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

By P. J. DU TOIT, J. G. LOUW, and A. I. MALAN, Section of Biochemistry, Onderstepoort.

CONTENTS.

I. INTRODUCTION.

In the first publication (du Toit, *et al*, 1932) of the above series it was stated that the investigation was undertaken to define the phosphorus deficient areas in the Union of South Africa. The possibility of other mineral deficiencies and a study of the feeding value in general, in so far as figures for crude protein, crude fibre and carbohydrates could provide a criterion was, however, also kept in mind when the scheme was under consideration. In other words the need for more detailed data on pastures generally and their bearing on problems of nutrition and disease may be considered to have formed the basis for the series of investigations.

Originally it was decided to analyse the soil from selected areas, the herbage growing on that soil and the blood of cattle grazing on the pasturage. It was thought that a definite correlation existed between these three sets of data and that possibly the collection of data on any one of these sets of analyses would yield sufficiently accurate results to render the other two superfluous. The scheme was divided into two parts, one of which aimed at studying the effect of stage of growth on the chemical composition, yield and digestibility of indigenous grasses established on experimental plots. The results of this work have been reported by du Toit *et al* (1934, 1935) and Louw (1938). The other part of the scheme dealt with a mineral survey of the pastures of the Union. Samples of soil, vegetation and blood were collected and forwarded to Onderstepoort by about forty Government field veterinary Officers, each selecting an aera for collection in his district. The first three surveys took place in May, 1930, May, 1931, and October, 1931, respectively, after which regular collections were made during January, April, July and October of each year until April, 1933. After the first three surveys which were reported on separately by du Toit *et al* (1932) the collection of soil samples was discontinued. The results warranted the conclusion that soil analysis does not provide a satisfactory method for studying the feeding value of natural pastures as obviously pasture on poor soil may yield excellent values if the samples for analysis are taken at an early stage of growth of the pasture.

Reporting on the succeeding surveys comprising the analysis of pasture and blood samples at three-monthly intervals collected until April, 1933, du Toit and his collaborators (1935) stated that the diagnosis of phosphorus deficiency in pasture by determining the inorganic phosphorus content of the blood of animals grazing such pastures is simple and accurate, but that the surveys were intended to be a study of the feeding value of South African pastures and not merely a study of their phosphorus content and hence pasture analysis, which is essential for a study of the greater problem of the feeding value of the pastures and which incidentally includes the determination of phosphorus in the pastures already covers the field of phosphorus deficiency. Blood analysis was therefore eliminated from the subsequent surveys which were carried out on an extensive scale. Naturally blood analysis would have involved the bleeding of many hundreds of animals over extended periods, a procedure which after several repetitions was generally met with a certain amount of opposition on the part of the farmers. Another obstacle in the way of drawing the blood and preparing it for despatch to the laboratory for analysis was that sufficient professional assistance was not available to analyse and handle such a large number of samples simultaneously.

On the other hand, Government stock inspectors are stationed practically all over the Union and it was consequently decided to entrust to these stock inspectors the work of collecting and despatching of pasture samples to Onderstepoort; this procedure increased the number of samples actually collected since November, 1933, very considerably. In fact, whereas previous to this date only about forty samples were collected every three months by a limited number of

field veterinary officers the stock inspectors collected and despatched to Onderstepoort every month between 200 and 250 pasture samples for analysis.

The present report deals with the results of this more comprehensive survey which covers a period of two years from November, 1933, to October, 1935.

II. PLAN OF THE INVESTIGATION AND METHODS.

In October, 1933, some 240 stock inspectors stationed all over the Union were instructed each to collect and forward to Onderstepoort a sample of pasturage during every month of the year. For this purpose each inspector had to choose three farms in his own area and on these farms the samples had to be collected in rotation as follows: a sample of the pasture was collected on farm No. 1, in, say, November. In December, when the second sample had to be collected, it was taken from farm No. 2 and in January on farm No. 3. In February the sample was again taken on farm No. 1, in March on farm No. 2, etc. Hence, over a period of 12 months, for instance, from November, 1933, to October, 1934, the samples would be collected—

on farm No. 1 in November, February, May and August,
on farm No. 2 in December, March, June and September, and
on farm No. 3 in January, April, July and October.

According to this new scheme the number of farms on which samples of pasturage would be collected was increased from approximately 40 to almost eight hundred and the method to be followed in collecting the samples was at the same time modified.

The choice of pasturage for analysis in the new scheme was indirectly delegated to the grazing animal itself, the underlying motive being to ensure the collection of a composite sample of herbage which would as far as is practicable be representative of what the animal actually ate on the day when the sample was collected. In order to accomplish this object a number of animals had to be followed while grazing by the stock inspectors who selected the analytical sample to correspond as closely as possible to what the animals he was following actually ate. If the animal followed took a mouthful of leaves of a certain kind of grass the stock inspector would also collect a handful of leaves from the same tuft, or from one of the same kind of grass,and place this in his collection bag. If the animal then took a mouthful of seedheads the Inspector would collect a handful of seedheads from that tuft or a similar one and place it in the same bag as the first handful of leaves. If the animal then took a mouthful of bushes he also collected a handful of the same bushes into the same bag as the first two samples, and after following five or six animals and collecting about 2 lb. of vegetation in this way his sample was taken to approximate that which the animals had actually eaten very closely. The inspectors were requested when following sheep to spare no pains to collect a representative sample of what the sheep actually consumed.

In areas where the pasture was composed only of grasses or of bushes the samples collected probably approached a true representative sample of what the animal actually consumed more closely than those collected in areas where mixed samples—grass and bush—were collected as obviously it is difficult to collect these in exactly the same proportions that they are consumed by the animal.

Differences in chemical composition do exist between one species of grass and another and the aerial parts of a grass plant (leaves, haulms, etc.) also differ in regard to their mineral and protein contents but these differences are not of such a magnitude that the composition of a sample collected by only approximate simulation of the grazing animal by the collector would differ materially from that of the herbage actually consumed by the animal. Samples collected on veld composed of bushes only will for similar reasons also be highly reliable as indices of actual consumption. Since, however, as will be evident when the results are discussed later on in this report, the chemical composition of bushes and grasses may differ considerably in the case of certain constituents, the collection of a representative sample of herbage on pasture composed of bushes and grasses will decidedly confront the collector with greater difficulties, in that he has to collect a sample which must not only contain the species (grass and bush) selected by the animal but the degree of preference exhibited by the animal for either grass or bush must be reflected in the percentage of either of these veld types in his composite sample to be submitted for analysis.

On reaching the central laboratory at Onderstepoort the samples were dried, if necessary, described, freed from soil, finely ground, bottled and put away for chemical analysis. The description of the pasture samples was somewhat superficial. The following is a brief explanation of the descriptive terms employed: Samples were composed of either grasses only, bushes only, or of mixtures of grasses and bushes in varying proportions. The term " bush " was used in the case of all non-graminaceous perennial and annual plants. A sample of grasses only was described as " grass, green "; " grass, mainly green "; " grass "; " grass, mainly brown "; and " grass, brown ". The terms " green " and " brown " are self-explanatory. The term " grass " indicates that it was judged that the sample was composed of roughly equal amounts of green and brown grass, respectively, whereas a sample was described as " mainly green " or " mainly brown " depending on the estimated amounts of green and brown grass in the composite sample. In addition, certain outstanding features in a grass sample were described. Thus, a sample was " leafy " when it was almost entirely composed of leaves only, few stalks being present; or " long " when the sample forwarded was made up of the aerial parts as a whole of grass tufts 12 inches or more in length. Also, the grass in a sample was described as " short " when the effective growth on the tufts was not more than about 2-3 inches in height either due to overgrazing or very little new growth at the commencement of the rainy season. The advancing stages of maturity in the case of bushes were not described, since, on the one hand, the bush samples received were in the majority of cases " green " and, on the other hand, the description for a mixed sample of bushes and grasses would have

been too long and cumbersome. The term " bush ", then, meant that the sample was composed of bushes only; describing a sample as " grass and bush " signified a composite sample of the two veld types in which the amounts of bush and grass were more or less in the ratio of 1:1. A preponderance of one or the other veld type in the composite sample was indicated by adding the words " mostly bush " or " mostly grass ", as the case may be, to the description given above. To illustrate, the description: " Grass, mainly green, leafy, and bush; mostly grass " would mean that, in the first place, there was proportionately more grass than bush in the composite sample and, in the second place, the grass moiety of the sample consisted almost exclusively of leaves, the majority of which were still in a green state.

The description of a sample was included with the scheme in order to give a rough indication of the stage of growth of the plants composing the pasture sample so that the influence of stage of growth on the chemical composition may be judged in the case of every sample collected. However, these descriptions as indices of stage of growth must be looked upon as only approximate; a " green " sample might for instance be composed of herbage at a stage of growth ranging from anything between two weeks and two months; i.e. at any stage from tillering to post-flowering or seeding.

As stated previously some 240 stock inspectors were entrusted with the task of collecting pasture samples and the actual work had to start in November, 1933. This meant that over 700 farms were involved, although this number oscillated considerably during the course of the investigation. The majority of officers responded immediately by forwarding their first samples during November while a few collected their first samples only in December or even January and February of 1934.

It was originally intended to continue the collection of samples for at least three years but it was soon realised that owing to the large amount of analytical work involved the available chemical staff would be unable to complete all the analyses in a reasonable length of time. For this reason it was decided to cover a period of two years only and the collection of samples which, as stated previously, was started in November, 1933, was discontinued in October, 1935.

It may, finally, be stated that the instructions in regard to the method of rotating the collection of samples on three chosen farms were strictly adhered to by officers in only about 50 per cent. of the cases. For good reasons many officers had to replace one or more of their original farms with different ones, or the date on which a collection had to be made on a certain farm had to be altered. This, however, is not considered a serious defect in the scheme since the object is not so much to determine the feeding value of the pasture on certain farms but to get an average quality index of pastures in different areas or districts of the Union at different times of the year.

All chemical analyses are given on a dry matter basis and the methods employed were the same as those described by Louw (1938). Altogether close on 5,000 samples were analysed.

III. RESULTS.

(1) General.

Tables giving the analysis on the basis of the dry matter together with a description of each individual pasture sample received are presented in an appendix to this report. Owing to the mass of data collected it is impossible to consider each farm or locality by itself. It has consequently been decided to divide the country into eighteen different areas (see Chart I) and to construct tables giving the average composition of all the samples collected in each area and during each month of the year separately. The principal districts comprising an area are given in a legend to Chart I. No samples were collected in areas (e.g. Basutoland) not marked on the chart, while the analyses of the limited number of samples which arrived from the strip of country stretching from Piquetberg on the west coast along the south coast to Humansdorp, marked " O ", are given in the appendix only; the calculation of averages from the available data for this region was not considered justifiable.

