. humidity.....	77	58	70	80	75	59	66	68	75	87	49	62	92
	Sunshine (hrs.).....	3·3	10·3	10·1	9·15	10·3	9·2	10·2	7·45	2·30	4·45	8·0	9·4	1·3
	Max. Temp.....	79·0	89·8	87·4	81·4	86·0	85·0	85·0	90·8	85·0	81·6	89·6	80·6	69·4
	Min. Temp.....	64·8	56	59	61	59·4	57	53	59	67	63·6	59·6	59	60·8
April.....	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	63	60	68	66	63	63	63	53	68	63	57	65	58
	Sunshine (hrs.).....	10·1	10·2	9·3	10·3	10·0	10·0	10·0	10·0	9·2	9·0	9·0	10·0	10·1
	Max. Temp.....	85	85	87	85	85	81·8	83·2	80·4	83·4	84·8	85	82·4	85
	Min. Temp.....	53	46	49	49	48	48	45·6	49	56	46	49·6	50	43
May.....	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	0·10
	R. humidity.....	65	69	62	65	70	72	56	51	62	60	59	65	58
	Sunshine (hrs.).....	9·0	9·0	6·3	8·1	8·1	9·0	9·3	9·3	8·3	9·0	7·0	9·0	9·2
	Max. Temp.....	73·6	69	69·4	71·8	74·2	74	78·4	77·4	76	78	77·8	83	84
	Min. Temp.....	49	56	49	49	40·4	38·0	38	39	38	37·6	38·6	39	43
June.....	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	68	76	76	68	58	71	65	68	58	57	45	48	42
	Sunshine (hrs.).....	9·2	0·15	1·3	7·3	8·4	8·2	8·4	9·0	9·0	9·1	9·1	9·0	9·2
	Max. Temp.....	77	65	68·8	75·4	76·2	73·2	73·8	57·8	68	72	74	77	78
	Min. Temp.....	38·4	39	51	36	42·4	35·0	31·0	35·0	39·4	34	34	30	32
July.....	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	54	53	55	58	51	57	60	64	71	54	49	41	39
	Sunshine (hrs).....	9·1	9·2	9·0	9·1	9·2	5·3	9·1	9·1	9·0	8·4	9·2	9·1	9·1
	Max. Temp.....	74	77	73	77	76	76	58	64	66	70	75	74	73
	Min. Temp.....	30	31	30	32	32	34	38	32	29	27	29	29	27
August.....	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	44	50	38	62	44	39	39	39	34	38	50	44	35
	Sunshine (hrs).....	9·2	9·1	9·3	9·3	9·3	9·4	9·4	9·5	9·4	9·4	9·4	9·5	9·4
	Max. Temp.....	74	77	72	71	75	75	77	76	79	75	75	76	78
	Min. Temp.....	31	32	34	31	32	31	30	32	35	32	30	30	32
September...	Rainfall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	—	51	60	61	41	56	39	43	47	32	19	—	53
	Sunshine (hrs.).....	—	10·0	10·1	10·1	10·1	10·1	6·3	7·3	10·0	10·3	—	—	8·1
	Max. Temp.....	87	85	79	84	86	79	81	78	77	83	—	83	76
	Min. Temp.....	—	42	46	42	41	45	46	51	43	35	41	—	40
October.....	Rainfall.....	0·12	—	0·88	0·58	—	—	—	—	—	—	—	—	—
	R. humidity.....	72	77	27	81	71	78	66	50	31	60	54	39	55
	Sunshine (hrs.).....	3·0	8·0	7·3	0·3	3·1	5·0	8·3	10·2	10·3	10·1	10·3	10·3	10·3
	Max. Temp.....	78	63	86	72	74	75	84	94	97	90	93	88	84
	Min. Temp.....	54	56	56	56	57	49	50	57	59	60	61	60	57
November...	Rainfall.....	0·03	—	—	0·06	—	—	0·72	—	—	0·22	—	—	—
	R. humidity.....	31	48	47	40	55	18	59	81	48	58	73	75	66
	Sunshine (hrs.).....	10·2	10·3	5·0	8·0	11·0	10·4	9·3	5·1	10·4	7·3	7·4	4·3	10·3
	Max. Temp.....	81	87	77	75	78	92	74	74	76	76	75	76	75
	Min. Temp.....	54	58	57	59	52	60	61	58	59	55	52	57	57
December....	Rainfall.....	—	—	—	0·5	—	—	—	—	—	—	—	0·06	0·09
	R. humidity.....	90	76	78	68	57	75	68	61	60	67	35	62	71
	Sunshine (hrs.).....	6·0	6·1	6·4	1·1	6·4	0·5	9·1	5·3	11·4	10·3	11·4	11·0	9·4
	Max. Temp.....	81	87	87	75	79	77	93	89	93	93	97	97	95
	Min. Temp.....	63	63	65	59	60	55	59	63	60	61	53	58	63
1933.														
January.....	Raintall.....	—	—	—	—	—	—	—	—	—	—	—	—	—
	R. humidity.....	61	60	56	50	65	60	44	70	64	50	60	45	66
	Sunshine (hrs.).....	7·4	9·3	8·2	11·4	9·0	10·4	11·4	6·4	10·5	5·4	5·1	8·0	6·2
	Max. Temp.....	83	90	90	95	89	94	97	89	93	91	89	89	93
	Min. Temp.....	54	55	61	60	66	60	58	67	62	63	59	61	65

Meteorological Data.

14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
0·16	—	—	1·4	—	0·43	0·05	—	—	—	—	0·20	—	—	0·48	0·02	—	—
57	67	68	66	73	78	48	70	68	—	58	52	78	71	73	90	—	—
7·4	10·0	10·2	6·0	10·0	2·3	7·4	9·1	9·0	6·4	10·3	8·1	3·0	9·1	2·4	3·1	—	—
89·0	89·8	90·4	83·6	85·0	79·6	86 5	78·0	81·2	91·0	97·0	90·2	85·0	83·5	82·0	82·8	—	—
—	60·0	59·0	62·0	61·0	64·0	62·0	55·0	57·0	60·0	57·0	64·0	62·0	64·0	61·0	61·0	—	—
—	—	—	—	—	—	0·29	0·05	—	—	—	—	—	—	—	0·04	—	—
64	78	58	73	81	70	86	73	75	75	64	63	70	57	66	67	64	66
10·2	4·4	2·0	2·3	5·3	4·3	2·4	9·1	5·4	8·0	10·0	7·3	9·0	8·0	7·2	6·2	8·3	10·0
78·2	84·0	83·0	78·6	80·0	83·8	78·0	80·6	79·0	83·8	85·0	82·6	87·2	90·2	89·0	85·0	86·6	85·4
51	50	60	62	57	63	62	53	60	51	53	53	54	60	55	57	53·0	54·0
—	—	—	—	—	—	—	—	—	0·17	0·23	0·04	0·31	—	—	—	—	—
51	63	54	44	42	45	45	49	63	73	95	95	95	79	78	68	65	—
10·1	10·0	10·0	9·4	10·2	10·1	7·3	7·0	0·10	2·0	0·0	3·0	5·1	6·4	9·4	8·0	9·0	—
85	84	86·2	89	90	90	90	91	72·2	74·0	65	73·6	78·6	76	77·4	80	79	—
42	44	43	47	51	45	50·8	53	51	52	57	56	52	55	51	49	52	—
—	0·05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
93	95	69	74	66	68	61	55	59	47	53	59	55	54	60	73	73	59
3·4	8·0	7·2	4·4	9·1	9·0	9·0	9·0	5·3	9·1	9·1	9·2	9·2	9·2	9·1	9·0	9·1	9·0
68·8	68	66·6	69·4	70	73	74	76	77	75	77	76·4	78	81	79	73	77	80
54	47·8	45·6	44·8	33·2	31·8	30·4	33	42	38	36	34	33·8	36·6	39	42·2	39	41·6
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
45	53	47	39	47	63	39	54	51	51	51	57	78	54	29	50	50	—
9·3	9·1	9·1	9·2	9·1	9·0	9·3	9·1	9·0	9·2	9·0	9·0	9·0	9·3	9·2	9·2	9·2	—
77	75	76	72	74	75	73	74	73	74	71	68	71	74	74	76	75	—
32	32	29	34	32	36	28	31	32	30	44	29	28	29	36	38	32	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
54	65	31	51	71	86	48	50	45	31	49	32	37	45	29	29	41	35
9·1	9·2	8·4	9·0	9·1	9·0	9·1	9·2	9·0	9·1	9·0	9·3	9·1	9·2	9·3	9·3	9·3	9·0
68	65	67	65	68	70	72	64	67	74	73	76	72	74	73	73	75	75
36	28	25	35	28	30	32	33	26	26	29	30	28	28	32	27	30·4	36
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	60	62	61	57	40	21	33	29	24	24	73	58	35	32	28	58	41
9·3	9·4	9·5	10·0	9·4	10·0	10·0	9·4	10·1	10·1	10·0	9·1	9·4	10·1	10·0	10·0	10·0	10·0
78	74	71	70	74	77	82	83	83	81	77	75	79	84	85	84	83	—
33	50	42	34	31	34	37	36	38	39	42	41	38	39	41	36	41	42
—	—	—	—	—	—	0·87	—	0·01	—	—	—	—	—	—	—	—	—
33	27	44	67	44	43	71	76	57	70	53	35	8	16	53	24	48	—
10·3	10·5	6·3	6·3	10·0	9·4	8·3	10·1	9·0	3·0	7·0	8·5	10·0	10·2	10·2	7·4	9·3	—
82	89	78	78	77	80	78	81	86	76	83	76	77	90	90	85	83	—
43	42	58	62	52	56	56	50	50	62	55	51	45	48	50	56	54	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·18	—	—	—
45	31	31	31	55	48	35	57	60	54	48	35	25	63	48	65	76	45
10·4	10·2	7·4	10·3	10·0	10·3	10·0	8·0	10·4	8·4	8·4	5·0	10·4	9·3	7·5	3·5	6·0	8·5
88	89	93	97	84	90	92	81	76	81	84	82	93	84	76	70	75	77
62	52	53	55	65	54	57	65	49	49	59	58	55	61	57	55	52	45
—	—	—	—	—	0·28	0·18	—	0·40	0·04	—	0·24	—	—	—	—	0·37	—
55	61	57	39	43	44	73	70	59	73	63	63	76	28	62	65	52	—
9·4	10·3	8·4	9·3	10·1	8·3	3·0	3·0	8·4	8·4	11·1	2·4	11·3	10·4	11·3	10·1	9·4	—
74	76	79	76	80	74	75	75	75	75	91	88	90	93	95	96	96	—
58	59	61	60	60	65	61	61	61	—	59	68	56	59	64	64	64	—
0·56	—	0·35	—	—	—	0·12	—	—	—	0·54	—	1·3	—	—	—	0·02	—
48	58	70	73	79	61	64	67	64	48	66	73	93	67	63	57	57	76
7·3	7·4	6·0	9·1	11·3	9·3	10·1	10·0	9·4	11·0	3·2	4·1	1·1	10·0	10·3	12·0	2·1	1·0
94	92	93	89	87	90	87	90	92	93	83	87	77	82	80	83	81	75
59	63	65	58	64	62	63	61	59	63	64	64	63	60	59	54	59	60
0·21	1·06	0·13	0·03	0·08	—	0·03	—	—	—	—	—	—	—	—	—	—	—
66	66	86	90	79	79	74	73	57	61	35	51	50	57	50	50	56	65
10·0	8·1	0·0	1·0	4·0	4·3	3·3	10·2	9·4	11·0	11·2	11·2	11·1	11·1	10·3	10·4	11·0	8·5
88	90	75	79	81	84	86	92	86	86	88	94	91	90	99	88	86	89
64	59	63	32	65	67	66	60	66	64	55	55	57	58	57	60	60	57

Several important factors are noticed in Table I which bear more or less directly on the subject of plant growth:—

(*a*) The total rainfall for the twelve months, 1st February, 1932, to 31st January, 1933, was 17·43 inches, compared with the normal average of 29 inches per annum. The unequal distribution of rain over the year is also worthy of note.

(*b*) No rain fell during the months June, July, August, and almost none in May.

(*c*) The first rain in spring fell on the 20th of September, so that plant growth after winter and up to that time was very little indeed, if any at all.

(*d*) With abundant sunshine and low relative humidity of the air, the rain could not be used to the greatest advantage by the plants. Such conditions would favour the rapid evaporation of soil moisture, and one would anticipate short periods of rapid growth immediately after a good rain followed by poorer growth or complete cessation of growth according to amount of soil moisture present until more precipitation takes place, when growth would begin again. This point will be referred to again in the article.

(*e*) The grasses were grown essentially under conditions of summer rainfall, when practically all the growth took place. During the 1932 winter, growth almost ceased on account of drought and cold.