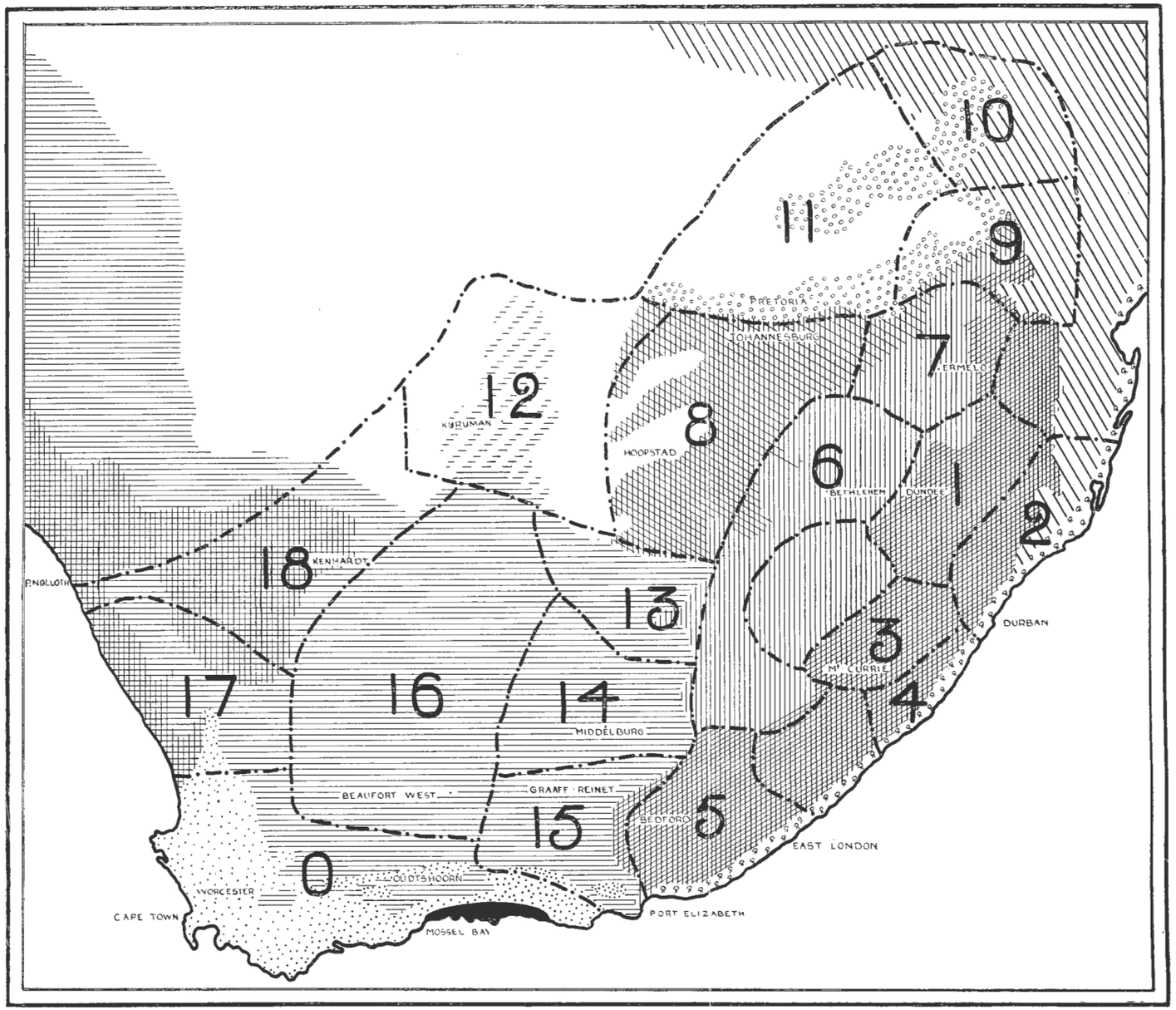
The division of the country into eighteen areas was made mainly on the basis of the Botanical Map of the Union of South Africa (Pole-Evans, 1936). Although, to a certain extent, rainfall was also taken into account, the division into areas remains somewhat arbitrary.

It was thought that more reliable values would be obtained for the composition of the pasture if the analyses of the separate years were not considered separately. Consequently, the analyses of all the samples collected during any one month, irrespective of the year, in, say, area 1 were grouped together and average values for each constituent calculated for that particular month. In this way average values for each constituent determined and for each of the twelve months, January to December, were calculated in the case of every one of the 18 areas into which the Union was divided. These average values for an " average " year though not, as may be expected, applicable to the pasture on each of the farms situated in that area separately may, nevertheless, be taken to provide a fair criterion for judging the feeding value of the pastures in the area as a whole, particularly with reference to the changes in the feeding value of the pastures from January to December.

The rainfall data for the two years from November, 1933, have been treated in a manner similar to that outlined above for the chemical analyses of pasture samples in order to arrive at average monthly rainfall figures for an " average " year in the case of each of the 18 areas in question. Briefly, it means that, for instance, the mean rainfall for January in area 1 was obtained by averaging all the available rainfall data registered on farms in area 1, from which samples were actually forwarded, during January, irrespective of the year. Unfortunately, not all the farms where the pastures were sampled were provided with rain guages, so that in many cases the rainfall data of the towns or villages nearest to such farms had to be

CHART I.

Vegetation Map of South Africa showing Division into Areas for the purpose of discussing the Mineral Content and Feeding Value of the Natural Pastures.



Legend to Chart I.

Area.	*Principal Districts.*
1.	Piet Retief, Utrecht, Newcastle, Vryheid, Dundee, Klip River, Helpmekaar, Weenen, Bergville, Estcourt, Lions River.
2.	Ubombo, Nongoma, Hlabisa, Lower Umfolosi, Nkandhla, Eshowe, Mtunzini, Kranskop, Umvoti, New Hanover, Lower Tugela, Inanda, Camperdown, Pinetown.
3.	Pietermaritzburg, Richmond, Himeville, Ixopo, Umzimkulu, Mt. Currie, Matatiele, Mt. Fletcher, Mt. Frere, Mt. Ayliff.
4.	Umzinto, Alfred, Port Shepstone, Bizana, Tabankulu, Flagstaff, Lusikisiki, Port St. Johns.
5.	Glen Grey, Queenstown, Cathcart, Stutterheim, Komgha, East London, Kingwilliamstown, Bedford, Somerset East, Albany, Bathurst.
6.	Wodehouse, Maclear, Barkly East, Herschel, Wepener, Zastron, Smithfield, Ladybrand, Bethlehem, Harrismith, Vrede, Frankfort.
7.	Standerton, Wakkerstroom, Bethal, Ermelo, Carolina, Belfast.
8.	Krugersdorp, Ventersdorp, Potchefstroom, Vereniging, Heidelberg, Klerksdorp, Wolmaransstad, Schweizer-Reneke, Christiana, Hoopstad, Kroonstad, Brandfort, Winburg, Bloemfontein.
9.	Middelburg, Lydenburg, Pilgrimsrest, Nelspruit, Barberton.
10.	Letaba, Zoutpansberg.
11.	Pietersburg, Potgietersrust, Waterberg, Rustenburg, Marico, Brits, Pretoria, Witbank.
12.	Mafeking, Vryburg, Kuruman, Taungs, Barkly West.
13.	Herbert, Jacobsdal, Fauresmith, Dewetsdorp, Trompsburg, Philippolis, Bethulie.
14.	Philipstown, De Aar, Hanover, Colesberg, Venterstad, Albert, Molteno, Middelburg, Richmond, Murraysburg.
15.	Tarka, Cradock, Graaff-Reinet, Pearston, Aberdeen, Willowmore, Jansenville, Steytlerville, Uitenhage, Port Elizabeth.
16.	Beaufort West, Sutherland, Fraserburg, Victoria West, Carnarvon, Williston, Britstown, Prieska, Hopetown, Hay.
17.	Van Rhynsdorp, Calvinia (partly), Namaqualand (partly).
18.	Gordonia, Kenhardt, Namaqualand (partly).

utilised in order to make the average figure as representative as possible of the area as a whole. The average monthly rainfall figures calculated as indicated are given in Table 1 in inches.

Judging from the averages for different areas given in a publication by Schumann and Thompson (1934) on certain aspects of rainfall in South Africa, and from the Reports of the Union Meteorological Office for the years 1934 and 1935, the former being on the whole above and the latter year below normal in regard to rainfall the "average" year arrived at from the data of the two years covering this investigation seems to be a fair indication of normal conditions.

A study of the descriptions of individual samples given in the appendix reveals the following: 93-99 per cent. of the samples originating from areas 1-4, from areas 6-8, and from area 11 were composed of grasses only, the rest being "bush". Grasses were predominant in mixed samples from areas 5, 9, 10, 12 and 13, the percentages of samples composed of bush only being 12·0, 10·0, 17·0, 26·0 and 34·0, respectively. On the other hand, the samples from Area 17 were made up almost exclusively of bushes; bushes predominated in the samples forwarded from Areas 15 and 16, only about 20 per cent. being composed of grass, whilst in the remaining two areas, numbers 14 and 18, the numbers of grass and bush samples, respectively, were approximately the same. The percentages of grass and bush samples cited above do not, of course, and are not intended to, reflect actual conditions in the veld with mathematical precision, but judging from a knowledge of veld conditions in some of the areas and the botanical map previously referred to, the proportions of grass and bush samples in the total numbers forwarded from the various areas, and reflected in these percentages, may be taken to be a fair approximation in the case of most areas.

The average monthly chemical composition and the range of variation in the composition of individual samples are given in tables 2 and 3 and tables 8 to 14 for each of the 18 areas into which the country has been divided. Reference should be made to table 2 for a record of the numbers of samples analysed for each month, and for an approximate description of the type of veld in an area as a whole. The range values, giving minimum and maximum figures for each month, were included to indicate the wide differences that may occur in the composition of samples collected during the same month in any one area.

Naturally, considerable variation is expected in samples secured over an extensive region of natural veld—the areas in question measure 8,000 square miles and more—if the factors influencing the chemical composition of such pastures are kept in mind. In this connection reference needs only to be made to the fact that most of the rain in the greater part of this country falls in the form of intermittent showers resulting often in considerable variation in the precipitation on two adjacent farms, let alone on farms 50 or more miles apart in the same area. Although the influence of soil fertility and botanical composition of the pasture is by no means negligible the main factor responsible for the wide differences in the chemical composition of pasture samples from the same area is no doubt the variable rainfall which in turn is responsible for pasturage at various

stages of maturity. The existence of the great variation in the mineral and protein contents of the pasture samples collected during the same month inevitably impairs the significance of the average values somewhat. At the same time the average values which will form the basis of the following discussion may be taken to describe even if it is only in a rough way, the quality of the pasturage of a specific area as a whole more closely than would any of the individual values within the range of variation observed. In particular the average values afford a valuable picture of the seasonal tendency in the chemical composition of the pasturage.

(2) Phosphorus and Crude Protein.

The average values for phosphorus and crude protein given in tables 2 and 3 for the 18 areas separately are presented in graphical form in Figs. 1 to 5. The outstanding feature in these graphs is the gradual downward tendency from January to July or August followed by a rise of varying intensity to November or December for both P and protein in the case of all the grassland areas of the Union. This downward and upward curve is closely correlated with the rainfall in the areas concerned as will be evident from a glance at table 1. On the other hand the graphs describing the monthly averages for mixed (grass and bush) veld do not show a definite tendency from January to December.

The irregular fluctuations may probably be mainly ascribed to varying proportions of bushes and grasses in the mixed samples collected from month to month and to the fact that bushes are more resistant to drought and retain their nutritive properties longer than do grasses, as is evident from the higher level in the average values for both phosphorus and protein in samples containing a high percentage of bush throughout the year. The mineral composition and protein content of bushes are influenced, though not to the same extent as are grasses, by rainfall as is evident from a study of the monthly average values and rainfall for Area 17, a winter rainfall area, and the only one in which the samples collected were practically all composed of bushes only. Unlike all other areas maximum values for P and protein were here obtained during the winter months.

An examination of the phosphorus and crude protein figures shows that at no time can the pastures of the Union be considered to be rich in these constituents as judged by oversea standards. In the summer rainfall grassland areas the phosphorus and protein values reach their highest levels in November, December or January, 0·12 to 0·17 per cent. and 7·0 to 9·0 per cent. respectively. From January there is a gradual decline to the extremely low values of 0·05 to 0·07 and 3·3 to 4·0 per cent. for phosphorus and protein, respectively, in July or August followed by a gradual rise to the higher values referred to above.