(*f*) The effect of the climatic conditions on the composition of the grasses cannot be gauged correctly until data for subsequent years have become available. At the same time it must be pointed out that all the grasses under consideration were subject to the same climatic conditions, and the results, therefore, are on a comparative basis.

METHODS OF ANALYSIS.

The methods employed in the analytical work were described fully in the first article. A few modifications that have since been introduced will be referred to briefly here: A new washing mixture in which caustic soda was replaced by ammonia was made up for magnesium determinations, and gave better results than that described by Malan and Van der Lingen (1930). For greater detail of the method reference must be made to an article by one of the authors (C.R.H.) in this Journal. The procedure for the determination of sodium was modified slightly and proved to be an improvement in every way on the original method. The principle of the method remained unaltered, and details are to be found in an article by J. G. Louw (1933). The absence of total ash determination remains a difficulty, and as the results now stand, the undetermined fraction consists of N-free extract, either soluble extract and ash, causing the first and most important fraction, viz., N-free extract to be only approximate. Part of the ash is, of course, that actually determined and given as mineral constituents. Still, the silica content is not known nor can mechanical contaminations with sand during the

process of sampling and classifying be excluded entirely or judged accurately while the extent of these factors undoubtedly affect the figure for N-free extractives.

Sand or soil contamination of the grass samples in the work under discussion was practically negligible, as the process of cutting is such, that would eliminate all contamination, and only mechanically adhering particles on the outside of the plant material might have found their way into the sampling bag. Briefly, the method of sampling is as follows: The superficial parts of the grass are grasped with the left hand, and cut about half an inch above the soil surface with a pair of scissors held in the right hand. The sample is then immediately transferred to the bag or container. The samples are then taken to a room and, when air dry, are again shaken and handled before a final sample is taken to be milled and analysed. The resulting sample for analysis would probably be as free from mechanically adhering sand particles as is practicable to get it under ordinary circumstances when several thousand complete analyses have to be carried out annually in routine procedure. Under the conditions described above the effect of the ultimately adhering soil particles on the values obtained for the chemical analyses of the pasture samples is to all intents and purposes negligible.

Unfortunately, however, the value for N-free extract is not entirely corrected by the procedure described, while the factors which are not protein, not fibre and not the inorganic constituents given in the list of determinations, remain undetermined, the percentage N-free extract obtained by difference between the percentage values obtained and 100 must remain approximate. As explained in the previous publication, the reason for omitting some determinations such as ether extract, silica free ash, etc., and therefore, including these automatically in the N-free extract fraction, was due to limitation of available assistance, while at the same time no serious error was introduced. Several of the mineral surveys, some of which have been dealt with in the previous article already referred to, and the analyses of the samples of the first 12 months of the plot experiments, have been discussed on this basis, while with more assistance, which has recently been forthcoming, a method for the determination of total ash and soluble ash in addition to the other fractions has been introduced automatically, thereby providing figures that are more truly accurate for the N-free extract. Full details of the ash determinations will be given in this Journal by J. G. Louw (1933).

PRESENTATION OF RESULTS.

As already stated, eleven species of grasses were studied and analysed, each giving a maximum of 12 monthly cuttings, 6 bi-monthly cuttings, 4 three-monthly cuttings, 3 four-monthly cuttings, 2 five-monthly cuttings, and 2 six-monthly cuttings, from February, 1932, to January, 1933. Actually, of course, growth did not take place equally well all the year round, so that none of the grasses gave the full number of monthly cuttings for the period in question. Nevertheless, six mineral constituents with protein and fibre, were regularly determined in each sample taken, involving several thousand analyses which present a problem as to the best method of presenting the results.

TABLE II.

P_2O_5 Content of Grasses.

(Period of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphitophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February.....	·40	·31	·42	·43	·29	·45	·46	·53	·38	·40	·59
March.....	·29	·29	·30	·27	·21	·32	·28	·30	·24	·23	·30
April.....	·17	·20	·18	·22	·12	·19	·17	·14	·17	·12	·16
May.....	·14	·16	·15	·13	·08	·14	·13	·10	·13	·07	·18
June.....	·13	·11	·09	·10	·07	·12	·12	·09	·07	·06	·16
July.....	·12	·12	·09	·09	·06	·11	·11	·09	·05	·05	·16
August.....	·15	·10	·08	·07	·06	·12	·10	·08	·08	·06	·12
September.....	·11	·11	·11	·11	·06	·19	·11	·09	·10	·07	·25
October.....	—	·14	·12	·10	·06	·13	·14	·11	·13	·10	·18
November.....	·10	·13	·12	·12	·06	·21	·12	·10	·11	·10	·22
December.....	·11	·16	·13	·09	·09	·17	·13	·12	·11	·11	·18
1933.											
January.....	·15	·16	·12	·10	·10	·27	·13	·13	·11	·12	·22

It appears best to deal with each constituent determined separately after the tables of analyses for that constituent have been given. The constituents to be considered are phosphorus, calcium, magnesium, sodium, potassium, chlorine, protein, and fibre.

Two tables will be given to represent the results of the analyses in regard to each of the constituents to be considered. The first gives the percentage content of the grasses of the particular constituent at the following periods of growth: 1 month, 2 months, 3 months and so on, up to twelve months. The second table gives the analyses of the grasses every month, another portion of the plot cut every two months, a third cut every three months, and so on, up to the two six-monthly cuttings. In each table, therefore, data are presented for the full 12-month period, i.e. from 27th January, 1932, until 26th January, 1933.

Phosphorus.

Tables II and IV present in tabular form the data obtained in regard to the phosphorus content of the eleven species of grasses studied.

A close study of Table II is both interesting and essential. As reference to the meteorological data given in Table I will be made constantly, a summary of Table I is given below, which will present at a glance the general trend of the climatic conditions during the period to be considered, viz., February, 1932, until January, 1933.

TABLE III.

	Rainfall in Inches.	Dates on which Rain Fell.	Average Humidity.	Average Hours Sunshine.	Average Maximum Temp.	Average Minimum Temp.
1932.						
February.....	4·85	2, 3, 4, 5, 14, 17, 19, 20, 25, 28, 29	69	7·7	86	61
March.....	2·08	8, 9, 12, 20, 21, 29	70	6·9	84	58
April.....	0·77	23, 24, 25, 26..	64	8·1	82	49
May.....	0·15	13, 15.....	63	8·6	75	40
June.....	—	—	55	8·4	73	34
July.....	—	—	50	9·0	71	30
August.....	—	—	43	9·6	77	36
September....	0·88	20, 22.....	45	8·8	82	49
October.....	1·76	1, 3, 4, 28.....	52	8·1	84	56
November....	2·54	1, 4, 7, 10, 19, 20, 22, 23, 25, 30	56	8·5	81	59
December.....	3·54	4, 12, 13, 14, 16, 20, 24, 26, 30	67	7·4	87	61
1933.						
January.....	1·54	14, 15, 16, 17, 18, 20	61	8·2	89	61

For all the species of grasses given in Table II a rapid drop in the percentage prosphorus occurred until new growth in spring began, when a slight improvement set in which was apparently kept up until the end of the period under consideration. Reference to Table III indicates that the first rains after the dry winter months fell in September, so that the September cuttings already contained some new growth, as is also evident from the observations given in Table A in the appendix for September. Another striking feature of the values for P_2O_5 given in Table II is the extraordinary low phosphorus content of the grasses. The values for February, i.e. after the grasses had grown for one month, represent fair figures, although quite a remarkable variation is noticeable in the phosphorus contents of the species given, *Urochloa pullulans*, one of the best and most palatable grasses, being the highest, and *Hyparrhenia hirta*, a coarse, fibrous grass, hardly ever eaten and usually called thatch grass, being the lowest in phosphorus. After two months' growth, i.e. at the end of March, about thirty per cent. drop in phosphorus had already set in, while the values after that period represent those of mature grass with hardly any new growth as a closer study of the descriptions given in Table A in the appendix will reveal.

This table undoubtedly suggests that winter pasture, even if the best feeding grasses like *Urochloa pullulans*, *Panicum maximum*, etc., are present, does not contain more than about ·1 per cent. P_2O_5 if it consists of mature grasses as it usually does on account of certain pasture being especially reserved for winter grazing. Twenty-five lb. of such pasture—the daily requirements of an average cow—contain about 12 gm. P_2O_5, some of which is not available and will pass out in the faeces of the animal, whereas a gallon cow loses about 15 gm. P_2O_5 in her milk apart from that required for maintenance. The phosphorus content of this type of grazing is quite insufficient for even poor milk production during winter under ranching conditions where no supplementary feeding takes place, if the figures obtained on the plots are at all representative of the phosphorus content of the natural pasture.

In spite of fairly good rains having fallen in November and December, and well distributed over the month, the phosphorus content of the grasses did not show a significant improvement, although, according to Table A, quite a fair amount of new growth had taken place. The figures obtained for the phosphorus content after new growth had begun, do not claim to represent the phosphorus content of the grasses as eaten by an animal which would graze selectively, probably including more young grass and less old grass than a representative sample of the whole plot for analyses would contain.

Table IV gives the P_2O_5 content of the grasses under consideration after definite periods of growth at various times of the year. For instance, six cuttings of the same portion of the plot were made of two months' growth each from February, 1932, until January, 1933.

Of the species of grasses considered *Urochloa pullulans* retained its comparatively high phosphorus content, when the same portion of the plot was cut monthly, better than the others. Both *Cynodon dactylon* and *Hyparrhenia hirta* remained more constant in their

TABLE IV.

P_2O_5 Content of Grasses.

		Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.												
1932	February....	·40	·31	·42	·43	·29	·45	·46	·53	·40	·383	·59
	March.....	·472	·336	·46	·47	·35	·494	·485	·565	·43	·44	·60
	April.....	·37	·28	·43	·40	·31	·43	·43	·48	·38	—	·51
	May.....	—	—	·47	—	—	—	—	—	·41	—	—
	August.....	—	—	·415	—	—	—	—	—	—	—	—
	September...	—	—	·34	·42	—	—	—	—	·34	·39	—
	October.....	—	·29	·306	·31	·28	·38	·40	—	·32	·30	·46
	November...	·27	·29	·34	·30	·28	·45	·35	·40	·31	·32	·50
	December....	·33	·28	·32	·25	·28	·44	·31	·44	·25	·29	·50
1933	January.....	·31	·295	·37	·32	·32	·39	·36	—	·31	·30	·49
Two-monthly Growth.												
1932	March.....	·29	·287	·30	·27	·21	·32	·28	·30	·23	·236	·296
	May.....	·30	·18	·34	·31	·28	·34	·38	·35	·27	·29	·36
	July.....	·38	—	·395	—	·29	—	—	—	·33	—	—
	September...	—	—	·31	·47	·34	·526	—	—	·37	·32	—
	November...	·235	·23	·22	·18	·22	·34	·29	·38	·23	·21	·46
1933	January.....	·24	·25	·24	·20	·21	·27	·26	·33	·25	·23	·42
Three-monthly Growth.												
1932	April.....	·17	·20	·18	·22	·12	·19	·17	·14	·12	·17	·16
	July.....	·29	·127	·28	—	·25	·38	·42	—	·19	·19	—
	October.....	·26	·265	·236	·28	·24	·28	·36	·46	·33	·22	·526
1933	January.....	·21	·226	·19	·20	·19	·25	·24	·32	·22	·19	·41
Four-monthly Growth.												
1932	May.....	·14	·16	·15	·13	·078	·14	·13	·10	·07	·13	·18
	September...	·33	·185	·295	·40	·34	·75	·47	—	·46	·27	1·12
1933	January.....	·20	·20	·19	·17	·21	·23	·20	·27	·21	·14	·41
Five-monthly Growth.												
1932	June.....	·13	·11	·09	·097	·072	·12	·12	·09	·056	·07	·16
	November...	·25	·20	·20	·16	·22	·32	·25	·37	·23	·16	·43
Six-monthly Growth.												
1932	July.....	·12	·116	·095	·089	·063	·11	·11	·086	·05	·054	·16
1933	January.....	·19	·19	·17	·17	·18	·24	·20	·28	·21	·15	·43

phosphorus content, but the values remained low throughout. All the other species showed a greater or smaller drop in their values for phosphorus from February, 1932, to January, 1933. A study of the meteorological data given in Table III does not throw further light on this observation, and it must be left provisionally until the analyses for at least another year have been completed.

There was undoubtedly significant differences in the amount of growth during winter. In the case of *Cymbopogon plurinodes* only June and July did not provide a sample of monthly growth for analysis, while at the other extreme *Amphilophis insculpta* did not show enough growth for analysis of monthly cuttings from May to October.

The analyses of the remaining periodic cuttings all suggest the same thing, viz., that the older the plant, i.e. the later the stage of growth, the lower is its phosphorus content. Two-monthly cuttings show lower figures than one-monthly, while five- and six-monthly growth is definitely lower in phosphorus than three- and four-monthly growths.