Except for Areas 17 and 18, the averages for samples from areas where a high percentage of bushes were present in the samples or where bushes were predominant show not only higher maxima but the minimum values also are higher than those of the grassland areas. Figures for phosphorus never go below 0·11 per cent. in the

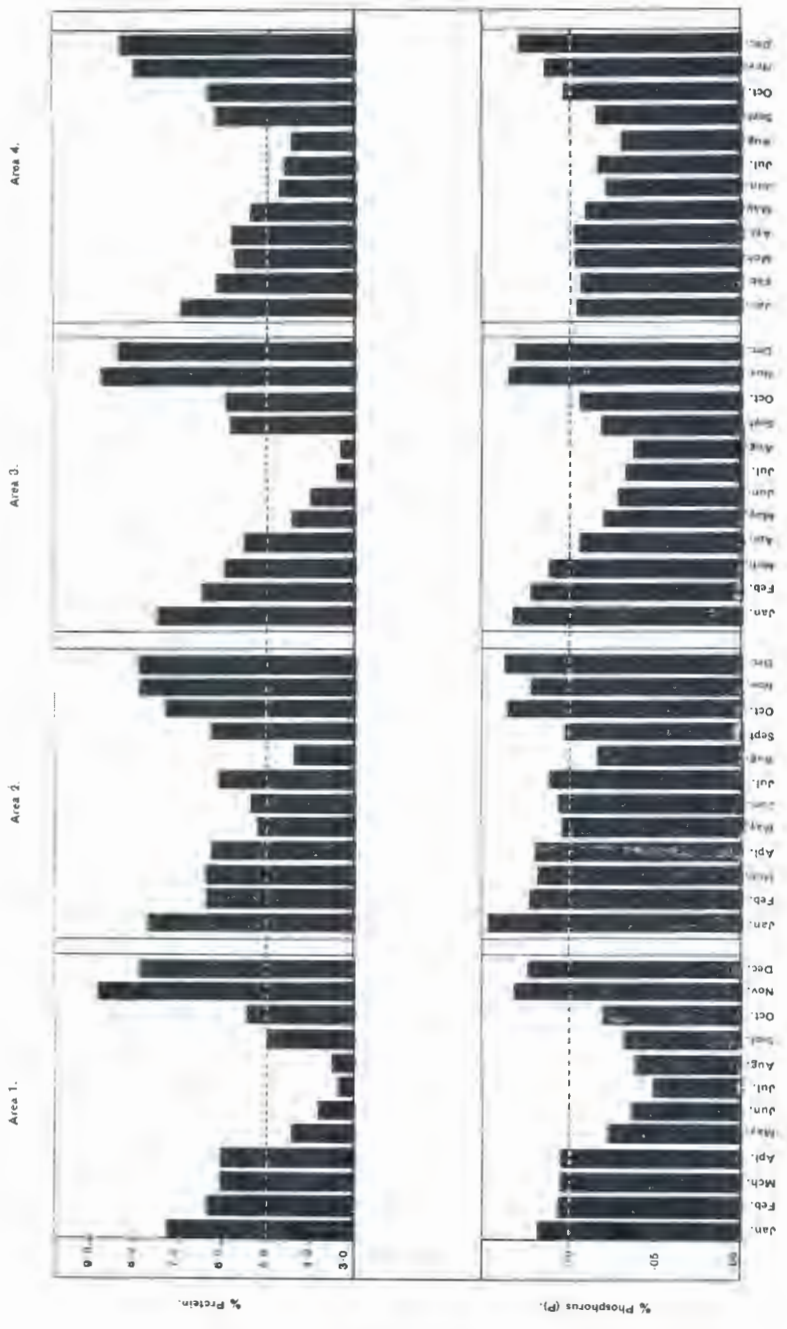


Fig. 1.—Showing the seasonal variation in the phosphorus and crude protein contents of the natural pastures of areas 1, 2, 3 and 4.

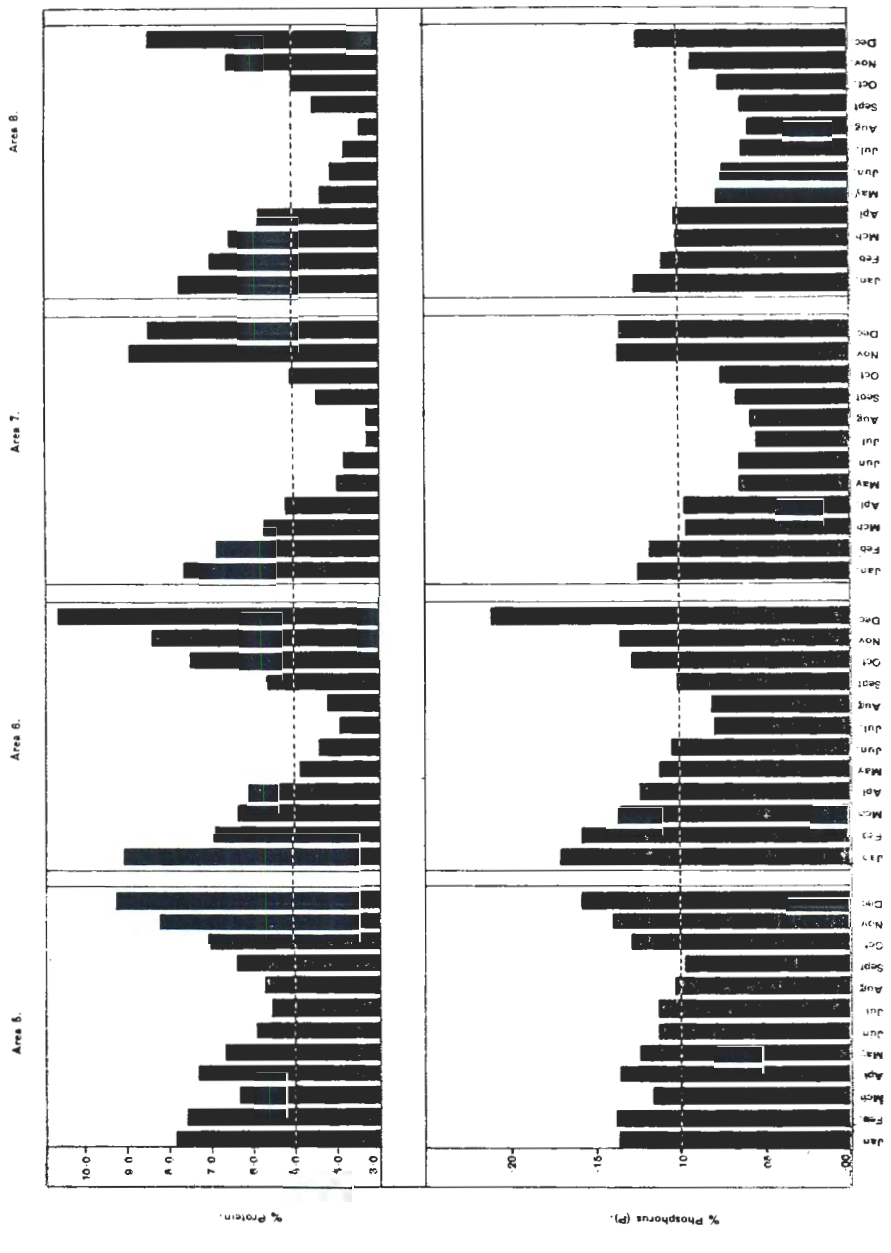


Fig. 2. Showing the seasonal variations in the phosphorus and crude protein contents of the natural pastures of areas 5, 6, 7 and 8.

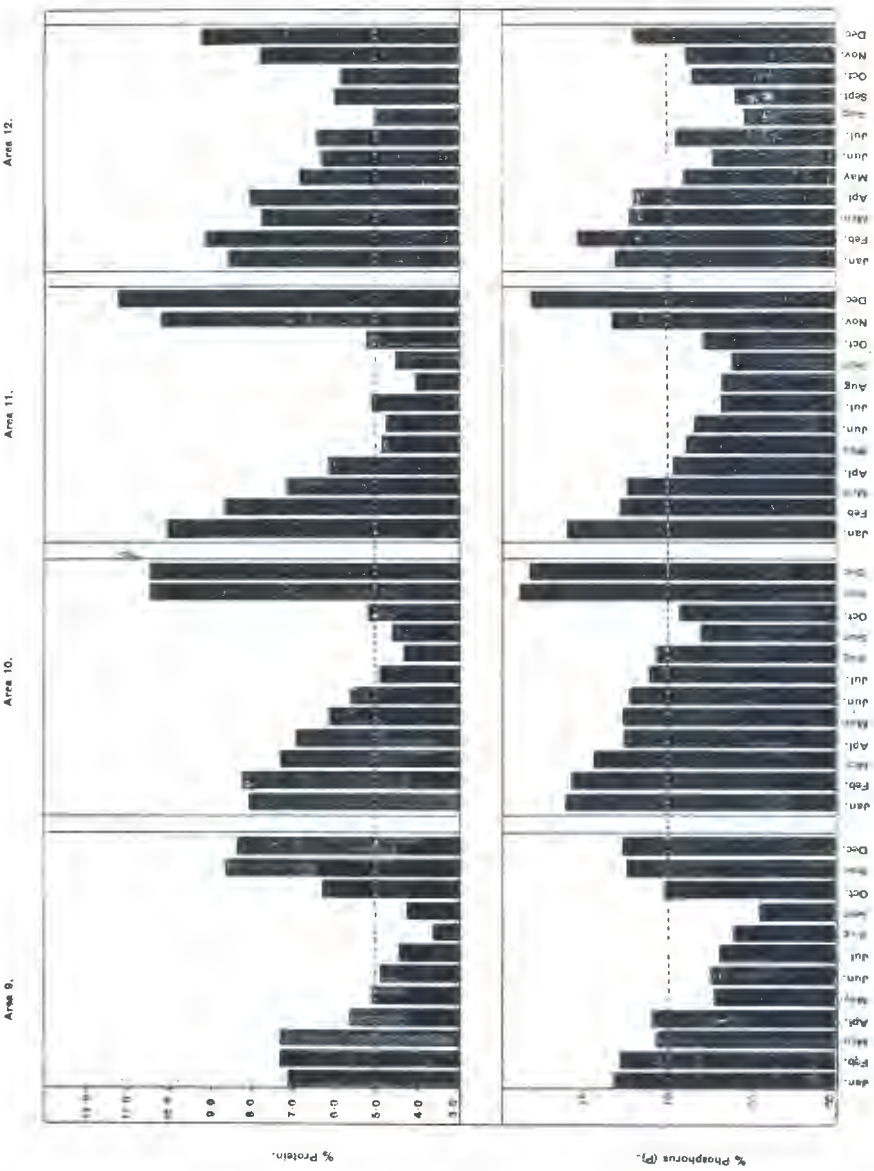


Fig. 3.—Showing the seasonal variations in the phosphorus and crude protein contents of the natural pastures of areas 9, 10, 11 and 12.

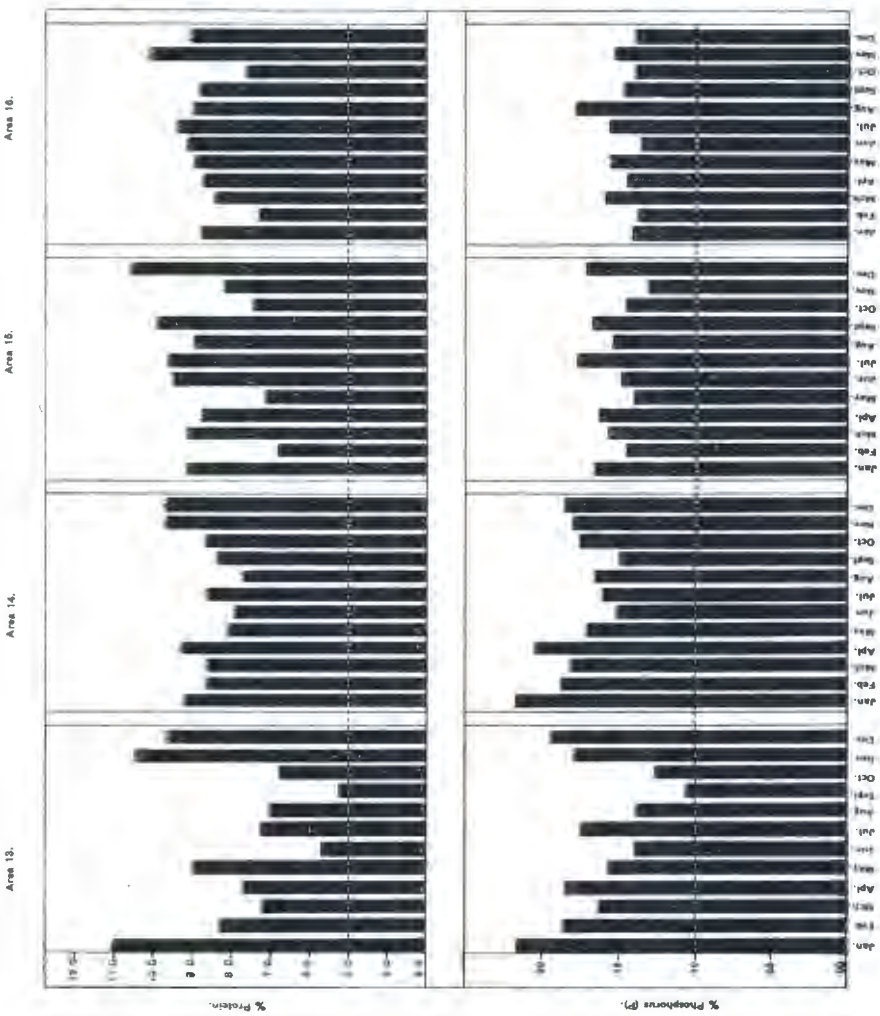


Fig. 4.—Showing the seasonal variations in the phosphorus and crude protein contents of the natural pastures of areas 13, 14, 15 and 16.

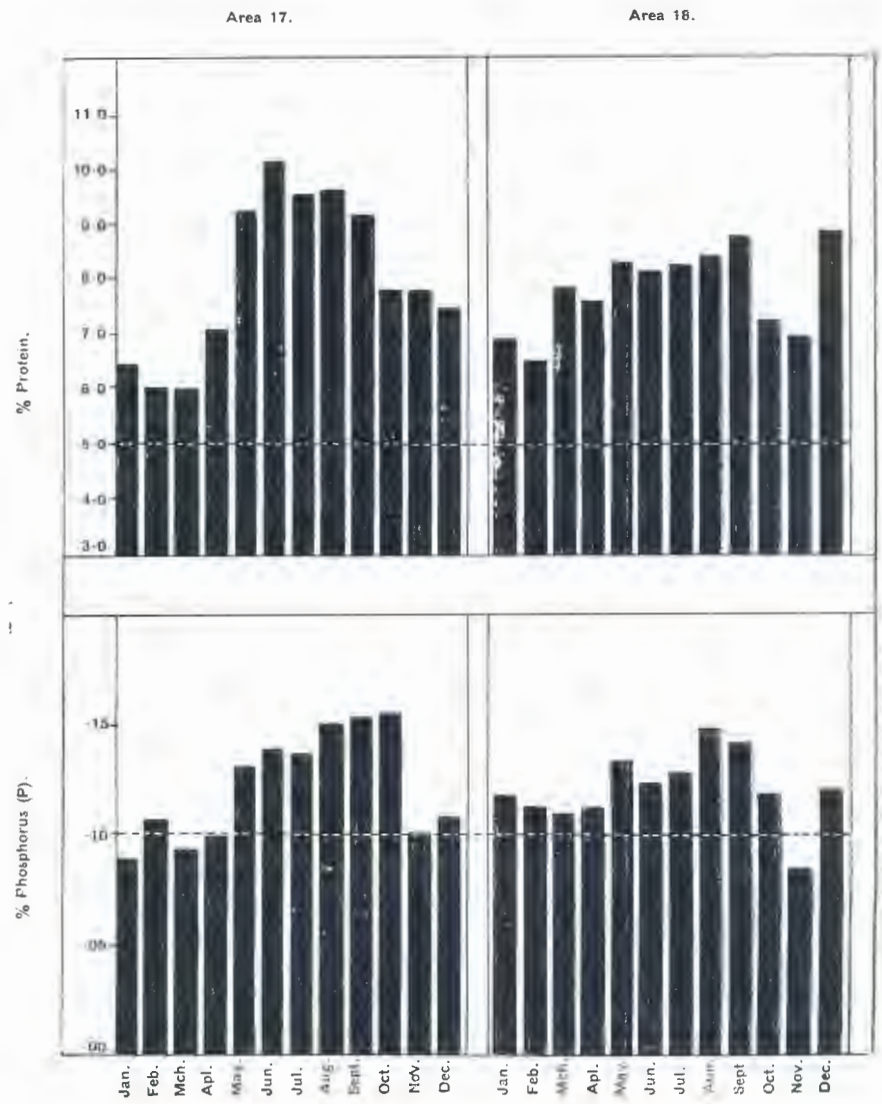


Fig. 5.—Showing the seasonal variations in the phosphorus and crude protein contents of the natural pastures of areas 17 and 18.

Table 1.

Average monthly rainfall for period October, 1933, to September, 1935, in inches.

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1.....	6·12	3·80	3·42	1·81	1·14	0·40	0·74	1·07	0·56	2·12	6·44	6·36	33·98
2.....	5·93	3·90	4·14	2·64	2·40	2·67	0·95	1·38	0·70	1·91	5·66	7·30	39·58
3.....	6·08	3·76	3·89	2·56	1·33	1·35	0·66	0·83	0·58	2·01	6·40	6·84	36·29
4.....	5·00	2·54	4·45	3·20	2·49	1·99	1·42	1·57	0·83	2·23	5·48	5·76	36·96
5.....	3·43	2·88	4·18	2·43	3·61	0·98	1·34	1·05	0·86	1·95	4·15	2·89	29·75
6.....	5·08	2·78	4·37	2·11	1·81	0·31	0·75	1·12	0·34	2·41	5·95	5·30	32·33
7.....	5·46	3·32	2·97	1·18	0·71	0·39	0·50	0·61	0·49	2·12	6·30	5·92	29·97
8.....	4·11	2·95	3·34	1·93	1·45	0·16	0·32	0·30	0·25	1·72	5·97	3·78	26·28
9.....	6·02	3·52	2·91	1·44	0·64	0·61	0·29	0·25	0·67	1·45	6·19	5·54	29·53
10.....	5·42	3·33	2·69	1·13	0·39	0·25	0·05	0·13	0·48	1·26	6·66	4·02	25·81
11.....	3·75	3·17	2·37	0·59	0·50	0·11	0·08	0·24	0·47	1·09	5·55	4·06	21·98
12.....	3·02	3·41	2·96	1·87	1·26	0·17	0·03	0·03	0·07	0·99	3·13	2·75	19·69
13.....	3·04	2·32	3·23	1·69	1·58	0·29	0·12	0·43	0·20	1·73	2·90	3·23	20·76
14.....	2·39	1·88	2·59	1·32	1·80	0·25	0·40	0·26	0·22	0·98	2·68	2·14	16·90
15.....	1·46	1·72	2·06	1·26	2·15	0·41	0·82	0·43	0·57	0·96	2·05	1·75	15·64
16.....	0·13	1·66	1·27	1·45	2·25	0·61	0·20	0·42	0·34	0·80	3·04	1·06	13·23
17.....	0·00	0·40	0·09	1·12	1·44	0·77	0·88	1·13	0·70	0·36	1·53	0·21	8·63
18.....	0·18	0·62	0·33	1·28	1·11	0·21	0·25	0·17	0·08	0·09	2·02	0·37	6·71

TABLE 2.

Mean Phosphorus (P) Content of Pastures (Numbers of Samples analysed and Range Values included).