The exceptions to this generalization should be studied in conjunction with Table III, and Tables A, B and C in the appendix. For instance, in Table IV *Eragrostis superba* and *Pennisetum ciliare* show a higher figure for phosphorus in September for a two-monthly cutting. Reference to the rainfall in Table III indicates that the first rains fell in late September, while Table C in the appendix shows not enough growth for a sample of these two grasses for the May to July period, and that in September the growth was green and short with 85 and 60 gm. respectively, for samples. In other words, the two-monthly samples consisted of entirely new growth of high phosphorus content. In case of four-monthly cuttings in September, the values of phosphorus given in Table IV are even more striking in that high values were obtained for all the grasses with the exception only of *Cynodon dactylon*, the sample which happened to be described in Table C as " mixed with flower heads " instead of " green short ", which applies to all the other samples for that period. The analyses of the five-monthly cuttings in Table IV read in conjunction with the description of the samples given in Table C, brings out the same point, viz., that stage of growth, depending in the first instance on climatic conditions, of which rainfall appeared to be the deciding factor, determined the phosphorus content of the grasses studied. As the grasses matured, the phosphorus content dropped, and under similar climatic conditions the phosphorus content of one month's growth would be higher than that of two months, while the latter is slightly higher than a three months' growth, although, after three months' growth, with an average figure of about ·2 per cent. P_2O_5 (see also Table II) there appears to be a variation in the P_2O_5 content between ·2 and about ·06 depending on the amount of new growth present and, therefore, included in the sample for analysis.

Comparing Tables II and IV, one is forced to the conclusion that a rise in the phosphorus content of the grasses was definitely brought about by periodic cutting after three, four, five and six months' growth when compared with the undisturbed growth for

TABLE V.

Crude Protein Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February	10·0	11·7	10·8	12·3	7·9	12·5	16·8	12·4	14·2	10·9	12·3
March	7·5	10·2	8·5	8·0	5·2	9·5	9·7	6·7	6·6	7·1	8·0
April	6·0	8·0	6·5	5·5	4·6	6·0	6·2	4·2	6·2	4·0	6·0
May	4·9	7·1	5·6	4·0	2·7	5·0	6·5	3·1	4·6	3·6	6·2
June	4·2	5·5	5·0	3·5	2·3	3·8	5·4	3·7	3·5	2·5	6·7
July	4·6	4·9	3·5	3·6	2·3	3·5	4·5	2·7	2·1	1·9	4·0
August	4·4	4·8	3·0	4·4	2·4	3·3	4·9	5·2	3·4	4·2	5·0
September	4·0	5·7	4·2	5·0	2·5	5·9	6·1	3·0	3·2	2·9	5·5
October	5·9	7·7	5·2	4·4	2·7	5·1	6·8	3·2	5·1	4·1	8·5
November	4·1	5·9	5·0	5·6	2·6	5·2	8·8	3·2	4·3	4·6	7·2
December	5·2	12·6	5·1	5·2	4·8	6·9	7·5	4·1	4·1	9·0	7·8
1933.											
January	5·0	11·5	4·9	6·5	4·7	5·3	9·4	7·0	4·1	5·7	8·4

the same periods given in Table I. For instance, a removal of the old grasses by cutting in June (Table IV five-monthly cutting) had greater effect on the composition of the next five months' growth in November than leaving the grass undisturbed and analysing it after 10 months' growth (cf. Table II, November). Obviously, the analyses will have to be carried out for several years to confirm the tentative conclusion mentioned above. Much more important is the observation that the grasses reached maturity and, therefore, a low value for phosphorus, very rapidly, and remained low in phosphorus for the rest of the twelve months' period in spite of new growth having taken place from time to time.

Protein.

The protein content of the grasses studied is given as indicated in Table V.

Table V reveals that the values for protein were highest after one month growth, dropped quite rapidly as in the case of phosphorus, until mid-winter, when they ranged round about a quarter of the original figure, then rose during spring, apparently when new growth began. It seems that the protein content of the grasses responded remarkably well to new growth, several values in January being approximately double those of July. As in the case of phosphorus, the protein values after one month's growth were higher than any other given in Table V. The younger the plant the higher apparently is the protein content, or again stage of growth determines ultimately the protein content of the plant.

Table VI presents further data on the protein content of the grasses as indicated.

There is no doubt that with the climatic conditions existing in 1932 the protein content of the grasses studied remained definitely higher when cut at intervals as stated in Table VI than when allowed to grow according to the scheme of analysis set forth in Table V. It is realized, of course, that increase in the protein, phosphorus and, maybe, other constituents of the plant by periodic cutting, has not much practical value unless the yield of grass is not too adversely affected by the periodic cutting. The plots were too small to study yield as already stated, although the weights of the grass samples obtained at each cutting as given in Tables A, B and C in the appendix, give some indication of the quantity of grass obtained, when cutting, for instance, every two months on six occasions, compared with that obtained for one cutting at the end of 12 months. On the whole, one cutting after twelve months produces from one and a half to twice as much grass as the total of six two-monthly cuttings. Furthermore, although the yield is much greater, the proportion of unpalatable hard fibrous grass in the long period sample is also much greater than in that cut at shorter intervals. There is the possibility that a smaller yield will be fully compensated for by better quality in the short term growth. This point, about improvement in quality at the expense of yield, will be considered at a later stage in the work under consideration when enough data have accumulated over several years under different climatic conditions. For the present, it can only be said that the protein content of

TABLE VI.

Crude Protein Content of Grasses.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.											
1932 February....	10·0	11·7	10·8	12·3	7·9	12·5	16·8	12·4	10·9	14·2	12·3
March.....	12·9	13·0	12·8	14·2	10·0	15·6	16·1	15·4	13·4	11·7	14·6
April.....	13·2	11·7	14·0	14·1	12·2	16·7	16·2	15·4	13·2	—	14·8
May.....	—	—	13·7	—	—	—	—	—	14·8	—	—
August.....	—	—	12·4	—	—	—	—	—	—	—	—
September...	—	—	12·6	16·0	—	—	—	—	13·3	12·7	—
October.....	—	10·5	11·5	13·9	11·5	16·1	20·1	—	15·0	9·5	19·2
November...	11·2	11·1	10·9	13·1	10·1	16·2	18·8	13·0	13·9	10·3	21·6
December...	13·6	21·5	18·4	13·6	16·4	15·8	—	15·8	15·3	11·5	22·3
1933 January.....	11·8	21·3	11·7	12·8	10·5	14·7	18·3	—	20·7	11·9	18·9
Two-monthly Growth.											
1932 March.....	7·5	10·2	8·1	8·0	5·2	9·5	9·7	6·7	7·1	6·6	8·0
May.....	11·1	7·9	11·3	10·0	11·2	13·7	15·8	11·5	10·7	10·0	12·7
July.....	10·7	—	12·8	—	10·5	—	—	—	10·8	—	—
September...	—	—	12·8	18·2	11·8	—	—	—	14·8	11·6	—
November...	9·0	12·1	7·4	8·3	7·7	13·0	16·8	10·7	11·5	7·2	17·2
1933 January.....	9·0	11·0	10·9	12·3	11·4	12·3	14·7	10·3	10·6	14·2	13·6
Three-monthly Growth.											
1932 April.....	6·0	8·0	6·5	5·5	4·6	6·0	6·2	4·2	4·0	6·2	6·0
July.....	10·8	5·6	12·9	—	9·2	15·7	16·1	—	10·0	6·7	—
October.....	10·7	12·5	10·0	13·6	9·4	12·1	16·8	13·8	13·0	9·7	16·9
1933 January.....	13·1	16·0	6·7	7·7	10·4	9·0	12·9	9·3	10·0	7·6	20·9
Four-monthly Growth.											
1932 May.....	4·9	7·1	5·6	4·0	2·7	5·0	6·5	3·1	3·6	4·6	6·2
September...	12·0	—	11·0	12·9	15·1	22·0	18·3	—	16·4	10·5	27·0
1933 January.....	8·2	9·3	6·6	10·6	11·4	12·3	12·2	12·8	—	5·5	13·7
Five-monthly Growth.											
1932 June.....	4·2	5·5	5·0	3·5	2·3	3·8	5·4	3·7	2·5	3·5	6·7
November...	10·0	10·2	10·9	12·1	8·3	11·2	14·8	11·1	10·8	10·4	16·3
Six-monthly Growth.											
1932 July.....	4·6	4·9	3·5	3·6	2·3	3·5	4·5	2·7	1·9	2·1	4·0
1933 January.....	7·4	8·7	5·3	7·0	7·3	12·3	12·1	7·8	9·4	8·9	12·9

TABLE VII.

Crude Fibre Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February.....	36·4	28·7	34·0	35·0	37·2	33·3	28·5	35·7	33·0	34·5	29·5
March.....	39·4	27·7	36·8	39·3	43·4	36·1	33·5	40·0	37·6	36·4	33·2
April.....	36·8	28·8	36·2	38·3	41·8	34·2	33·4	40·9	36·0	34·3	33·4
May.....	38·6	28·1	33·0	37·9	41·6	35·5	33·1	41·0	32·8	37·2	28·4
June.....	39·8	28·4	33·4	36·7	40·5	35·5	33·8	40·1	32·6	34·9	30·8
July.....	38·3	29·2	36·3	35·4	41·0	34·5	34·8	42·7	36·9	34·6	32·9
August.....	37·6	31·1	35·7	37·4	41·5	34·1	34·0	41·6	31·9	34·8	30·8
September.....	39·8	28·6	35·7	32·7	41·7	35·9	32·3	41·3	34·2	34·7	34·1
October.....	34·5	28·5	31·1	36·4	41·8	34·3	31·3	39·8	35·9	35·7	32·3
November.....	37·2	26·7	32·1	33·1	42·1	32·6	29·6	40·1	36·3	34·4	29·2
December.....	34·7	28·6	33·9	36·4	39·1	36·5	32·2	38·0	32·7	33·5	28·0
1933.											
January.....	38·7	31·0	36·4	35·2	35·8	35·1	30·3	39·6	33·8	33·5	31·4

samples cut at monthly intervals (Table VI) is enough to provide for the requirements of a 2-gallon cow under ranching conditions, and that, judging from the eleven species of grasses studied, the protein content does not vary as much from species to species as from one stage of growth to another.

Fibre.

Tables VII and VIII contain data on the fibre content of eleven species of grasses at various stages of growth.

Hyparrhenia hirta and *Rhynchelythrum roseum* are highest in fibre according to Table VII, although *Amphilophis insculpta* used for making hay sometimes, and *Cymbopogon plurinodes*, or turpentine grass, are not much lower, and are almost on a par with what are commonly called good grasses, like *Panicum maximum*, *Urochloa pullulans*, *Eragrostis superba*, *etc.* As a matter of fact, the fibre content of all the grasses given in Table VII are high. When cut at intervals of one month, as stated in Table VIII, the fibre content of the grasses decreases from about 35 per cent. to approximately 25 per cent., although according to Woodman's work (1926 *et seq.*) it is doubtful whether the digestibility improves accordingly. Increase in fibre lowers palatability, and is also undoubtedly associated with advance of stage of growth which in its turn, as will appear from the analyses, indicates a decrease in the "quality" of the grass. The association of fibre content with palatability, is very important, but cannot be considered in this investigation. Finally, a consideration of digestibility in relation to increase in fibre, i.e. advance of stage of growth, is of the utmost importance. Woodman (1932) states that during a season of favourable rainfall five-weekly cutting of herbage prevented greatly reduced digestibility as increased lignification was practically negligible. This may not apply to South African conditions where growth is more rapid under conditions of favourable rainfall and lignification may set in sooner than at Cambridge.

Further information will be obtained on the question of maturation of pasture and its effect on digestibility early next spring, when digestibility trials on pasture at different stages of growth will be undertaken.

Calcium.

The calcium content of the eleven species of grasses is given as indicated in Tables IX and X.

With the doubtful exception of *Cynodon dactylon*, there is apparently a slight but inconsistent drop in the calcium content of the grasses as they mature. This tendency for calcium to be lower on the whole for advanced stages of growth is more apparent if the figures for the calcium content of monthly growth in Table X are compared with the corresponding figures given in Table XI for the same grass from one month old up to twelve months.

TABLE VIII.

CRUDE FIBRE CONTENT OF GRASSES.

		Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.												
1932	February....	36·4	28·7	34·0	35·0	37·2	33·3	28·5	35·7	34·5	33·0	29·5
	March.....	32·8	27·1	30·4	28·8	30·0	30·4	26·6	30·3	32·7	30·8	25·6
	April.....	32·4	25·6	29·0	26·6	32·4	28·3	25·2	29·1	28·3	—	23·2
	May.....	—	—	26·7	—	—	—	—	—	24·3	—	—
	August.....	—	—	—	—	—	—	—	—	—	—	—
	September...	—	—	26·4	25·7	—	—	—	—	26·1	27·0	—
	October.....	—	24·7	26·9	29·0	28·1	26·1	19·7	—	27·1	31·3	17·2
	November...	29·8	26·1	26·8	27·9	28·6	22·0	21·0	29·8	29·0	28·3	16·6
	December....	30·4	27·8	29·8	29·7	31·1	28·4	22·8	30·1	32·4	29·2	19·9
1933	January.....	32·4	26·2	28·3	28·3	28·3	29·2	24·0	—	30·5	28·4	19·2
Two-monthly Growth.												
1932	March.....	39·4	27·7	36·8	39·3	43·4	36·1	33·5	40·0	36·4	37·6	33·2
	May.....	30·5	27·7	26·0	27·5	29·1	28·6	22·2	29·1	25·3	27·4	24·1
	July.....	29·5	—	25·3	—	25·5	—	—	—	23·8	—	—
	September...	—	—	27·2	26·0	27·4	29·6	—	—	25·6	27·8	—
	November...	32·0	24·4	30·2	32·6	31·8	36·0	21·8	32·8	29·3	31·6	19·3
1933	January.....	34·7	26·8	34·6	33·6	34·7	33·1	26·6	32·8	32·0	31·0	24·1
Three-monthly Growth.												
1932	April.....	26·8	28·8	36·2	38·3	41·8	34·2	33·4	40·9	34·3	36·0	33·4
	July.....	29·2	28·5	25·2	—	27·0	27·0	24·2	—	24·5	27·7	—
	October.....	30·2	25·0	30·6	30·6	30·1	27·6	21·2	26·4	25·7	32·6	17·4
1933	January.....	31·9	28·4	33·2	33·0	34·3	32·8	26·5	32·0	32·2	31·2	23·0
Four-monthly Growth.												
1932	May.....	38·6	28·1	33·0	37·9	41·6	35·5	33·1	41·0	37·2	32·8	28·4
	September...	30·4	27·0	26·7	26·6	25·6	28·6	20·7	—	24·2	28·3	16·5
1933	January.....	30·1	27·3	33·1	33·9	31·8	33·3	26·6	32·2	30·1	31·2	22·1
Five-monthly Growth.												
1932	June.....	39·8	28·4	33·4	36·7	40·5	35·5	33·8	40·1	34·9	32·6	30·8
	November...	29·8	25·8	30·3	34·3	28·3	27·5	27·3	28·0	27·3	31·8	16·1
Six-monthly Growth.												
1932	July.....	38·3	29·2	36·3	35·4	41·0	34·5	34·8	42·7	34·6	36·9	32·9
1933	January.....	32·5	26·6	34·8	31·2	31·3	30·7	25·3	40·3	30·0	33·5	22·6

TABLE IX.

CaO Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February	·51	·54	·35	·52	·32	·33	·81	·52	·51	·43	·74
March	·43	·57	·30	·41	·29	·26	·41	·30	·39	·36	·54
April	·47	·61	·39	·48	·35	·34	·51	·32	·52	·45	·48
May	·45	·63	·39	·46	·30	·48	·78	·38	·59	·45	·44
June	·51	·60	·43	·59	·33	·38	·66	·36	·58	·61	·51
July	·55	·77	·40	·47	·34	·33	·58	·38	·55	·60	·65
August	·50	·77	·33	·42	·44	·29	·81	·38	·72	·61	·71
September	·45	·71	·34	·51	·36	·39	1·12	·44	·52	·65	·74
October	—	·64	·36	·36	·32	·47	·67	·42	·50	·57	·90
November	·44	·60	·40	·44	·29	·37	1·03	·43	·44	·65	·88
December	·50	·65	·32	·43	·38	·45	·81	·51	·44	·61	·89
1933.											
January	·53	·72	·30	·39	·28	·44	1·05	·50	·48	·67	·79

TABLE X.

CaO Content of Grasses.

		Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhunchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.												
1932	February....	·51	·54	·35	·52	·32	·33	·81	·52	·43	·51	·74
	March.....	·53	·51	·34	·50	·39	·28	·64	·45	·40	·46	·65
	April.....	·60	·58	·45	·62	·50	·43	·77	·58	·50	—	·88
	May.....	—	—	·42	—	—	—	—	—	·55	—	—
	August.....	—	—	·44	—	—	—	—	—	—	—	—
	September...	—	—	·55	·80	—	—	—	—	·68	·66	—
	October.....	—	·63	·47	·60	·60	·56	1·23	—	·65	·53	1·12
	November...	·60	·67	·46	·68	·48	·52	1·26	·62	·57	·57	·98
	December....	·63	·65	·42	·69	·53	·52	1·22	·72	·56	·68	·96
1933	January.....	·61	·56	·39	·72	·54	·49	1·00	—	·61	·70	·81
Two-monthly Growth.												
1932	March.....	·43	·57	·30	·41	·29	·26	·41	·30	·36	·39	·54
	May.....	·70	·50	·53	·93	·78	·54	1·17	·80	·79	·73	·93
	July.....	·86	—	·62	—	·95	—	—	—	·87	—	—
	September...	—	—	·64	·78	·74	·57	—	—	·69	·72	—
	November...	·57	·71	·47	·62	·59	·55	1·21	·63	·71	·59	1·15
1933	January.....	·63	·58	·36	·61	·47	·49	·89	·57	·67	·67	·83
Three-monthly Growth.												
1932	April.....	·47	·61	·39	·48	·35	·34	·51	·32	·45	·52	·48
	July.....	·91	·55	·66	—	1·01	·71	1·32	—	1·05	·88	—
	October.....	·76	·69	·49	·60	·57	·64	1·05	·70	·81	·48	1·08
1933	January.....	·63	·59	·38	·53	·43	·52	·90	·55	·66	·61	·76
Four-monthly Growth.												
1932	May.....	·45	·63	·39	·46	·30	·49	·78	·38	·45	·59	·44
	September...	·79	·61	·69	·87	·84	·63	1·19	—	·69	·59	·88
	January.....	·60	·62	·41	·51	·46	·49	1·01	·52	·69	·56	·74
Five-monthly Growth.												
1932	June.....	·51	·60	·43	·59	·33	·38	·66	·36	·61	·58	·51
	November...	·70	·71	·54	·63	·71	·58	1·25	·63	·80	·53	·99
Six-monthly Growth.												
1932	July.....	·55	·77	·40	·47	·34	·33	·58	·38	·60	·55	·65
1933	January.....	·55	·58	·39	·51	·45	·43	1·02	·49	·69	·48	·77

TABLE XI.

Na_2O Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February	·04	—	·035	·075	·02	·066	·38	·057	—	·06	1·01
March	·03	·014	·02	·02	·013	·04	·90	·027	·015	·012	·47
April	·02	·029	·015	·02	·014	·02	·73	·02	·02	·019	·42
May	·01	·02	·014	·03	·023	·019	·40	·016	·013	·016	·42
June	·046	·026	·012	·02	·02	·016	·44	·017	·009	·019	·23
July	·04	·024	·031	·02	·028	·04	·27	·022	·016	·025	·058
August	·04	·029	·018	·03	·026	·06	·23	·026	·022	·036	·155
September	·04	·036	·024	·03	·02	·04	·117	·021	·016	·022	·10
October	—	·042	·029	·03	·02	·043	·29	·012	·01	·044	·245
November	·025	·041	·027	·026	·017	·035	·33	·01	·01	·032	·06
December	·027	·037	·028	·025	·02	·04	·35	·018	·016	·036	·047
1933.											
January	·036	·032	·031	·023	·02	·047	·356	·02	·022	·046	·056

TABLE XII.

Na_2O Content of Grasses.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.											
1932 February....	·04	—	·035	·075	·02	·066	·38	·057	·06	—	1·01
March.....	·027	·016	·035	·047	·019	·067	·47	·07	·03	·03	·70
April.....	·034	·029	·038	·026	·025	·05	·51	·048	·034	—	·70
May.....	—	—	·025	—	—	—	—	—	·15	—	—
August.....	—	—	·076	—	—	—	—	—	—	—	—
September...	—	—	·036	·049	—	—	—	—	·039	·043	—
October.....	—	·036	·025	·044	·027	·064	·84	—	·045	·038	1·18
November...	·079	·055	·04	·04	·033	·055	·73	·035	·04	·036	·54
December....	·086	·039	·048	·027	·03	·096	·55	·047	·049	·03	·50
1933 January.....	·09	·037	·056	·036	·029	·057	·87	—	·052	·04	·60
Two-monthly Growth.											
1932 March.....	·03	·014	·02	·02	·013	·04	·90	·027	·012	·015	·47
May.....	·02	·02	·016	·02	·02	·03	·47	·127	·03	·027	·49
July.....	·04	—	·037	—	·039	—	—	—	·056	—	—
September...	—	—	·028	·05	·025	·041	—	—	·034	·038	—
November...	·034	·039	·039	·035	·03	·041	·66	·032	·043	·019	·50
1933 January.....	·052	·045	·044	·035	·022	·06	·63	·039	·048	·027	·26
Three-monthly Growth.											
1932 April.....	·02	·029	·015	·02	·014	·02	·73	·02	·019	·02	·42
July.....	·04	·027	·027	—	·035	·048	·31	—	·035	·024	—
October.....	·047	·042	·026	·049	·031	·059	·60	·039	·040	·03	·51
1933 January.....	·044	·041	·029	·036	·025	·051	·50	·043	·045	·026	·17
Four-monthly Growth.											
1932 May.....	·01	·02	·014	·03	·023	·019	·40	·016	·016	·013	·42
September...	·047	·018	·026	·04	·029	·032	·315	—	·059	·044	·516
1933 January.....	·053	·032	·042	·029	·023	·054	·37	·029	·048	·015	·115
Five-monthly Growth.											
1932 June.....	·046	·026	·012	·02	·02	·016	·44	·017	·019	·009	·23
November...	·04	·036	·033	·024	·025	·025	·45	·041	·039	·022	·32
Six-monthly Growth.											
1932 July.....	·04	·024	·031	·02	·028	·04	·27	·022	·025	·016	·058
1933 January.....	·036	·029	·038	·025	·02	·058	·33	·033	·055	·013	·10

There is a remarkable variation in the calcium content of different species of grasses at different stages of growth. *Cymbopogon-plurinoides* or turpentine grass, *Hyparrhenia hirta* or thatch grass, and *Rhynchelythrum roseum*, all show poor values while *Urochloa pullulans* and *Panicum maximum*, which make good grazing, are high.

If these eleven species of grasses are at all indicative of the calcium content of natural grazing, it is extremely unlikely that stock will suffer from a calcium deficiency under ranching conditions. A cow producing 2 gallons of milk would consume under grazing conditions about four times as much calcium as she secretes in her milk. Even mature grasses according to Table IX are fairly high in calcium if hard fibrous grasses like *Cymbopogon plurinoides* and *Hyparrhenia hirta*, which in any case animals will not touch at that stage of growth, are omitted.

Sodium.

The sodium contents of the grasses studied are given in Tables XI and XII.

A very significant feature of the sodium content of the grasses is the great variation in sodium for different species at the same stage of growth. *Urochloa pullulans* and *Panicum maximum* are outstandingly high in sodium, while the other species vary from about ·01 to ·04 per cent., which does not appear to vary for different satges of growth. *Urochloa* shows a remarkable drop in Table XI, which is not so pronounced for *Panicum maximum*.

The value for sodium appear to be remarkably low on the whole, and Table XI suggests that the intake of sodium by cattle on grazing certainly justifies serious consideration of a possible deficiency of this constituent. Basing the sodium requirements of a cow again on a two-gallon production standard approximately 10 gm. of Na_2O are secreted in her daily milk, while 25 lb. of grazing on the dry basis contain approximately 11 gm. of Na_2O, which have to suffice for milk production as well as for the maintenance of the cow. ·025 gm. Na_2O for the composition of pasture eaten is obviously an arbitrary figure, but is sufficiently correct to bring out the possibility of too little sodium being present in pasture for milk production without supplementary feeding. Later results, especially when mixed pasture is being considered, will throw more light on this problem of a possible sodium deficiency.

Potassium and Chlorine.

Potassium and chlorine may be taken together for the purpose of discussion as they show great similarity in at least two respects in the Tables XIII, XIV, XV and XVI, which give the results as indicated:—

TABLE XIII.