Area and Type of Veld.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	
1 (Grass)	41	46	47	52	50	49	52	34	42	44	38	38	Number of samples.
	·118	**·106**	**·105**	**·105**	**·079**	**·065**	**·053**	**·062**	**·069**	**·082**	**·133**	**·123**	**Mean.**
	·064–·21	·055–·18	·06 –·21	·052–·31	·032–·16	·016–·12	·016–·11	·027–·15	·029–·15	·031–·21	·061–·26	·052–·32	Range.
2 (Grass)	41	40	40	39	42	36	35	38	33	39	38	34	Number of samples.
	·147	**·123**	**·118**	**·120**	**·104**	**·105**	**·111**	**·084**	**·103**	**136**	**123**	**·138**	**Mean.**
	·057–·36	·058–·25	·044–·32	·039–·31	·03 –·26	·035–·29	·038–·31	·027–·22	·033–·21	·037–·30	·057–·24	·064–·26	Range.
3 (Grass)	29	31	34	32	30	30	26	33	26	25	31	28	Number of samples.
	·132	**·121**	**·111**	**·094**	**·080**	**·070**	**·066**	**·062**	**·079**	**094**	**·131**	**·131**	**Mean.**
	·065–·28	·06 –·20	·07 –·23	·052–·17	·043–·14	·033–·13	·032–·19	·025–·12	·047–·19	·04 –·25	·05 –·22	·07 –·22	Range.
4 (Grass)	15	15	21	21	25	25	19	20	19	19	17	11	Number of samples.
	·095	**·092**	**·096**	**·096**	**·090**	**·078**	**·083**	**·069**	**·084**	**·103**	**·115**	**·128**	**Mean.**
	·053–·14	·05 –·19	·052–·22	·055–·23	·049–·19	·03 –·17	·044–·22	·036–·18	·035–·21	·05 –·28	·053–·23	·083–·23	Range.
5 (Mainly Grass)	29	32	35	36	30	38	33	33	29	31	33	28	Number of samples.
	·136	**·137**	**·117**	**·135**	**·124**	**·113**	**·113**	**·104**	**·097**	**130**	**·140**	**·158**	**Mean.**
	·068–·26	·06 –·24	·044–·24	·058–·26	·064–·30	·034–·26	·044–·32	·042–·21	·035–·21	·054–·39	·052–·32	·06 –·35	Range.
6 (Grass)	28	29	25	29	29	24	22	23	23	25	21	22	Number of samples.
	·173	**·158**	**·138**	**·125**	**·113**	**·106**	**·082**	**·084**	**·101**	**·129**	**·137**	**·212**	**Mean.**
	·096–·31	·064–·31	·066–·24	·066–·22	·038–·21	·042–·23	·025–·18	·044–·17	·053–·19	·047–·21	·066–·25	·077–·45	Range.
7 (Grass)	33	32	34	35	33	33	31	32	32	31	31	34	Number of samples.
	·126	**·119**	**·095**	**·096**	**·065**	**·065**	**·055**	**·058**	**·068**	**·075**	**·138**	**·138**	**Mean.**
	·084–·25	·066–·32	·048–·15	·032–·24	·025–·12	·025–·12	·029–·12	·024–·11	·028–·19	·033–·17	·062–·24	·092–22·	Range.
8 (Grass)	24	26	27	25	26	27	23	24	23	22	17	21	Number of samples.
	·127	**·112**	**·101**	**·102**	**·079**	**·075**	**·064**	**·060**	**·063**	**·076**	**·093**	**·127**	**Mean.**
	·054–·23	·065–·19	·056–·17	·050–·15	·029–·17	·04 –·14	·029–·11	·031–·098	·025–·15	·045–·13	·042–·16	·065–·22	Range.
9 (Mainly Grass)	20	24	21	22	22	22	22	20	21	20	23	25	Number of samples.
	·132	**·128**	**·106**	**·109**	**·072**	**·075**	**·069**	**·061**	**·045**	**·101**	**·124**	**·126**	**Mean.**
	·058–·27	·064–·32	·052–·19	·043–·25	·03 –·15	·033–·16	·036–·17	·021–·093	·028–·09	·032–·24	·056–·26	·059–·26	Range.
10 (Mainly Grass)	40	41	39	43	36	29	31	31	32	34	40	37	Number of samples.
	·161	**·157**	**·144**	**·126**	**·126**	**·122**	**·111**	**·106**	**·080**	**·093**	**·189**	**·183**	**Mean.**
	·039–·30	068–·31	·071–·26	·044–·36	·061–·32	·031–·27	·041–·23	·046–·23	·043–·22	·035–·21	·044–·51	·078–·32	Range.
11 (Grass)	16	27	33	31	32	29	27	30	28	19	27	18	Number of samples.
	·160	**·128**	**·124**	**·096**	**·088**	**·085**	**·066**	**·066**	**·061**	**·078**	**·133**	**·182**	**Mean.**
	·07 –·29	·074–·27	·062–·28	·057–·20	·041–·19	·028–·21	·035–·16	·025–·22	·025–·13	·038–·26	·056–·38	·07 –·33	Range.
12 (Mainly Grass)	11	14	16	14	10	15	14	14	10	14	9	7	Number of samples.
	·131	**·153**	**·123**	**·120**	**·088**	**·071**	**·095**	**·053**	**·059**	**·086**	**·089**	**·120**	**Mean.**
	·07 –·35	·087–·22	·07 –·25	·074–·19	·054–·17	·038–·14	·038–·23	·026–·10	·028–·077	·045–·17	·042–·16	·043–·18	Range.
13 (Grass and bush)	7	8	9	8	9	7	8	8	8	8	4	6	Number of samples.
	·216	**·186**	**·164**	**·185**	**·157**	**·140**	**·175**	**·138**	**·105**	**·126**	**·180**	**·195**	**Mean.**
	·10 –·30	·15 –·28	·095–·26	·087–·23	·083–·27	·07 –·25	·14 –·21	·082–·24	·074–·14	·063–·18	·12 –·32	·16 –·26	Range.
14 (Grass and bush)	12	12	15	17	13	14	13	12	15	14	10	9	Number of samples.
	·218	**188**	**·183**	**206**	**·171**	**·151**	**·163**	**·167**	**150**	**·177**	**·180**	**·187**	**Mean.**
	·12 –·44	·15 –·25	·11 –·30	·11 –·31	·08 –·36	·10 –·20	·11– ·23	·14 –·20	·09 –·25	·12 –·26	·12 –·26	·14 –·26·	Range.
15 (Mainly bush)	12	11	14	14	12	14	13	13	16	11	13	12	Number of samples.
	·167	**·147**	**·158**	**·164**	**142**	**·150**	**·179**	**·156**	**·168**	**·146**	**·132**	**·176**	**Mean.**
	·08 –·38	·04 –·27	·093–·27	·09– ·25	·033–·25	·07– ·26	·12– ·32	·12 –·30	·056–·30	068–·23	·066–·22	·13 –·26	Range.
16 (Mainly bush)	15	17	19	21	18	19	13	11	20	17	16	14	Number of samples.
	·143	**·140**	**·162**	**·145**	**158**	**·136**	**·158**	**·180**	**·148**	**·140**	**·155**	**·139**	**Mean.**
	·08 –·22	·094–·23	·11 –·31	·084–·19	·048–·29	·077–·22	·073–·23	·06 –·32	·05 –·29	·076–·22	·067–·25	·05– ·21	Range.
17 (Bush)	10	8	10	9	8	10	7	8	9	10	13	9	Number of samples.
	·087	**·106**	**·092**	**·098**	**·130**	**·140**	**·136**	**·149**	**·152**	**·153**	**·100**	**·108**	**Mean.**
	·05 –·13	·057–·21	·046–·17	·05 –·14	·083–·26	·094–·20	·11 –·16	·095–·18	·086–·21	·087–·33	·057–·13	·072–·15	Range.
18 (Grass and bush)	11	10	11	11	11	9	11	9	10	10	11	11	Number of samples.
	·117	**·112**	**·108**	**·111**	**·133**	**·121**	**·127**	**·147**	**·142**	**·116**	**·084**	**·120**	**Mean.**
	·027–·27	·078–·14	·073–·16	·053–·16	·075–·19	·07 –·16	·097–·16	·078–·24	·10 –·24	·06 –·15	·06 –·15	·061–·20	Range.

TABLE 3.

Mean Crude Protein Content of Pastures (Range Values included).

Area.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	
1	**7·4**	**6·4**	**6·1**	**6·1**	**4·4**	**3·8**	**3·4**	**3·5**	**5·0**	**5·5**	**9·0**	**8·0**	**Mean.**
	3·3–15·6	3·1– 8·7	3·3 10·5	3·4–18·0	2·2– 8·5	2·2– 8·9	2·1– 5·8	2·0– 8·1	2·3 15·4	2·6–12·4	4·1–16·3	4·6–14·4	Range.
2	**7·9**	**6·5**	**6·5**	**6·4**	**5·3**	**5·5**	**6·2**	**4·4**	**6·4**	**7·4**	**8·1**	**8·1**	**Mean.**
	4·3–16·8	2·4–15·9	3·3 12·5	3·1–16·2	2·7–11·0	2·4–14·8	2·3–16·6	1·8–11·5	1·9–15·0	2·9–17·7	2·2–18·0	2·8–15·7	Range.
3	**7·6**	**6·6**	**6·1**	**5·6**	**4·4**	**4·0**	**3·4**	**3·3**	**5·9**	**6·0**	**9·0**	**8·5**	**Mean.**
	5·0–12·9	3·9– 9·6	3·6– 7·6	3·3–10·1	2·7– 6·9	2·6– 9·7	2·2– 6·7	1·8– 6·4	2·7 15·5	2·6–13·5	3·2–15·7	5·3–11·6	Range.
4	**7·1**	**6·2**	**5·8**	**5·9**	**5·4**	**4·8**	**4·7**	**4·5**	**6·3**	**6·4**	**8·2**	**8·5**	**Mean.**
	4·1–13·5	3·7– 7·9	3·4– 9·2	3·9–12·3	3·5– 8·7	2·6– 9·8	2·4–11·2	2·0– 8·9	3·2–16·5	3·6–11·2	4·2–12·9	5·0–13·4	Range.
5	**7·8**	**7·5**	**6·3**	**7·3**	**6·6**	**5·9**	**5·5**	**5·7**	**6·4**	**7·0**	**8·2**	**9·2**	**Mean.**
	4·2–13·3	3·2–14·3	2·7–11·2	3·7–12·2	3·7–12·3	3·1–13·7	2·7 12·4	2·8– 9·2	2·4–15·4	2·9–15·5	3·1–18·7	3·7–19·1	Range.
6	**9·0**	**6·9**	**6·4**	**6·0**	**4·9**	**4·4**	**3·9**	**4·2**	**5·7**	**7·5**	**8·4**	**10·7**	**Mean.**
	4·4–17·2	3·9–10·1	3·9 9·4	3·6–10·8	2·9– 7·8	2·7– 9·0	2·5– 6·0	2·5– 8·4	2·1–12·2	3·1–13·0	4·1–14·2	4·8–19·6	Range.
7	**7·6**	**6·8**	**5·7**	**5·2**	**4·0**	**3·8**	**3·3**	**3·3**	**4·5**	**5·1**	**9·0**	**8·5**	**Mean.**
	4·2–11·9	4·5–11·6	3·2– 8·0	3·2–11·6	1·9– 7·9	2·3– 7·4	2·4– 4·8	2·1– 6·7	2·1–11·7	3·0–11·7	4·0–14·9	5·7–11·8	Range.
8	**7·7**	**7·0**	**6·5**	**5·8**	**4·3**	**4·1**	**3·7**	**3·4**	**4·5**	**5·0**	**6·5**	**8·4**	**Mean.**
	4·3–14·6	3·9–11·1	4·1 11·8	4·3– 8·3	2·5– 7·9	2·4– 8·4	2·3– 6·6	2·0– 5·5	2·8– 9·6	2·9– 8·1	3·4–12·1	5·4–14·3	Range.
9	**7·1**	**7·3**	**7·3**	**5·6**	**5·1**	**4·9**	**4·4**	**3·6**	**4·3**	**6·3**	**8·6**	**8·3**	**Mean.**
	3·9–10·7	3·8–16·4	3·7 15·8	2·9–12·8	2·9–11·3	2·4–13·3	2·5–11·3	2·3– 6·7	2·4–17·1	2·4–14·1	3·0–22·5	3·8–15·1	Range.
10	**8·0**	**8·2**	**7·3**	**6·9**	**6·1**	**5·6**	**4·9**	**4·3**	**4·6**	**5·2**	**10·4**	**10·4**	**Mean.**
	2·9–16·3	4·4–18·8	3·8 13·0	3·0–16·7	3·0–17·0	2·0–11·4	1·5 10·5	1·8– 7·4	1·8– 8·6	1·8–13·3	2·6–18·8	5·6–20·6	Range.
11	**10·0**	**8·6**	**7·1**	**6·1**	**4·8**	**4·7**	**5·1**	**4·0**	**4·5**	**5·2**	**10·1**	**11·2**	**Mean.**
	5·1–14·7	5·4–15·4	3·5 16·2	3·6–10·8	2·6– 9·5	2·4–16·3	2·4–15·4	2·1–12·1	1·9 9·5	2·7–16·6	4·3–18·8	7·0–16·2	Range.
12	**8·5**	**9·1**	**7·7**	**8·0**	**6·8**	**6·3**	**6·4**	**5·0**	**6·0**	**5·8**	**7·8**	**9·2**	**Mean.**
	3·8–20·5	5·5–14·4	3·7 16·5	4·4–13·1	3·6–11·0	2·7–14·8	2·5 12·9	2·7– 9·2	3·6– 9·9	3·3–10·7	3·1–13·0	3·0–14·1	Range.
13	**11·8**	**8·4**	**7·3**	**7·8**	**9·1**	**5·7**	**7·4**	**7·1**	**5·3**	**6·8**	**10·5**	**9·8**	**Mean.**
	4·8–19·1	3·6–12·2	4·9 11·2	4·4–11·8	3·2–14·8	2·2–10·6	3·5–10·4	2·1–12·4	2·7– 9·0	2·6–12·2	5·8–16·5	6·1–13·8	Range.
14	**9·4**	**8·8**	**8·8**	**9·4**	**8·2**	**8·0**	**8·8**	**7·8**	**8·5**	**8·8**	**9·9**	**9·9**	**Mean.**
	4·4–17·7	5·2–14·2	5·9 15·4	5·2–13·2	5·1–12·4	2·7–12·0	5·5 17·3	4·0–12·0	5·0–15·2	5·2–13·6	6·2–14·2	5·7–12·3	Range.
15	**9·3**	**6·9**	**9·3**	**8·9**	**7·2**	**9·7**	**9·8**	**9·1**	**10·1**	**7·5**	**8·3**	**10·8**	**Mean.**
	5·3–18·1	4·0–10·7	5·2 14·5	6·2–14·8	4·0 11·4	4·6–15·9	5·3 19·8	5·4–15·8	3·7–18·2	3·8–12·3	3·9–13·1	6·2–14·4	Range.
16	**9·0**	**7·4**	**8·6**	**8·9**	**9·1**	**9·3**	**9·5**	**9·1**	**9·0**	**7·7**	**10·3**	**9·2**	**Mean.**
	5·3–12·8	4·5–12·8	5·7 14·1	5·4–14·8	4·3–12·9	2·8–14·5	3·3–14·3	6·0–13·7	4·8–13·9	2·8–12·8	6·1–16·5	2·9–14·4	Range.
17	**6·4**	**6·0**	**5·0**	**7·1**	**9·2**	**10·1**	**9·5**	**9·6**	**9·1**	**7·8**	**7·8**	**7·5**	**Mean.**
	4·5– 9·1	3·7–11·4	3·8 8·1	5·1– 9·4	4·8–19·3	7·2 13·1	7·8 11·7	6·1–13·9	6·4–10·7	5·7–14·0	5·6–10·0	4·8–10·0	Range.
18	**6·9**	**6·5**	**7 8**	**7·6**	**8·3**	**8·1**	**8·2**	**8·4**	**8·8**	**7·2**	**6·9**	**8·9**	**Mean.**
	2·8– 9·4	4·1–10·2	5·3 11·2	3·8–11·2	4·2–12·0	5·7–10·8	5·4–11·2	5·1–14·0	6·8–11·0	4·0– 9·4	4·1–10·4	5·3–15·7	Range.