K_2O Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February	2·57	1·87	2·66	2·8	2·13	5·4	3·50	3·40	2·28	3·88	3·04
March	1·91	1·34	1·99	1·78	1·61	3·6	1·89	2·07	1·55	2·34	2·74
April	1·30	1·00	1·14	1·23	1·28	2·6	1·60	1·55	1·20	1·62	2·45
May	1·19	·94	1·05	·99	1·05	1·92	1·70	1·28	1·05	1·84	2·30
June	1·20	·70	1·01	·84	·98	1·62	1·84	1·27	1·08	2·05	2·30
July	1·17	·65	·81	·91	·77	1·56	1·75	1·20	1·04	1·36	2·15
August	1·24	·69	·84	·61	·74	1·51	1·59	1·35	1·04	1·52	2·22
September	·94	·36	·64	·64	·45	1·20	1·04	·75	·68	·78	1·47
October	—	·76	·65	·78	·50	1·10	1·18	·47	·97	·86	·93
November	·68	·64	·83	·92	·55	1·39	·91	·42	·65	·95	1·15
December	·69	·99	·76	·82	·59	1·45	1·33	·33	·70	·97	1·20
1933.											
January	1·15	·99	·70	·88	·79	1·35	1·35	·38	·69	1·12	2·14

TABLE XIV.

K_2O Content of Grasses.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.											
1932 February....	2·57	1·87	2·66	2·8	2·13	5·4	3·50	3·40	3·88	2·28	3·04
March.....	2·20	1·65	2·42	2·51	2·25	4·96	2·81	3·93	3·52	1·82	3·47
April.....	2·01	1·32	2·28	1·93	1·94	4·85	2·23	2·57	2·67	—	3·24
May.....	—	—	2·83	—	—	—	—	—	2·55	—	—
August.....	—	—	2·10	—	—	—	—	—	—	—	—
September...	—	—	1·69	2·24	—	—	—	—	2·98	1·73	—
October.....	—	1·64	2·16	2·20	1·62	4·95	2·05	—	3·47	1·83	3·05
November...	2·09	1·44	2·41	1·92	1·75	5·00	2·75	2·37	3·48	1·87	4·44
December....	2·30	1·31	2·22	1·54	1·64	4·75	2·67	2·46	2·97	1·44	3·63
1933 January.....	2·42	1·53	2·59	1·96	1·86	4·00	2·91	—	3·07	1·39	4·00
Two-monthly Growth.											
1932 March.....	1·91	1·34	1·99	1·78	1·61	3·6	1·89	2·07	2·34	1·55	2·74
May.....	1·92	1·04	2·01	1·45	1·83	4·31	2·00	1·52	2·30	1·37	2·07
July.....	1·01	—	2·41	—	1·74	—	—	—	2·07	—	—
September...	—	—	1·85	1·98	1·80	3·65	—	—	3·10	1·53	—
November...	2·02	1·33	1·78	1·56	1·78	4·90	2·70	1·80	3·13	1·50	3·81
1933 January.....	1·83	1·42	1·81	·57	1·65	3·10	2·56	1·87	2·77	1·38	3·22
Three-monthly Growth.											
1932 April.....	1·30	1·00	1·14	1·23	1·28	2·6	1·60	1·55	1·62	1·20	2·45
July.....	1·58	·78	1·69	—	1·40	2·60	2·00	—	1·59	1·27	—
October.....	2·07	1·29	1·67	2·03	2·12	3·87	2·59	2·33	4·50	1·70	3·90
1933 January.....	1·68	1·50	1·50	1·41	1·61	2·87	2·52	1·71	2·89	1·16	3·56
Four-monthly Growth.											
1932 May.....	1·19	·94	1·05	·99	1·05	1·92	1·70	1·28	1·84	1·05	2·30
September...	1·40	·77	1·57	1·78	1·43	4·52	2·30	—	4·10	1·51	7·8
1933 January.....	1·82	1·29	1·44	1·21	1·76	2·53	2·31	1·41	2·62	·94	3·55
Five-monthly Growth.											
1932 June.....	1·20	·70	1·01	·84	·98	1·62	1·84	1·27	2·05	1·08	2·30
November...	1·95	1·27	1·62	1·36	1·72	3·76	2·28	1·67	3·43	1·38	1·89
Six-monthly Growth.											
1932 July.....	1·17	·65	·81	·91	·77	1·56	1·75	1·20	1·36	1·04	2·15
1933 January.....	1·63	1·24	4·92	1·14	1·38	2·52	2·51	1·28	2·47	1·03	3·66

TABLE XIII.

K_2O Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February	2·57	1·87	2·66	2·8	2·13	5·4	3·50	3·40	2·28	3·88	3·04
March	1·91	1·34	1·99	1·78	1·61	3·6	1·89	2·07	1·55	2·34	2·74
April	1·30	1·00	1·14	1·23	1·28	2·6	1·60	1·55	1·20	1·62	2·45
May	1·19	·94	1·05	·99	1·05	1·92	1·70	1·28	1·05	1·84	2·30
June	1·20	·70	1·01	·84	·98	1·62	1·84	1·27	1·08	2·05	2·30
July	1·17	·65	·81	·91	·77	1·56	1·75	1·20	1·04	1·36	2·15
August	1·24	·69	·84	·61	·74	1·51	1·59	1·35	1·04	1·52	2·22
September	·94	·36	·64	·64	·45	1·20	1·04	·75	·68	·78	1·47
October	—	·76	·65	·78	·50	1·10	1·18	·47	·97	·86	·93
November	·68	·64	·83	·92	·55	1·39	·91	·42	·65	·95	1·15
December	·69	·99	·76	·82	·59	1·45	1·33	·33	·70	·97	1·20
1933.											
January	1·15	·99	·70	·88	·79	1·35	1·35	·38	·69	1·12	2·14

TABLE XIV.

K_2O Content of Grasses.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.											
1932 February....	2·57	1·87	2·66	2·8	2·13	5·4	3·50	3·40	3·88	2·28	3·04
March.....	2·20	1·65	2·42	2·51	2·25	4·96	2·81	3·93	3·52	1·82	3·47
April.....	2·01	1·32	2·28	1·93	1·94	4·85	2·23	2·57	2·67	—	3·24
May.....	—	—	2·83	—	—	—	—	—	2·55	—	—
August.....	—	—	2·10	—	—	—	—	—	—	—	—
September...	—	—	1·69	2·24	—	—	—	—	2·98	1·73	—
October.....	—	1·64	2·16	2·20	1·62	4·95	2·05	—	3·47	1·83	3·05
November...	2·09	1·44	2·41	1·92	1·75	5·00	2·75	2·37	3·48	1·87	4·44
December....	2·30	1·31	2·22	1·54	1·64	4·75	2·67	2·46	2·97	1·44	3·63
1933 January.....	2·42	1·53	2·59	1·96	1·86	4·00	2·91	—	3·07	1·39	4·00
Two-monthly Growth.											
1932 March.....	1·91	1·34	1·99	1·78	1·61	3·6	1·89	2·07	2·34	1·55	2·74
May.....	1·92	1·04	2·01	1·45	1·83	4·31	2·00	1·52	2·30	1·37	2·07
July.....	1·01	—	2·41	—	1·74	—	—	—	2·07	—	—
September...	—	—	1·85	1·98	1·80	3·65	—	—	3·10	1·53	—
November...	2·02	1·33	1·78	1·56	1·78	4·90	2·70	1·80	3·13	1·50	3·81
1933 January.....	1·83	1·42	1·81	·57	1·65	3·10	2·56	1·87	2·77	1·38	3·22
Three-monthly Growth.											
1932 April.....	1·30	1·00	1·14	1·23	1·28	2·6	1·60	1·55	1·62	1·20	2·45
July.....	1·58	·78	1·69	—	1·40	2·60	2·00	—	1·59	1·27	—
October.....	2·07	1·29	1·67	2·03	2·12	3·87	2·59	2·33	4·50	1·70	3·90
1933 January.....	1·68	1·50	1·50	1·41	1·61	2·87	2·52	1·71	2·89	1·16	3·56
Four-monthly Growth.											
1932 May.....	1·19	·94	1·05	·99	1·05	1·92	1·70	1·28	1·84	1·05	2·30
September...	1·40	·77	1·57	1·78	1·43	4·52	2·30	—	4·10	1·51	7·8
1933 January.....	1·82	1·29	1·44	1·21	1·76	2·53	2·31	1·41	2·62	·94	3·55
Five-monthly Growth.											
1932 June.....	1·20	·70	1·01	·84	·98	1·62	1·84	1·27	2·05	1·08	2·30
November...	1·95	1·27	1·62	1·36	1·72	3·76	2·28	1·67	3·43	1·38	1·89
Six-monthly Growth.											
1932 July.....	1·17	·65	·81	·91	·77	1·56	1·75	1·20	1·36	1·04	2·15
1933 January.....	1·63	1·24	4·92	1·14	1·38	2·52	2·51	1·28	2·47	1·03	3·66

TABLE XV.

Cl Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February.....	·91	·27	·53	·49	·47	·64	·82	·42	·54	·55	1·21
March.....	·73	·22	·38	·34	·39	·55	·91	·41	·44	·62	1·10
April.....	·39	·12	·27	·16	·26	·48	·85	·24	·33	·42	1·03
May.....	·36	·14	·27	·16	·27	·45	·79	·20	·27	·62	·89
June.....	·36	·14	—	·13	·26	·38	·30	·23	·31	·59	·80
July.....	·39	·15	·35	·11	·19	·29	·81	·17	·34	·51	·71
August.....	·33	·13	·26	·07	·23	·31	·63	·17	·34	·56	·68
September.....	·18	·09	·22	·10	·10	·26	·40	·085	·15	·18	·60
October.....	—	·17	·22	·17	·10	·35	·50	·076	·27	·31	·42
November.....	·16	·136	·25	·24	·13	·31	·43	·06	·18	·39	·40
December.....	·21	·175	·22	·19	·19	·27	·65	·04	·18	·36	·37
1933.											
January.....	·41	·23	·23	·24	·08	·26	·52	·046	·25	·38	·85

TABLE XV.

Cl Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February.....	·91	·27	·53	·49	·47	·64	·82	·42	·54	·55	1·21
March.....	·73	·22	·38	·34	·39	·55	·91	·41	·44	·62	1·10
April.....	·39	·12	·27	·16	·26	·48	·85	·24	·33	·42	1·03
May.....	·36	·14	·27	·16	·27	·45	·79	·20	·27	·62	·89
June.....	·36	·14	—	·13	·26	·38	·30	·23	·31	·59	·80
July.....	·39	·15	·35	·11	·19	·29	·81	·17	·34	·51	·71
August.....	·33	·13	·26	·07	·23	·31	·63	·17	·34	·56	·68
September.....	·18	·09	·22	·10	·10	·26	·40	·085	·15	·18	·60
October.....	—	·17	·22	·17	·10	·35	·50	·076	·27	·31	·42
November.....	·16	·136	·25	·24	·13	·31	·43	·06	·18	·39	·40
December.....	·21	·175	·22	·19	·19	·27	·65	·04	·18	·36	·37
1933.											
January.....	·41	·23	·23	·24	·08	·26	·52	·046	·25	·38	·85

TABLE XVI.

Cl Content of Grasses.

		Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.												
1932	February....	·91	·27	·53	·49	·47	·64	·82	·42	·55	·54	1·21
	March.....	·88	·30	·49	·40	·56	·56	·74	·44	·59	·44	1·00
	April.....	·66	·21	·34	·28	·40	·71	·78	·40	·55	—	·84
	May.....	—	—	·44	—	—	—	—	—	·65	—	—
	August.....	—	—	·39	—	—	—	—	—	—	—	—
	September...	—	—	·41	·49	—	—	—	—	·58	·41	—
	October.....	—	·33	·46	·44	·48	·82	·76	—	·74	·47	1·16
	November...	·76	·30	·48	·45	·47	·82	·88	·48	·71	·46	1·17
	December....	·76	·23	·39	·34	·45	·79	·75	·46	·59	·39	·89
1933	January.....	·68	·30	·53	·42	·56	·89	·85	—	·71	·48	·94
Two-monthly Growth.												
1932	March.....	·73	·22	·38	·34	·39	·55	·91	·41	·62	·44	1·10
	May.....	·75	·18	·42	·36	·61	·98	·84	·43	·76	·38	·96
	July.....	·94	—	·48	—	·79	—	—	—	·65	—	—
	September...	—	—	·47	·50	·57	·73	—	—	·74	·39	—
	November...	·84	·30	·43	·33	·52	·97	1·01	·38	·80	·43	1·11
1933	January.....	·83	·31	·48	·34	·50	·97	·92	·39	·83	·50	·95
Three-monthly Growth.												
1932	April.....	·39	·12	·27	·16	·26	·48	·85	·24	·42	·33	1·03
	July.....	·89	·14	·66	—	·78	·96	1·57	—	·77	·54	—
	October.....	·82	·31	·55	·46	·68	1·19	1·05	·59	1·15	·53	1·47
1933	January.....	·61	·32	·36	·32	·42	·90	·91	·40	·84	·40	1·04
Four-monthly Growth.												
1932	May.....	·36	·14	·27	·16	·27	·45	·79	·20	·62	·27	·89
	September...	·61	·116	·54	·46	·66	·93	·87	—	·93	·44	3·05
1933	January.....	·67	·30	·44	·29	·45	·76	·85	·28	·71	·29	1·10
Five-monthly Growth.												
1932	June.....	·36	·13	—	·13	·26	·38	·30	·23	·59	·31	·80
	November...	·76	·29	·45	·35	·54	·93	·92	·38	1·03	·38	1·27
Six-monthly Growth.												
1932	July.....	·39	·15	·35	·11	·19	·29	·81	·17	·51	·34	·71
1933	January.....	·65	·32	·35	·29	·37	·68	·90	·28	·68	·28	1·07

Both potassium and chlorine show a remarkable drop as the grasses mature.

It would seem that the drop should be greatest during the winter months, especially after the first heavy frosts have killed the grasses. That is, however, not the case, and it is especially noticeable in the case of potassium, where the minimum is reached from September to November (see Table XIII), in spite of new growth of high potassium content that took place after the first rains in September and October. It appears that the new growth was insufficient in bulk to increase the percentage potassium in the whole sample, which consisted of growth from January to May plus that from September to the time of sampling. Also, although new growth gradually increased from September onwards, the potassium content does not show marked response. The new growth in most cases, as is evident from Table XIV, remains fairly high in potassium up to six months old, so that the sample for analyses of *Amphilophis insculpta* (Table XIII) for November for instance, would be made up of new growth fairly high in potassium ±1·95 (Table XIV), plus old growth, which took place before July and which at that stage showed 1·17 per cent. K_2O. Obviously, the figure actually obtained for the November sample, viz., ·68, is lower and suggests that the old growth of the sample must have contained less K_2O than it did in July. In other words, the process of losing potassium, whether this be returned to the soil as Henrici (1930) reported for phosphorus, or whether this be due to the old grass tuft being exposed and losing, due to climate, more leaves than stalks, comparatively poorer in K_2O or whether rain leaches out the potassium, this process of decreasing the percentage K_2O in the old grass seems to continue into late spring or early summer. This point will be investigated further during the present year when new growth begins. From the data available it appears that potassium, chlorine and phosphorus, are more involved in this loss than the other constituents determined.

Tables XIII to XVI suggest that a chlorine or potassium deficiency at any stage of growth is probably entirely unwarranted in animals on pasture only when considering the production of anything up to two gallons of milk per day under ranching conditions.

The potassium content of different species of grasses varies remarkably at the same stage of growth. Less variation is shown in the case of chlorine.

Magnesium.

Magnesium is present in the grasses studied in high concentrations as revealed by the following tables:—

TABLE XVII.

MgO Content of Grasses.

(Time of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Themeda triandra.*	*Setaria Gerrardii.*	*Urochloa pullulans.*
1932.											
February.....	·38	·24	·26	·38	·23	·47	·73	·56	·23	·42	·66
March.....	·31	·20	·21	·31	·21	·49	·69	·37	·18	·36	·45
April.....	·35	·33	·27	·29	·25	·61	·72	·43	·29	·42	·51
May.....	·31	30	·25	·26	·22	·72	·72	·35	·28	·40	·48
June.....	·31	·31	·30	·33	·22	·65	·76	·40	·27	·53	·54
July.....	·35	·39	·23	·27	·23	·56	·78	·48	·28	·46	·48
August.....	·35	·40	·16	·26	·32	·56	·88	·41	·30	·47	·54
September.....	·29	·36	·23	·27	·22	·51	·94	·31	·28	·35	·47
October.....	—	·42	·22	·21	·27	·55	·63	·33	·22	·39	·62
November.....	·29	·39	·21	·22	·19	·41	·85	·30	·27	·33	·52
December.....	·35	·43	·24	·24	·23	·50	·73	·31	·21	·39	·57
1933.											
January.....	·33	·45	·25	·25	·16	·41	·82	·39	·27	·45	·64

TABLE XVIII.

MgO Content of Grasses.

		Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
Monthly Growth.												
1932	February....	·38	·24	·26	·38	·23	·47	·73	·56	·42	·23	·66
	March.....	·41	·21	·24	·37	·28	·51	·78	·54	·40	·24	·52
	April.....	·55	·30	·34	·56	·46	·66	·98	·85	·55	—	·78
	May.....	—	—	·34	—	—	—	—	—	·64	—	—
	August.....	—	—	·32	—	—	—	—	—	—	—	—
	September...	—	—	·41	·69	—	—	—	—	·49	·27	—
	October.....	—	·50	·33	·51	·49	·89	1·38	—	·59	·29	1·33
	November...	·45	·49	·33	·53	·40	·78	1·34	·82	·51	·27	1·17
	December....	·47	·40	·32	·57	·45	·84	1·29	·91	·55	·30	1·16
1933	January.....	·48	·36	·35	·61	·43	·91	1·10	—	·65	·36	1·00
Two-monthly Growth.												
1932	March.....	·31	·20	·21	·31	·21	·49	·69	·37	·36	·18	·45
	May.....	·54	·31	·33	·65	·55	·69	1·08	·85	·74	·34	·81
	July.....	·59	—	·36	—	·61	—	—	—	·58	—	—
	September...	—	—	·36	·68	·52	·64	—	—	·54	·30	—
	November...	·39	·47	·32	·50	·42	·77	1·34	·80	·67	·27	1·19
1933	January.....	·45	·38	·29	·49	·33	·80	1·03	·64	·65	·35	·74
Three-monthly Growth.												
1932	April.....	·35	·33	·27	·29	·25	·61	·72	·43	·42	·29	·51
	July.....	·59	·35	·44	—	·64	·68	1·24	—	·74	·46	—
	October.....	·55	·46	·33	·35	·42	·90	1·25	·79	·69	·28	1·10
1933	January.....	·44	·42	·29	·34	·32	·73	·96	·60	·63	·30	·75
Four-monthly Growth.												
1932	May.....	·31	·30	·25	·26	·22	·72	·72	·35	·40	·28	·48
	September...	·49	·36	·40	·49	·59	·61	·93	—	·48	·27	·68
1933	January.....	·41	·39	·31	·31	·35	·69	·88	·51	·60	·31	·63
Five-monthly Growth.												
1932	June.....	·31	·31	·30	·33	·22	·65	·76	·40	·53	·27	·54
	November...	·45	·44	·33	·37	·53	·78	1·09	·64	·65	·27	·90
Six-monthly Growth.												
1932	July.....	·35	·39	·23	·27	·23	·56	·78	·48	·46	·28	·48
1933	January.....	·39	·39	·25	·33	·36	·60	·93	·48	·60	·26	·70

There is quite a marked variation in the magnesium content of the different species of grasses at the same stage of growth, as a glance at the tables given above reveals. Apparently the magnesium content of any particular species is not appreciably affected by the stage of growth, there being no noticeable drop in the values given in Table XVII from February, 1932, to January, 1933. It would seem, however, from Table XVIII that regular cutting does tend to keep the magnesium content of grasses at a higher level. This is especially so in the case of *Panicum maximum* and *Urochloa pullulans*, where the tendency for the values of the samples cut at monthly intervals is to lie round about one per cent. instead of between the lower limits given for these two grass species in Table XVII.

Further analyses and more data therefore are bound to shed further light on this point when more figures are available for consideration.

Distribution of the Constituents Determined in the Grasses.

Each of the samples of monthly, two-monthly, three-monthly, up to twelve-monthly stages of growth of four of the species of grasses, was divided into leaves, stalks, and inflorescence respectively, and these fractions separately analysed in order to determine the distribution of the constituents in the grasses. The four species of grasses selected were *Amphilophis insculpta*, *Eragrostis superba*, *Hyparrhenia hirta* and *Pennisetum ciliare* and the data are presented in Tables XIX to XXII hereunder:—

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TABLE XIX.

(Period of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

GRASS: *Amphilophis insculpta.*

	LEAVES.								STALKS.								INFLORESCENCE.								Proportions of Leaves: stalks: inflorescence.
	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fibre.	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fibre.	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fibre.	
1932.																									
February	·45	·61	·43	·03	2·28	·94	11·5	34·1	0·28	·32	·28	·07	3·33	·91	6·9	43·4	·658	·30	·35	—	2·11	·43	11·6	29·0	1 : ·6 : ·1
March	·342	·60	·39	·025	1·67	·77	9·6	36·0	·169	·24	·23	·037	2·51	·81	4·0	45·4	·455	·31	·23	·03	0·98	·31	9·8	34·2	1 : ·8 : ·2
April	·21	·65	·45	·02	1·19	·42	7·7	33·0	·086	·23	·21	·017	1·56	·39	2·8	43·2	·30	·43	·37	·025	0·89	·24	8·7	32·7	1 : ·7 : ·2
May	·19	·64	·41	·01	0·93	·32	6·9	34·2	·10	·27	·22	·01	1·45	·40	2·7	42·9	—	+	—	—	—	—	7·6	33·9	1 : 1 : ·02
June	·16	·73	·40	·042	0·89	·33	6·1	36·0	·08	·33	·24	·046	1·45	·39	2·4	43·0	·32	·32	·29	·059	1·66	·43	7·5	34·4	1 : 1·2 : ·1
July	·16	·77	·41	·034	0·97	·35	6·5	35·1	·09	·36	·29	·047	1·37	·43	2·7	41·6	·08	+	—	—	—	·31	—	—	1 : 1 : ·1
August	·19	·76	·48	·045	1·04	·31	6·4	34·3	·10	·25	·23	·037	1·44	·34	2·6	40·8	·37	·32	·29	·09	1·47	·37	—	—	1 : 1 : ·1
September	·17	·70	·35	·039	0·72	·13	6·5	34·7	·066	·28	·24	·04	1·09	·21	2·3	43·6	·146	·40	·30	·04	0·98	·20	4·0	38·5	1 : 1·5 : ·2
October	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
November	·15	·64	·37	·025	0·77	·24	6·3	30·2	·05	·25	·20	·025	0·58	·088	1·8	44·3	·25	+	—	—	—	·26	6·0	—	1 : ·9 : ·1
December	·14	·63	·42	·03	0·78	·26	6·2	31·3	·06	·24	·21	·023	0·49	·09	2·7	41·9	—	+	—	—	—	—	9·2	—	1 : ·5 : ·01
January, 1933	·176	·69	·39	·033	1·07	·42	6·3	36·2	·08	·34	·25	·043	1·29	·41	2·8	41·9	·42	·34	·35	·086	0·85	·30	9·1	36·7	1 : – : ·1

TABLE XX.

(Period of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

GRASS: *Eragrostis superba.*

1932.																									
February	·44	·63	·46	·086	2·76	·52	13·1	33·2	·245	·20	·17	·035	3·34	·55	7·7	42·6	·756	0·28	·26	—	2·05	·18	15·0	34·5	1 : ·3 : 1
March	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
April	·24	·67	·39	·02	1·32	·16	7·4	30·5	·11	·29	·23	·014	1·38	·18	3·5	44·0	·39	0·50	·23	·025	0·73	·13	6·3	40·9	1 : 1·1 : ·5
May	·15	·65	·31	·028	0·85	·15	5·1	31·6	·10	·31	·23	·033	1·10	·17	3·2	41·8	·63	1·00	·24	·05	0·64	·10	4·7	37·0	1 : 1·7 : ·1
June	·12	·92	·46	·023	0·88	·14	4·4	31·4	·077	·31	·23	·023	0·82	·12	2·8	41·3	·09	0·48	·28	·026	0·64	·12	3·2	37·6	1 : 1·1 : ·1
July	·11	·75	·36	·025	1·07	·12	4·6	30·9	·077	·30	·22	·019	0·82	·10	3·0	38·1	·067	+	—	—	—	·11	3·3	—	1 : 1·6 : ·1
August	·09	·66	·31	·025	0·76	·10	3·8	31·3	·06	·34	·24	·03	0·55	·05	4·8	39·7	·057	—	—	—	—	·10	2·5	—	1 : 2·6 : ·2
September	·18	·66	·30	·026	0·87	·14	6·6	28·7	·066	·40	·26	·027	0·48	·07	3·8	35·6	·03	0·45	·17	·038	0·20	·044	4·5	37·6	1 : 1·2 : ·1
October	·14	·45	·23	·03	1·17	·30	6·7	32·4	·05	·27	·19	·025	0·40	·04	2·0	40·4	·10	—	—	—	—	·07	3·4	—	1 : ·9 : ·1
November	·14	·51	·25	·028	1·13	·30	6·8	30·3	·04	·24	·13	·02	0·27	·04	1·7	41·4	·13	—	—	—	—	·13	4·2	—	1 : ·3 : ·1
December	·12	·51	·26	·026	1·00	·23	5·9	32·5	·056	·35	·22	·025	0·64	·15	4·3	40·5	·16	0·37	·22	·036	0·70	·16	5·5	37·3	1 : ·9 : ·1
January, 1933	·12	·46	·26	·021	1·04	·29	8·1	31·5	·06	·31	·24	·026	0·70	·19	4·7	39·5	·19	0·39	·22	0·27	0·76	·17	5·7	35·8	1 : ·8 : ·1

TABLE XXI.