course of the year while values of between 0·14 and 0·20 per cent. are the rule rather than the exception. Similarly crude protein figures seldom fall below 7·0 per cent., most values fluctuating between 7·0 and 10·0 per cent. Phosphorus values for Areas 17 and 18 are somewhat lower than and protein values on the whole of a similar magnitude as those for the other " bush veld " areas.

The differences in regard to phosphorus and protein contents of the pastures in the 18 different areas are most pronounced between those areas classified as " grass land " and those in which bushes predominate in the pastures. Whereas in the lastmentioned areas the phosphorus content of the pastures fluctuates between about 0·12 and 0·20 per cent. and the protein between 7·0 and 10·0 per cent. in the course of the year, the percentage of these constituents in samples composed of grasses only fall from peak values around 0·14 per cent. phosphorus and 8·0 per cent. crude protein during summer to as low as 0·05 per cent. and 3.3 per cent, respectively, in the dry winter months, corresponding with a change from green and succulent to dry and brown pasturage. Furthermore, the low values in the grass pastures persist for a considerable part of the year. In fact, speaking generally, phosphorus values are below 0·10 per cent. and protein less than 5·0 per cent. for three to six months of the year depending on the area. From a purely qualitative point of view, taking chemical composition as the criterion it seems warranted to conclude that bush pastures are superior to grass pastures under our climatic conditions. However, a conclusion based only on the qualitative indices of pastures cannot under all circumstances be accepted as final. The problem of the quantity and density of edible herbage available and that of the type of animal to be grazed on the pastures must necessarily be taken into consideration. In this connection it may be mentioned that the pastures of Areas 13, 14, 15, 16, 17 and 18 classified botanically as " desert shrub " are best grazed by sheep, the small karroo bushes which are the mainstay of these pastures, especially during dry seasons, being not so suitable for cattle farming. On the other hand, the natural grasslands of the northern provinces and Natal may be utilised for both cattle and sheep. On the whole it may be expected that these grass pastures will yield more food per unit of area than will the bush pastures of the Cape Province. In general it may, therefore, be stated that an animal will require less time and a smaller area to fulfill its daily requirements in regard to the amount of food needed on grass than on " bush " pastures.

A study of the average phosphorus and protein values for each of the 18 areas separately reveals differences in the quality of the pastures not only between the two major groups " grass " and " bush " as indicated above but also within each of these two main types of pasture in the Union.

Areas 1 to 5 comprise practically the whole of the tall grass area lying east of the Drakensberg escarpment and the coastal belt stretching from East London northwards. Of these areas numbers 2 and 5, both including a portion of the coastal belt, may be considered to be superior to Areas 1, 3 and 4, as judged by the average phosphorus and protein contents of the pastures. In the case of phosphorus the graphs show that not only are the maximum values

obtained for the summer months higher in the pastures of Areas 2 and 5 than in those of Areas 1, 3 and 4 but also the minimum values for the winter months are appreciably higher in the former than in the latter set of areas. The average protein values in Areas 2 and 5 are likewise better than those in Areas 1, 3 and 4 in that the winter averages do not fall to such low levels. It should be mentioned that a fair percentage of bushes were present in the samples from Area 5.

Of the remaining three areas situated in the typically grassland regions of the Union, viz. Areas 6, 7 and 8, the last two areas may be taken to be practically the same as Areas 1 and 3 with reference to the average phosphorus and protein figures of the pastures from January to December. On the other hand, Area 6, comprising a stretch of country which includes a portion of the north-eastern Cape and eastern half of the Orange Free State shows a definite improvement in comparison with Areas 7 and 8, phosphorus and protein values being on an average higher both during the rainy and dry seasons.

Areas 9, 10, 11 and 12 are situated practically wholly in the Parkland region of South Africa. Although this region is characterised botanically as " open woodland and orchard country of evergreen and deciduous tree and bush, open woodland country of suptropical evergreen and deciduous tree and thorn forest, and thorn country " (Pole Evans, 1936) the samples of edible pasture forwarded from the areas situated in this region were composed mainly of grasses. The position in regard to the phosphorus and protein content of the samples from Areas 9, 11 and 12 is no better than that in, for instance, Area 7. Here again, however, an improvement is noticeable in the case of Area 10, comprising the Letaba and Zoutpansberg districts. About one-sixth of the samples from this area were composed of evergreen deciduous tree and bush, and this circumstance, no doubt, was responsible for higher average phosphorus and protein figures although the improvement in the protein values are not such as to warrant special mention. It is to be noted, however, that in the case of Area 12 covering the Mafeking, Vryburg, Kuruman and Barkley West districts and situated in thorn country with an infiltration of Desert Shrub, the presence of about one quarter of the total samples analysed in the form of bush while improving the average protein figures from January to December did not materially improve the phosphorus figures when compared with an exclusive grassland region like Area 8. The low values obtained for this area in spite of a fair admixture of bushes in the samples, an admixture which in all other cases resulted in higher phosphorus values, bear out the known prevalence of Lamsiekte on the natural pastures of this region.

Of the remaining six areas numbers 13, 14, 15 and 16 lie exclusively in the Desert Shrub region while the vegetation of Areas 17 and 18 covering the north western portion of the Cape Province is mainly composed of desert succulents and desert grass. The phosphorus figures for the latter two areas are as previously pointed out lower than those for the Desert Shrub region but are nevertheless better than the figures for purely grassland areas. The superiority of the Desert Shrub to the grassland country with reference to the

phosphorus and protein contents of its pastures has already been referred to. It remains only to point out that judging from the graphs depicting average phosphorus and protein figures Area 14 is somewhat better than Areas 13, 15 and 16.

From a purely qualitative point of view, i.e., judging from their percentage content of the essential nutrients, phosphorus and protein, the natural pastures of the Union may, therefore, be provisionally divided into three categories, viz., those low in phosphorus and protein a second group showing medium values, and, lastly, those pastures containing comparatively high percentages of phosphorus and protein when judged by South African standards. Areas 1, 3, 4, 7, 8, 9, 11, and 12 which includes the greater part of the Grassland region of the Union may be classified in the first category, i.e., low values for phosphorus and protein; Areas 2, 5, 6, 10, 17 and 18 comprising a part of the Tall Grass area the major portion of the Short Grass region, and the whole of the Desert Succulents and Desert Grass area would fall under medium pastures, and finally the Desert Shrub area which has been divided into Areas 13, 14, 15 and 16 may be considered to be comparatively high in phosphorus and protein. Such a division, based as it is on chemical analyses alone, does not of course, finally determine the economic value of the several pastural regions for the production of livestock. As previously stated the amount of food available to the animal in a given area is a factor of paramount importance. In this connection it is of interest to record that according to Pole-Evans (*loc. cit*) in the Desert Shrub and Desert Succulent regions " the plants are always widely spaced in bare soil " while for instance in parts of the Tall Grass area the grasses form " a dense cover and a uniform sward ". Thus an animal on a farm in Namaqualand (Areas 17 or 18—medium P and protein) may die from starvation whilst an animal on a farm in the Dundee district (Area 1—low P and protein in winter) may merely suffer a temporary set back due to a deficiency of protein and phosphorus in an otherwise adequate diet.

In any case, there is no doubt that while grasses show fair figures for phosphorus and protein during the period of active growth associated with the rainy season these values drop to extremely low levels after the cessation of the rains into the cold winter months. On the other hand, while they are undoubtedly influenced by the rainfall, trees, shrubs, and other edible herbaceous plants do not only appear to be on the whole richer in phosphorus and protein than the grasses but they retain these nutritive constituents to a great extent even in the absence of rain.

Before passing on to a consideration of the other constituents determined it will be interesting and instructive to devote some space to a brief discussion of the growth requirements of cattle and sheep for phosphorus and protein in the light of the available information on the subject and with reference to the amounts of the said constituents present in South African natural pastures as shown in the present report.

In order to assess the value of these pastures as sources of phosphorus and protein for the growing animal it is necessary to know, apart from the chemical data here presented, the requirement

of the animal for the nutrients, the amount of dry matter it will consume under grazing conditions, and the extent to which the animal organism is able to utilize the ingested nutrients.

It is not necessary to review the literature bearing on the subject of the mineral requirements of animals as this has been ably accomplished in a recent bulletin by Mitchell and McClure (1937). In connection with the calcium and phosphorus requirements of cattle as given in the literature the authors remark that " the results summarised (above) are peculiarly incomplete and contradictory ". For instance, the phosphorus requirement for growth as a percentage of the ration fed ranges from 0·1 to 0·26 per cent. in the said summary of data from the literature. In the publication referred to Mitchell and McClure estimated the daily feed phosphorus requirement of growing Holstein-Friesian cattle (female) at about 10 grams phosphorus and that for growing beef steers at about 12 grams feed phosphorus per day, 70 per cent. of which represents the net phosphorus requirement of these animals. From their experiments at this Institute Theiler *et al* (1937) concluded that 10 grams feed phosphorus daily are adequate for normal growth and development in the case of high-grade Friesland heifers and steers. The figure for the daily phosphorus intake of Merino sheep, viz. 1·53 grams, on which the animals made excellent gains in weight in the experiments of du Toit and co-workers (1930, 1932) is essentially the same as that (1·46 grams) estimated by Mitchell and McClure (*loc. cit.*) as the feed phosphorus requirements of growing Shropshire sheep. Du Toit and collaborators could not register an improvement in the performance of the sheep by increasing the daily phosphorus intake to 2·92 grams and they consequently concluded that " it is practically certain that a daily intake of about 1·53 grams phosphorus is nearer the optimum amount of phosphorus for growing sheep than an intake of 2·92 grams per day ".