(Period of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

GRASS: *Hyparrhenia hirta.*

	LEAVES.								STALKS.								INFLORESCENCE.								Proportions of leaves : stalks : inflorescence.
	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fibre.	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fibre.	P_2O_5.	CaO.	MgO.	Na_2O.	K_2O.	Cl.	Crude Protein.	Crude Fiber.	
1932.																									
February	·357	·39	·28	—	2·07	·45	10·0	34·2	·14	·18	·12	·02	2·43	·58	3·2	48·6	·366	·18	·23	—	1·45	·24	7·4	32·5	1 : ·5 : ·1
March	·30	·45	·29	·013	1·55	·44	8·3	35·0	·106	·15	·14	·011	1·84	·43	2·3	51·6	·328	·30	·24	·02	0·92	·21	7·4	36·0	1 : 1·4 : ·4
April	·17	·54	·36	·015	1·29	·32	6·6	34·3	·05	·18	·14	·014	1·17	·23	2·4	47·2	·27	·39	·27	·02	0·93	·16	6·9	33·3	1 : 1·2 : ·3
May	·125	·55	·34	·01	0·81	·30	4·4	33·4	·05	·17	·15	·031	1·01	·25	1·8	46·0	·206	·31	·26	·045	1·13	·30	—	32·7	1 : 2 : ·1
June	·115	·59	·37	·018	0·73	·32	3·7	33·0	·045	·18	·13	·023	1·13	·23	1·4	45·2	·15	·36	·26	·05	1·04	·23	—	31·2	1 : 1·7 : ·03
July	·092	·60	·39	·027	0·58	·26	3·7	33·3	·04	·16	·13	·026	0·89	·16	1·6	48·0	·08	·38	·25	·042	0·79	·17	—	33·3	1 : 1·6 : ·3
August	—	·76	·45	·026	1·03	·43	3·8	32·1	·034	·26	·25	·024	0·52	·12	1·4	48·5	·09	·45	·26	·044	1·03	·28	3·1	32·8	1 : 1·7 : ·3
September	·09	·57	·32	·021	0·32	·11	4·1	34·3	·044	·22	·17	·016	0·56	·09	1·5	46·7	·065	·33	·17	·041	0·28	·076	2·4	36·8	1 : 1·5 : ·3
October	·12	·47	·30	·02	0·70	·21	5·4	33·8	·03	·22	·27	·022	0·43	·05	1·1	47·0	·06	·35	·14	·028	0·17	·026	2·8	34·1	1 : 1·8 : 3
November	·12	·39	·23	·015	0·71	·24	4·9	33·2	·03	·24	·18	·018	0·49	·08	1·3	47·5	·06	·28	·11	·022	0·22	·04	3·2	35·6	1 : 1·8 : ·2
December	·12	·49	·27	·017	0·71	·28	6·3	32·8	·036	·29	·21	·022	0·40	·08	2·1	47·0	·15	·37	·23	·022	0·83	·27	8·8	33·3	1 : 1·1 : ·3
January, 1933	·14	·38	·22	·018	0·86	·24	7·6	39·6	·04	·20	·11	·019	0·63	·12	1·8	45·4	·19	·29	·21	·028	1·06	·23	6·4	34·0	1 : 1·4 : ·5

TABLE XXII.

(Period of growth: 1 month, 2 months, 3 months, etc., up to 12 months.)

GRASS: *Pennisetum ciliare.*

1932.																									
February	·46	·39	·50	·07	5·60	·60	12·9	33·5	·31	·09	·39	·06	5·34	·83	10·2	38·2	·806	·22	·38	—	3·13	·51	14·6	32·1	1 : ·2 : ·1
March	·36	·39	·64	·04	4·38	·64	10·2	32·7	·164	·04	·29	·037	2·85	·42	7·5	42·0	·453	·19	·30	·039	1·92	·42	10·9	37·7	1 : ·5 : ·2
April	·23	·58	·87	·027	3·30	·72	7·9	31·4	·14	·07	·33	·013	1·75	·21	3·4	37·3	—	—	—	—	—	—	6·9	36·5	1 : ·8 : ·1
May	·16	·77	·94	·03	2·15	·61	6·1	32·2	·11	·10	·42	·018	1·63	·25	3·5	37·6	—	—	—	—	—	—	5·0	32·8	1 : ·7 : ·1
June	·11	·64	·91	·01	1·69	·56	4·4	33·3	·12	·08	·36	·033	1·55	·18	3·0	38·0	—	—	—	—	—	—	4·1	—	1 : ·9 : ·04
July	·10	·61	·83	·053	1·65	·42	4·5	33·3	·11	·08	·32	·028	1·47	·17	2·5	35·7	—	—	—	—	—	—	3·6	—	1 : 1 : ·1
August	·10	·54	·82	·083	1·51	·49	3·9	32·9	·13	·09	·34	·041	1·52	·16	2·7	35·1	—	—	—	—	—	—	3·5	—	1 : 1·2 : ·04
September	·22	·66	·67	·038	1·09	·35	6·0	35·1	·16	·09	·33	·04	1·32	·15	6·0	36·8	—	—	—	—	—	—	2·7	—	1 : ·8 : ·06
October	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
November	·25	·62	·50	·041	2·06	·54	7·1	31·7	·17	·11	·32	·03	0·72	·08	3·1	33·6	—	—	—	—	—	—	5·6	—	1 : 1 : ·04
December	·19	·75	·59	·043	1·85	·36	8·2	34·0	·11	·11	·41	·033	0·82	·12	4·5	40·0	·44	·21	·31	·058	2·25	·49	11·3	34·4	1 : ·8 : ·1
January, 1933	·27	·80	·51	·056	1·78	·37	6·4	34·3	·25	·11	·32	·037	0·84	·13	3·8	35·9	·57	·19	·31	·066	2·25	·56	10·7	35·2	1 : 1 : ·1

Two of the samples were unfortunately not divided up in October as was also not the sample of *Eragrostic superba* taken in March.

The proportion of stalks appears to be greater during the winter months, or in the case of two less leafy grasses, *Hyparrhenia hirta* and *Amphilophis insculpta* in spring after stalks of the new season's growth have been formed. In any case, an important omission was made after the winter of 1932 by not sub-dividing leaves and stalks and inflorescence each again into new growth and old growth respectively. This matter has been rectified in the samples for the present year. Such a sub-division may throw light on the cause of the continued low content, especially of phosphorus, potassium and chlorine, even after new growth had started. The values (Tables II, XII and XV) remain lower in spite of new growth, high in these minerals, than their respective values for the winter months. It is important, therefore, to distinguish in the analyses of the samples between old growth and new growth. A continued drop in the potassium content, for instance, of the old growth may be masked partly or wholly by the high potassium content of the new growth unless old growth is separated from new growth and separately analysed. Furthermore, the present system of sub-dividing the samples has not brought to light the reason for the continued drop in certain constituents, which vary appreciably with stage of growth even after the mature stage in winter had been reached. It would appear that the time of poorest grazing as far as phosphorus was concerned was not limited to the winter months, but extended in the case of some grasses into early summer well after new growth had taken place.

It is evident from Tables XIX to XXII that except in the case of *Hyparrhenia hirta* on many occasions not enough inflorescence was present to provide a sample for analysis. The constituents determined were present in greater concentration in the leaves than in the stalks and the difference between the leaf-content and the stalk-content of anyone constituent becomes more noticeable as the plant matures, or when old grass is present, e.g. after March, 1932. In the case of some constituents the difference between the leaf-content and stalk-content of a particular constituent is quite marked, e.g. phosphorus and calcium, and is less obvious in other cases, e.g. sodium.

Growth during Winter, 1932.

A glance at any of the tables giving the analyses of monthly cuttings of the same part of a plot reveals that in none of the species did enough growth for analyses occur during the severest winter months. Some species, however, continued growing later into the winter and others started earlier in spring than did the rest.

Table B in the appendix presents the data in regard to growth during winter and response to regular monthly cutting of the eleven species of grasses in 1932.

From a consideration of Table B there appears to be considerable variation in the response of the grasses to regular monthly cutting and to growth during the winter months. *Cymbopogon plurinodis* and *Setaria gerrardii* were undoubtedly the hardiest species, while *Rhynchelythrum roseum*, a coarse fibrous grass, practically died out as a result of the severe treatment.

GENERAL SUMMARY AND CONCLUSIONS.

The results of plot experiments are reported in this publication. Eleven species of grasses, grown on separate plots, were exposed to the same climatic conditions and analysed at monthly intervals according to the following plan: A portion of each plot was cut at monthly intervals so that the analyses for monthly cuts all the year round for each grass could be made. Another portion of the plot was cut at two-monthly intervals for the full period, each subsequently analysed, a third portion was cut at three-monthly intervals, a fourth at four-monthly intervals and so on, up to twelve months, when a sample of twelve-months' growth was taken off each plot and analysed. The results are presented in tabulated form and discussed for the period February, 1932, to January, 1933.

The samples were analysed for crude protein, fibre, phosphorus, calcium, sodium, potassium, magnesium and chlorine, and the results of each constituent in all the species of grasses, presented separately and discussed. 1932 was a dry year and the results obtained cannot be applied except in broad outline to other years. However, the work is continuing and will be presented from time to time.

Probably all the constituents determined in the grasses are affected by the stage of growth to a greater or smaller extent. Phosphorus, protein, chlorine, sodium and potassium diminished rapidly as the stage of growth of the grasses advanced from one month to maturity. This decrease was less noticeable or even doubtful in the case of magnesium, calcium and even fibre. Most of the constituents that show an appreciable drop in the grasses during the winter to no rise directly new growth begins in the samples composed of old pre-winter growth plus new growth, e.g. a sample of nine-monthly growth of any of the species. This point was rather baffling and is receiving special attention during the present season.

The composition of the soil was the same in all the plots so that the effect of soil fertility and composition on the composition of the grasses is not being considered.

The different species of grasses showed very remarkable variations in the content of constituent determined at the same stage of growth. Apparently, however, if a grass is high in any one constituent, it is high in the others, which make for good quality. For instance, *Panicum maximum* and *Urochloa pullulans* registered high values throughout, except for fibre and are undoubtedly the two best grasses considered, while *Hyparrhenia hirta* and *Rhynchelythrum roseum* have verified their reputations of being hard coarse grasses of low feeding value if eaten by stock. The above indicates the importance of determining both botanical composition and chemical composition when evaluating pasture.

Digestibility trials were not carried out on the grasses as the plots were too small for this type of work. Digestibility work on a number of grass species will, however, be carried out as soon as the growth of the new season begins.

The deplorably low phosphorus content of the grasses as the period of growth advances beyond a month as is usually the case in natural pasture, is emphasized. Under such conditions a phosphorus deficiency seems to be a foredrawn conclusion, as is borne out by the first report already published (1932) on a mineral survey of the Union. The analyses may suggest lower values than actually exist in the pasture as eaten, for in taking samples for analysis, no notice is taken of selective grazing by the animal.

The values for protein and sodium are low on the whole and suggest the possibility of both being present in inadequate amounts for production at certain times of the year. The other constituents appear to be present in abundance and the analyses of the grasses in question do not suggest a shortage of these constituents in natural pasture.

A number of additional plots have been planted with other species of grasses which are also being studied and analysed during the present year. A further publication will be made in due course.

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APPENDIX.

(Numbers in Tables A, B, and C indicate yield of air-dry grass in grams.)

TABLE A.