According to the data developed in a Report by Mitchell (1929) on the minimum protein requirements of cattle the daily requirement of digestible protein by growing Hereford-Shorthorn calves is estimated to decrease from 0·67 lb. (304 grams) for an animal of 200 lb. live-weight to 0·56 lb. (254 grams) for one weighing 800 lb., or 604 and 508 grams feed crude protein, if the digestibility is taken at 50 per cent. for the two live-weights, respectively. Smuts and Marais (1938) studied the endogenous nitrogen metabolism of the Merino sheep and from their data they calculated the maintenance requirement for protein. In terms of digestible protein the maintenance requirement for a 100-lb. sheep according to these workers is 23·0 grams which expressed as feed protein, assuming a digestion coefficient of 60 per cent., become 38·3 grams. For normal growth the animal will naturelly require an additional amount of protein. Unfortunately no experiments have up to now been conducted in this country with the object of determining the optimum protein requirement for growth of the Merino sheep. In the experiments of du Toit and co-workers already referred to and which aimed at an estimation of the phosphorus requirements of growing sheep the daily feed protein intake of the animals was approximately 68 grams. Since those animals in the experiment whose daily phosphorus intake was 1·53 grams were reported to have made satisfactory gains in weight

and to have been in excellent condition at the conclusion of the experiment it seems warranted to utilise the protein intake of these animals as a basis for assessing the capacity of South African pastures to fulfil the protein requirement for growth of the Merino sheep. Compared with, for instance, the figure of $1\frac{3}{4}$ lb. of digestible protein per week as the requirement for growth and fattening given by Wood and Woodman (1932) the figure of 68 grams feed crude protein per day must be looked upon as a gross underestimation of the protein requirement for normal growth. However, as will become evident presently, any figure for the growth requirement which is higher than the maintenance requirement will suffice to illustrate the shortcomings of South African natural pastures during certain seasons of the year.

Very little information is available on the amount of dry matter different classes of stock will consume while grazing on the open veld. Garrigus (1934) reported figures for the dry matter consumption of grazing steers ranging from 10·2 to 25·8 lb. with an average of 16 lb. per day. Smuts (1939) applied the same method as that employed by Garrigus to grazing sheep and found an average daily dry matter consumption of 660 grams for a sheep weighing between 60 and 70 lb. In view of this finding and in the light of the figures given in the literature (see Mitchell and McClure *[loc. cit]*) for the dry matter requirement of growing sheep it seems safe to assume that a 100-lb. sheep will consume 900-1,000 grams of dry matter under grazing conditions.

The following estimations, then, of the daily requirements of growing sheep and cattle for phosphorus and crude protein in terms of feed phosphorus and feed crude protein and the amount of dry matter they will consume under grazing conditions will be used as criteria for judging the feeding value of South African pastures during different seasons of the year:—

Species.	Live-weight.	Crude Protein.	Phosphorus.	Dry Matter Consumption.
	lb.	Grams.	Grams.	Grams.
Cattle.....	800	500	10·0	7,300
Sheep.....	100	70	1·5	900

Employing the figures given above for the dry matter consumption of grazing cattle and sheep and those describing the average phosphorus and crude protein contents of the natural pastures in Areas 1 to 18 presented in Tables 2 and 3 figures showing the estimated intakes of feed phosphorus and feed crude protein of cattle and sheep on natural veld, for months and areas separately, have been calculated. The data thus obtained are given in Tables 4 and 5 for cattle and in Tables 6 and 7 for sheep.

TABLE 4.

Estimated Phosphorus Intake of Cattle on Natural Veld in Grams per day.

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Type of Veld.
1	8·6	7·7	7·7	7·7	5·8	4·7	3·9	4·5	5·0	6·0	9·7	9·0	Grass.
2	10·7	9·0	8·6	8·8	7·6	7·7	8·1	6·1	7·5	9·9	9·0	10·1	Grass.
3	9·6	8·8	8·0	6·9	5·8	5·1	4·8	4·5	5·8	6·9	9·8	9·6	Grass.
4	6·9	6·7	7·0	7·0	6·6	5·7	6·1	5·0	6·1	7·5	8·4	9·3	Grass.
5	9·9	10·0	8·5	9·9	9·1	8·2	8·2	7·6	7·0	9·5	10·2	11·5	Mainly grass.
6	12·6	11·5	10·1	9·1	8·3	7·7	6·0	6·1	7·4	9·4	10·0	15·5	Grass.
7	9·2	8·7	6·9	7·0	4·7	4·7	4·0	4·2	5·0	5·5	10·1	10·1	Grass.
8	9·3	8·2	7·4	7·4	5·8	5·5	4·7	4·4	4·6	5·5	6·8	9·3	Grass.
9	9·6	9·3	7·7	8·0	5·3	5·5	5·0	4·5	3·3	7·4	9·1	9·2	Mainly grass.
10	11·8	11·5	10·5	9·2	9·2	8·9	8·1	7·7	5·8	6·8	13·8	13·4	Mainly grass.
11	11·7	9·3	9·1	7·0	6·4	6·2	4·8	4·8	4·5	5·7	9·7	13·3	Grass.
12	9·6	11·2	9·0	8·8	6·4	5·2	6·9	3·9	4·3	6·3	6·5	8·8	Mainly grass.
13	15·8	13·6	12·0	13·5	11·5	10·2	12·8	10·1	7·7	9·2	13·1	14·2	Grass and bush.
14	15·9	13·7	13·4	15·0	12·5	11·0	11·9	12·2	10·9	12·9	13·1	13·7	Grass and bush.
15	12·2	10·7	11·5	12·0	10·4	10·9	13·1	11·4	12·3	10·7	9·6	12·8	Mainly bush.
16	10·4	10·2	11·8	10·6	11·5	9·9	11·5	13·1	10·8	10·2	11·3	10·1	Mainly bush.
17	6·3	7·7	6·7	7·1	9·5	10·2	9·9	10·9	11·1	11·2	7·3	7·9	Bush.
18	8·5	8·2	7·9	8·1	9·7	8·8	9·3	10·7	10·4	8·5	6·1	8·8	Grass and bush.

TABLE 5.

Estimated Crude Protein Intake of Cattle on Natural Veld in Grams Per Day.

Area.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	540	467	445	445	321	278	248	255	365	402	657	582
2	577	475	475	467	387	402	453	321	467	540	591	591
3	555	482	445	409	321	292	248	241	431	438	657	620
4	518	453	423	431	394	351	343	329	460	467	598	620
5	570	548	460	533	482	431	402	416	467	511	598	672
6	657	504	467	438	358	321	285	307	416	548	613	780
7	555	497	416	380	292	278	241	241	329	372	657	620
8	562	511	475	423	314	300	270	248	329	365	475	613
9	518	533	533	409	372	358	321	263	314	460	628	606
10	584	598	533	504	445	409	358	314	336	380	760	760
11	730	638	518	445	351	343	372	292	329	380	738	818
12	620	664	562	584	496	460	467	365	438	423	570	672
13	860	613	533	570	664	416	540	518	387	496	766	715
14	686	642	642	686	598	582	642	570	620	642	722	722
15	680	504	680	650	526	708	715	664	737	547	606	688
16	657	540	628	650	664	678	693	664	657	562	752	672
17	467	438	438	518	672	737	693	700	664	570	570	547
18	504	475	570	555	606	591	598	613	642	526	504	650

TABLE 6.

Estimated Phosphorus Intake of Sheep on Natural Veld in Grams Per Day.

Area.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	1·06	·95	·95	·95	·71	·59	·48	·56	·62	·74	1·20	1·11
2	1·32	1·11	1·06	1·08	·94	·95	1·00	·76	·93	1·22	1·11	1·24
3	1·19	1·09	1·00	·85	·72	·63	·59	·56	·71	·85	1·21	1·18
4	·86	·83	·86	·86	·81	·70	·75	·62	·76	·93	1·04	1·15
5	1·22	1·23	1·05	1·22	1·12	1·02	1·02	·94	·87	1·17	1·26	1·42
6	1·56	1·42	1·24	1·13	1·02	·95	·74	·76	·91	1·16	1·23	1·91
7	1·13	1·07	·86	·86	·59	·59	·50	·52	·61	·68	1·24	1·24
8	1·14	1·01	·91	·92	·71	·68	·58	·54	·57	·68	·84	1·14
9	1·19	1·15	·95	·98	·65	·68	·62	·55	·41	·91	1·12	1·13
10	1·45	1·41	1·30	1·13	1·13	1·10	1·00	·95	·72	·84	1·70	1·65
11	1·44	1·15	1·12	·86	·79	·77	·59	·59	·55	·70	1·20	1·64
12	1·18	1·38	1·11	1·08	·79	·64	·86	·48	·53	·77	·80	1·08
13	1·94	1·67	1·48	1·67	1·41	1·26	1·58	1·24	·95	1·13	1·62	1·76
14	1·96	1·69	1·65	1·85	1·54	1·36	1·47	1·50	1·35	1·59	1·62	1·68
15	1·50	1·32	1·42	1·48	1·28	1·35	1·61	1·40	1·51	1·31	1·19	1·58
16	1·29	1·26	1·46	1·31	1·42	1·22	1·42	1·62	1·33	1·26	1·40	1·25
17	·78	·95	·83	·88	1·17	1·26	1·22	1·34	1·37	1·38	·90	·97
18	1·05	1·01	·97	1·00	1·20	1·09	1·14	1·32	1·28	1·04	·76	1·08

TABLE 7.

Estimated Crude Protein Intake of Sheep on Natural Veld in Grams Per Day.

Area.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	67	58	55	55	40	34	31	32	45	50	81	72
2	71	59	59	58	48	50	56	40	58	67	73	73
3	68	59	55	50	40	36	31	30	53	54	81	77
4	64	56	52	53	49	43	42	41	57	58	74	77
5	70	68	57	66	59	53	50	51	58	63	74	83
6	81	62	58	54	44	40	35	38	51	68	76	96
7	68	61	51	47	36	34	30	30	41	46	81	77
8	69	63	59	52	39	37	33	31	41	45	59	76
9	64	66	66	50	46	44	40	32	39	57	77	75
10	72	74	66	62	55	50	44	39	41	47	94	94
11	90	77	64	55	43	42	46	36	41	47	91	100
12	77	82	69	72	61	57	58	45	54	52	70	83
13	106	76	66	70	82	51	67	64	48	61	95	88
14	85	79	79	85	74	72	79	70	77	79	89	89
15	84	62	84	80	65	87	88	82	91	68	75	97
16	81	67	77	80	82	84	86	82	81	69	93	83
17	58	54	54	64	83	91	86	86	82	70	70	68
18	62	59	70	68	75	73	74	76	79	65	62	80

Since the phosphorus and protein contents of the pastures in the respective areas and in the course of the year have already been discussed it remains only to focus attention on a few outstanding features in connection with the figures giving the estimated intakes of animals on these pastures with reference to their requirements for growth.

A study of the relevant data in Tables 4 and 6 reveals that during the whole year both cattle and sheep seldom ingest sufficient phosphorus for maximum growth on the pastures of Areas 1, 3, 4, 7, 8, 9, 11 and 12. During the summer months when the veld is usually green and succulent the deficiency on the required intake, especially in the case of cattle, is, however, small and may for this reason and in view of the approximate nature of the figure (10 grams phosphorus) representing the requirement for growth be considered as negligible. On the other hand during winter when the veld is dry and brown the intake sometimes falls to as low as only 40 per cent, of the requirement for growth, a deficiency which cannot exist without serious consequences to the well-being and production of the animals. This sub-optimum intake of phosphorus appears to be more serious with sheep than with cattle in the areas mentioned. It should, however, be mentioned that the majority of samples from these areas were collected by following cattle, and since sheep can be expected to graze more selectively than cattle are able to do the phosphorus content of the samples may probably have been somewhat higher had sheep been followed with their collection.

Passing on to the set of areas, viz. Nos. 2, 5, 6, 10, 17 and 18, classified earlier in this discussion as " medium " with regard to the phosphorus and protein contents of their pastures a definite improvement in the phosphorus nutrition of cattle and sheep on these pastures is indicated as judged by the estimated intakes. Not only are the pastures able to provide the optimum requirement for growing cattle for about five months of the year but also during the dry season which corresponds with winter in most areas the intake is not as low as indicated for the first mentioned series of areas.