SUCCESSIVE MONTHLY GROWTH.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
1932.											
February.....	Green, with flower heads 497	Green, with flower heads 330	Green, with flower heads 215	Green, with flower heads 125	Green, with flower heads 307	Green, with flower heads 390	Green, with flower heads 285	Green, with flower heads 375	Green, with flower heads 355	Green, with flower heads 185	Green, with flower heads 353
March.....	Green, seeds falling out 760	Green, with flower heads 420	Green, seeds falling out 430	Green, with flower heads 950	Green, with flower heads 1482	Green, with flower heads 695	Green, seeds falling out 620	Green, seeds falling out 1250	Green, seeds falling out 700	Green, with flower heads 670	Green, seeds falling out 1300
April.....	Mixed, mainly green, seeds falling out 1110	Mixed, mainly green, seeds falling out 303	Mixed, mainly green, seeds falling out 570	Mixed, mainly green, seeds falling out 470	Mixed, mainly green, seeds falling out 1540	Mixed, mainly green, seeds falling out 874	Mixed, mainly green, seeds falling out 950	Mixed, mainly green, seeds falling out 1400	Mixed, mainly green, seeds falling out 750	Mixed, mainly green, seeds falling out 450	Mixed, mainly green, seeds falling out 1400
May.....	Mixed, mainly brown, seeds fallen out 1150	Mixed, seeds falling out 220	Mixed, mainly brown, seeds falling out 600	Mixed, seeds falling out 927	Mixed, seeds falling out 1572	Mixed, seeds falling out 780	Mixed, seeds fallen out 600	Mixed, seeds falling out 850	Mixed, mainly brown, seeds fallen out 550	Mixed, seeds falling out 550	Brown, seeds fallen out 1500
June.....	Brown, seeds fallen out 978	Mixed, mainly brown, seeds falling out 390	Mixed, mainly brown, seeds falling out 720	Mixed, mainly brown, seeds fallen out 730	Mixed, mainly brown, seeds falling out 1466	Mixed, mainly brown, seeds falling out 785	Mixed, mainly brown, seeds fallen out 750	Brown, seeds fallen out 1150	Brown, seeds fallen out 550	Mixed, mainly brown, seeds falling out 475	Brown, seeds fallen out 980
July.....	Brown, seeds fallen out 612	Mixed, mainly brown, seeds falling out 545	Brown, seeds falling out 755	Mixed, mainly brown, seeds fallen out 621	Brown, seeds fallen out 1475	Brown, seeds fallen out 623	Brown, seeds fallen out 765	Brown, seeds fallen out 980	Brown, seeds fallen out 575	Brown, seeds fallen out 425	Brown, seeds fallen out 935
August.....	Brown, seeds fallen out 1010	Brown, seeds falling out 620	Brown, seeds falling out 495	Brown, seeds fallen out 650	Brown, seeds fallen out 1766	Brown, seeds fallen out 605	Brown, seeds fallen out 720	Brown, seeds fallen out 1230	Brown, seeds fallen out	Brown, seeds fallen out	Brown, seeds fallen out 1110
September....	Mixed, mainly brown, seeds fallen out 493	Mixed, mainly brown, seeds falling out 625	Mixed, mainly brown, seeds fallen out 675	Mixed, mainly brown, seeds fallen out 637	Mixed, mainly brown, seeds fallen out 1155	Mixed, mainly brown, seeds fallen out 888	Mixed, mainly brown, seeds fallen out 805	Mixed, mainly brown, seeds fallen out 830	Mixed, mainly brown, seeds fallen out 485	Mixed, mainly brown, seeds fallen out 835	Mixed, mainly brown, seeds fallen out 1035
October.....	Mixed, mainly brown, new flower heads present 435	Mixed	Mixed, mainly brown, seeds fallen out 635	Mixed, mainly brown, new flower heads present 710	Mixed, mainly brown, new flower heads present 728	Mixed, new flower heads present 1220	Mixed, new flower heads present 810	Mixed, mainly brown, new flower heads present 680	Mixed, mainly brown, new flower heads present 370	Mixed, mainly brown, new flower heads present	Mixed, seeds fallen out 1070
November....	Mixed, with flower heads 1686	Mixed, mainly green, new flower heads 1120	Mixed, new flower heads present 1250	Mixed, with flower heads 1060	Mixed, with flower heads 2460	Mixed, with flower heads 1374	Mixed, mainly green, with flower heads	Mixed, mainly brown, with flower heads 1220	Mixed, with flower heads	Mixed, with flower heads 995	Mixed, new flower heads present 1120
December.....	Mixed, mainly green, with flower heads 3816	Mixed, mainly green, with flower heads 1500	Mixed, with flower heads 4000	Mixed, mainly green, with flower heads 4184	Mixed, with flower heads 4200	Mixed, with flower heads 3366	Mixed, mainly green, with flower heads 2200	Mixed, mainly brown, with flower heads 2020	Mixed, with flower heads 1470	Mixed, mainly green, with flower heads 1600	Mixed 2110
1933.											
January.....	Mixed, mainly green, seeds falling out 3060	Mixed, mainly green, with flower heads 2370	Mixed, mainly green, with flower heads 4145	Mixed, seeds falling out 4160	Mixed, seeds falling out 3299	Mixed, seeds falling out 4416	Mixed, mainly green, seeds falling out 1780	Mixed, mainly brown, seeds falling out 4230	Mixed, seeds falling out 1745	Mixed, with flower heads 1960	Mixed, mainly green, seeds falling out 4030

APPENDIX—(*continued*).

TABLE B.

ONE-MONTHLY GROWTH.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
1932.											
February.....	Green, with flower heads 497	Green, with flower heads 330	Green, with flower heads 215	Green, with flower heads 125	Green, with flower heads 307	Green, with flower heads 390	Green, with flower heads 285	Green, with flower heads 375	Green, with flower heads 355	Green, with flower heads 185	Green, with flower heads 353
March.....	Green, with flower heads 260	Green, with flower heads 170	Green, with flower heads 110	Green, with flower heads 200	Green, with flower heads 250	Green, with flower heads 230	Green, with flower heads 170	Green, with flower heads 120	Green, with flower heads 210	Green, with flower heads 70	Green, with flower heads 320
April.....	Green, short, 130	Green, short, 95	Green, short, 60	Green, short, 100	Green, short, 120	Green, short, 120	Green, short, 70	Green, short, 90	Green, with flower heads 100	Green, short, little growth	Green, short, 100
May.....	Green, short, little growth	Green, short, little growth	Green, short, 50	Green, short, little growth	Green, short, little growth	Green, short, little growth	Green, short, little growth	Green, short, little growth	Green, short, 70	Green, short, little growth	Green, short, little growth
June.....	Practically no growth	Practically no growth	Green, short, little growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth
July.....	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth
August.....	Practically no growth	Practically no growth	Green, short, little growth 10	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth	Practically no growth
September....	Practically no growth	Green, short, little growth	Green, short, 35	Green, short, 60	Green, short, little growth	Green, short, little growth	Green, short, little growth	Practically no growth, some dying	Green, short, 35	Green, short, 30	Green, short, little growth
October.....	Green, short, little growth	Green, short, 50	Green, short, 75	Green, with flower heads 150	Green, with flower heads 45	Green, short, 80	Green, short, 15	Green, short, some dying 45	Green, with flower heads 70	Green, with flower heads 115	Green, short, 55
November....	Green, short, 65	Green, short, 30	Green, with flower heads 60	Green, with flower heads 130	Green, with flower heads 55	Green, short, 100	Green, short, 20	Green, with flower heads, some dying 35	Green, with flower heads 75	Green, short, 50	Green, short, 50
December.....	Green, with flower heads 75	Green, short, 45	Green, with flower heads 65	Green, with flower heads 135	Green, with flower heads 65	Green, with flower heads 160	Green, short, 30	Green, with flower heads, some dying	Green, with flower heads 115	Green, short, 55	Green, short, 75
1933.											
January.....	Green, with flower heads 85	Green, short, 40	Green, with flower heads 45	Green, with flower heads 105	Green, with flower heads 55	Green, with flower heads 205	Green, with flower heads 35	Dead	Green, with flower heads 95	Green, with flower heads 45	Green, short,

APPENDIX—(*continued*).

TABLE C.

Two-monthly Growth.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
1932.											
March.....	Green, seeds falling out 760	Green, with flower heads 420	Green, seeds falling out 430	Green, with flower heads 950	Green, with flower heads 1482	Green, with flower heads 695	Green, seeds falling out 620	Green, seeds falling out 1250	Green, seeds falling out 700	Green, with flower heads 670	Green, seeds falling out 1300
May.....	Mixed, mainly green, short 230	Green, short 115	Mixed, mainly green, short 150	Mixed, mainly green, short 90	Mixed, mainly green, short 170	Mixed, mainly green, short 205	Mixed, mainly green, short 50	Mixed, mainly green, short 100	Mixed, mainly green, short 130	Mixed, mainly green, short 100	Mixed, mainly green, short 75
July.....	Mixed, mainly brown 45	—	Green, short 30	—	Green, short 30	—	—	—	Green, short 23	—	—
September....	—	—	Green, short 95	Green, short 85	Green, short 55	Green, short 60	—	—	75	Green, short 65	—
November....	Green, with flower heads 255	Green, with flower heads 60	Green, with flower heads 350	Green, with flower heads 475	Green, with flower heads 355	Green, with flower heads 335	Green, with flower heads 130	Green, with flower heads 170	Green, with flower heads 205	Green, with flower heads 295	Green, short 100
1933.											
January.....	Green, with flower heads 545	Green, with flower heads 215	Green, with flower heads 365	Green, with flower heads 585	Green, with flower heads 520	Green, with flower heads 930	Green, with flower heads 310	Green, with flower heads 225	Green, seeds falling out 255	Green, with flower heads 45	Green, with flower heads 285

Three-monthly Growth.

1932.											
April.....	Mixed, mainly green, seeds falling out 1110	Mixed, mainly green, seeds falling out 303	Mixed, mainly green, seeds falling out 570	Mixed, mainly green, seeds falling out 470	Mixed, mainly green, seeds falling out 1540	Mixed, mainly green, seeds falling out 874	Mixed, mainly green, seeds falling out 950	Mixed, mainly green, seeds falling out 1400	Mixed, mainly green, seeds falling out 750	Mixed, mainly green, seeds falling out 450	Mixed, mainly green, seeds falling out 1400
July.....	Mixed, mainly brown, short 70	Green, short 135	Green, short 85	—	Green, short 70	Mixed, mainly green, short 45	Mixed, mainly green, short 25	—	Green, short 25	Green, short 115	—
October.....	Green, with flower heads 125	Green, short 70	Green, with flower heads 305	Green, with flower heads 235	Green, with flower heads 270	Green, with flower heads 190	Green, short 115	Green, with flower heads 100	Green, with flower heads	Green, with flower heads 415	Green, short 130
1933.											
January.....	Green, seeds falling out 505	Green, with flower heads 205	Green, with flower heads 710	Green, seeds falling out 395	Green, with flower heads 855	Green, seeds falling out 805	Green, seeds falling out 385	Green, seeds falling out 330	Green, seeds falling out 330	Green, with flower heads 350	Green, with flower heads 465

APPENDIX—(*continued*).

TABLE C—(*continued*).

Four-monthly Growth.

	Amphilophis insculpta.	*Cynodon dactylon.*	*Cymbopogon plurinodis.*	*Eragrostis superba.*	*Hyparrhenia hirta.*	*Pennisetum ciliare.*	*Panicum maximum.*	*Rhynchelythrum roseum.*	*Setaria Gerrardii.*	*Themeda triandra.*	*Urochloa pullulans.*
1932.											
May.....	Mixed, mainly brown, seeds fallen out 1150	Mixed, seeds fallen out 220	Mixed, mainly brown, seeds falling out 600	Mixed, seeds falling out 927	Mixed, seeds falling out 1572	Mixed, seeds falling out 780	Mixed, seeds fallen out 600	Mixed, seeds falling out 850	Mixed, mainly brown, seeds fallen out 550	Mixed, seeds falling out 550	Brown, seeds fallen out 1500
September....	Green, short 50	Mixed, with flower heads 105	Green, short 125	Green, short 110	Green, short 45	Green, short 45	Green, short 20	Green, short	Green, short 30	Green, short	Green, short 25
1933.											
January.....	Green, seeds falling out 670	Green, with flower heads 305	Green, with flower heads 630	Green, seeds falling out 720	Green, with flower heads 500	Green, seeds falling out 770	Green, seeds falling out 335	Green, seeds falling out 345	Green, seeds falling out 245	Green, with flower heads 505	Green, with flower heads 455

Five-monthly Growth.

1932.											
June.....	Brown, seeds fallen out 978	Mixed, mainly brown, seeds falling out 390	Mixed, mainly brown, seeds falling out 720	Mixed, mainly brown, seeds fallen out 730	Mixed, mainly brown, seeds falling out 1466	Mixed, mainly brown, seeds falling out 785	Mixed, mainly brown, seeds fallen out 750	Brown, seeds fallen out 1150	Brown, seeds fallen out 550	Mixed, mainly brown, seeds falling out 475	Brown, seeds fallen out 980
November....	Green, with flower heads 270	Green, short 130	Green, with flower heads 335	Green, with flower heads 485	Green, with flower heads 280	Green, with flower heads 300	Green, short 170	Green, with flower heads 175	Green, with flower heads 155	Green, with flower heads 430	Green, short 135

Six-monthly Growth.

1932.											
July.....	Brown, seeds fallen out 612	Mixed, mainly brown, seeds falling out 545	Brown, seeds falling out 755	Mixed, mainly brown, seeds fallen out 621	Brown, seeds fallen out 1475	Brown, seeds fallen out 635	Brown, seeds fallen out 765	Brown, seeds fallen out 980	Brown, seeds fallen out 595	Brown, seeds fallen out 425	Brown, seeds fallen out 935
1933											
January.....	Green, seeds falling out 545	Mixed, mainly green, with flower heads 470	Green, with flower heads 1570	Green, seeds falling out 790	Green, with flower heads 635	Green, seeds falling out	Green, seeds falling out 505	Mixed, mainly green, seeds falling out 500	Green, seeds falling out 315	Green, with flower heads 580	Green, with flower heads 380