A glance at the figures giving the estimated intakes of phosphorus on the pastures of areas, Nos. 13, 14, 15 and 16 shows that an intake below the optimum requirement for growing cattle and sheep occurs but seldom in the course of the year. Provided sufficient food is available on the veld the chances of animals suffering from a phosphorus deficiency on these pastures seem to be remote.

In general, the remarks made in connection with the phosphorus nutrition of cattle and sheep on the pastures of Areas 1 to 18 apply equally well to the intake of crude protein on these pastures. Except for Areas 13 to 18 where the estimated intake of crude protein falls at the outside during three months of the year below the estimated requirement for growth the crude protein content of the natural pastures of the Union are for periods ranging from five to nine months of the year, depending on the locality, so low that growth is either seriously retarded or temporarily stopped. In fact, if the feed crude protein maintenance requirement of sheep is taken to be 46·0 grams [Smuts (*loc. cit.*) gave this requirement as 23·0 grams digestible

crude protein) an inspection of Table 7 reveals that on some of the grassland pastures the intake of this nutrient may be for several months during winter below the requirement for maintenance.

The phosphorus and protein contents of the natural pastures of South Africa during summer and winter, respectively, have recently been presented as coloured charts in popular fashion in an article in *Farming in South Africa* (June, 1940). These charts are included in the appendix of this report as they present at a glance the outstanding features in the above discussion.

Average values for summer and winter have been calculated and presented in separate charts; "summer" denotes the period November to April—being the period of greatest food abundance—and "winter" extends from May to October, or the period of food scarcity, generally speaking. The key to the coloured charts is given in the following table:—

Colour.	Percentage Phosphorus (P) in Pasture.	Percentage Protein in Pasture.	Remarks.
Red	Less than 0·09	Less than 4·5	Below requirements for growth.
Light Red	0·09 to 0·11	4·5—5·0	
Yellow	0·11 to 0·14	5·0—7·0	Limited growth.
Pale blue	0·14 to 0·18	7·0—9·0	Sufficient for normal growth.
Dark blue	More than 0·18	More than 9·0	

It should again be emphasized that in judging the economic value of the pastures in the respective areas as delimitated in this report the question of the available feed supply should not be lost sight of. For instance, the estimated intake of crude protein on the pastures of the North-western Cape (Areas 17 and 18), a region with an average rainfall of only 5 inches per annum, seldom is below the estimated requirements for growth, but, on the other hand, it is a matter of common experience in this region that animals die at times from sheer starvation; the amount of food available becomes the limiting factor.

To conclude these remarks on the phosphorus and protein contents of our natural pastures in relation to the needs for growth of animals reference may be made to the fact that the requirements for growth only of a 800 lb. bovine and a 100 lb. sheep have been chosen as the basis for assessing the feeding value of the pastures. Younger animals may be expected to consume less dry matter than the amounts taken to be the capacity of the above-mentioned animals, so that, assuming the growth requirements to be the same, it will mean that the percentages of phosphorus and crude protein in their diet should be higher than in that of older animals; a circumstance which will result in the shortening or the total absence of a period of optimum growth in the case of younger stock on our natural pastures. Similar remarks are valid in the case of pregnant or lactating animals in

that amounts of phosphorus and crude protein superimposed in many cases on the requirements for growth have to be allowed for in the ration. In any case, from what has been said it is clear that most of the natural pastures of this country should be either improved or supplemented during the greater part of the year to ensure continuous production by animals.

(3) Calcium and Magnesium.

Unlike phosphorus and protein the averages for calcium and magnesium given in Tables 8 and 9 fluctuate only slightly from month to month. They show, however, no definite tendency and remain in general fairly constant throughout the year. As in the case of phosphorus and protein the major difference with reference to the calcium and magnesium contents of the pastures of the Union is encountered as one passes from the all-grass to the mixed and all-bush pastures, the latter veld type being invariably richer in both calcium and magnesium than the first mentioned type. This circumstance is consequently held responsible for greater month to month fluctuations in the percentages of calcium and magnesium in areas where the samples were composed of varying amounts of bushes and grasses.

The calcium figures for the grassland Areas 1 to 8 fluctuate around 0·30 per cent. and the magnesium values around 0·14 per cent., except for Area 5, with a fair admixture of bushes in the samples analysed which shows better values for calcium than any of the areas mentioned, values fluctuating between 0·34 and 0·40 per cent. from January to December, and Area 4 in which the monthly averages for calcium vary between only 0·22 and 0·31 per cent. with an annual average of about 0·25 per cent. Compared with data from the British Isles, these figures for Ca are definitely low. In fact they may be compared with the figures obtained for " not eaten " herbage of the Scottish hill pastures (Godden, 1926) a statement which should, however, not be taken to imply that these South African pastures are deficient in calcium.

Areas 9, 10 and 11 situated in the Parkland region of the Transvaal show higher figures for the two constituents under discussion in comparison with the typical grasslands of Natal and the Orange Free State. Average monthly values fluctuate on a higher plane and the annual averages for calcium in the case of the three areas are 0·42, 0·48 and 0·40 per cent., respectively. Magnesium values, also, are higher, being around 0·18, 0·21 and 0·19 on an average for the three areas.

The pastures of the remaining seven Areas 12 to 18 comprising the Desert Shrub region of the country may be considered to be rich in calcium and magnesium, the figures being comparable to those for cultivated pastures overseas. Corresponding on the whole with an increasing number of samples composed of bushes only (see tables in appendix) in the total number analysed the calcium and magnesium figures rise steadily from Area 12 to Area 18. There are, of course, fluctuations in the average monthly values in each area but

TABLE 8.

Mean Calcium (Ca) content of Pastures. (Range values included.)

Area.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	
1	**·29**	**·28**	**·29**	**·30**	**·32**	**·30**	**·29**	**·27**	**·32**	**·26**	**·28**	**·28**	**Mean.**
	·16– ·62	·18– ·44	·19– ·53	·18– ·43	·16– ·63	·13– ·54	·18– ·53	·17– ·41	·18– ·57	·12– ·48	·16– ·74	·18– ·60	Range.
2	**·29**	**·27**	**·32**	**·30**	**·29**	**·32**	**·35**	**·26**	**·31**	**·29**	**·27**	**·31**	**Mean.**
	·13– ·78	·13– ·95	·12– ·81	·11– ·80	·14– ·55	·15– ·73	·15–1·04	·14– ·59	·12– ·75	·13– ·86	·14– ·62	·14– ·97	Range.
3	**·27**	**·29**	**·28**	**·30**	**·31**	**·29**	**·29**	**·30**	**·26**	**·25**	**·29**	**·28**	**Mean.**
	·16– ·44	·16– ·53	·15– ·45	·18– ·49	·18– ·58	·13– ·51	·16– ·54	·18– ·46	·15– ·42	·16– ·42	·18– ·66	·15– ·65	Range.
4	**·23**	**·24**	**·25**	**·26**	**·31**	**·27**	**·26**	**·24**	**·22**	**·23**	**·23**	**·24**	**Mean.**
	·18– ·29	·14– ·35	·12– ·45	·18– ·33	·14– ·57	·18– ·45	·15– ·73	·16– ·37	·13– ·34	·16– ·36	·16– ·31	·17– ·33	Range.
5	**·35**	**·39**	**·34**	**·39**	**·37**	**·37**	**·36**	**·40**	**·37**	**·38**	**·37**	**·35**	**Mean.**
	·18– ·71	·16–1·12	·19–1·19	·21– ·85	·18– ·82	·16– ·93	·19– ·70	·21–1·22	·19–1·09	·17– ·93	·17– ·79	·18– ·79	Range.
6	**·30**	**·30**	**·34**	**·34**	**·35**	**·31**	**·32**	**·31**	**·31**	**·32**	**·30**	**·36**	**Mean.**
	·17– ·55	·17– ·80	·23– ·88	·18– ·56	·21– ·64	·23– ·68	·19– ·61	·17– ·65	·14– ·53	·18– ·94	·17– ·48	·18–1·22	Range.
7	**·29**	**·30**	**·33**	**·33**	**·31**	**·30**	**·31**	**·29**	**·32**	**·28**	**·27**	**·31**	**Mean.**
	·17– ·46	·15– ·72	·17– ·72	·16– ·59	·16– ·92	·14– ·51	·16– ·54	·20– ·40	·11– ·58	·11– ·48	·10– ·70	·16– ·59	Range.
8	**·29**	**·28**	**·32**	**·32**	**·34**	**·34**	**·34**	**·32**	**·32**	**·32**	**·27**	**·31**	**Mean.**
	·17– ·53	·19– ·54	·17– ·53	·21– ·47	·16– ·57	·18– ·62	·16– ·51	·16– ·63	·19– ·54	·13– ·56	·15– ·49	·16– ·56	Range.
9	**·32**	**·37**	**·56**	**·37**	**·41**	**·59**	**·40**	**·33**	**·53**	**·34**	**·35**	**·45**	**Mean.**
	·14– ·70	·16–1·39	·14–1·76	·18–1·19	·18–1·34	·12–2·59	·18–1·77	·17– ·65	·11–3·57	·14– ·91	·15–1·00	·18–1·78	Range.
10	**·40**	**·44**	**·49**	**·50**	**·46**	**·49**	**·50**	**·54**	**·43**	**·43**	**·54**	**·49**	**Mean.**
	·21–1·08	·20–1·59	·18–1·05	·20–1·82	·21–1·55	·15–1·02	·11–1·44	·20–1·86	·14–1·20	·13–1·20	·16–1·41	·16–1·29	Range.
11	**·40**	**·36**	**·37**	**·37**	**·37**	**·38**	**·40**	**·42**	**·42**	**·37**	**·48**	**·48**	**Mean.**
	·22– ·69	·22– ·93	·17– ·94	·17–1·30	·22– ·89	·15–1·38	·20–1·16	·20–2·04	·17–1·73	·14– ·91	·20–2·08	·21–1·34	Range.
12	**·49**	**·61**	**·61**	**·70**	**·69**	**·62**	**·74**	**·56**	**·49**	**·52**	**·56**	**·62**	**Mean.**
	·17–1·22	·28–1·34	·25–1·95	·28–1·60	·29–1·09	·21–1·54	·16–2·35	·18–1·68	·21– ·92	·23–1·43	·14–1·07	·12–1·64	Range.
13	**·64**	**·46**	**·41**	**·66**	**·84**	**·56**	**·75**	**·70**	**·49**	**·53**	**·60**	**·38**	**Mean.**
	·21–1·79	·32– ·71	·20– ·73	·23–1·04	·22–1·63	·19– ·98	·39–1·34	·26–1·21	·25– ·96	·21–1·11	·28–1·01	·20– ·70	Range.
14	**·45**	**·47**	**·67**	**·79**	**·68**	**·75**	**·72**	**·56**	**·72**	**·71**	**·61**	**·48**	**Mean.**
	·24– ·72	·22– ·90	·29–1·48	·22–1·47	·33–1·28	·31–1·19	·40–1·33	·26– ·84	·36–1·52	·26–1·65	·35–1·04	·29– ·89	Range.
15	**·75**	**·85**	**·81**	**·91**	**·78**	**·85**	**·89**	**·99**	**·90**	**·89**	**·81**	**·86**	**Mean.**
	·34–1·09	·30–1·85	·24–1·36	·47–1·65	·37–1·49	·28–1·36	·46–1·55	·63–1·68	·21–1·80	·42–1·43	·28–1·68	·20–1·15	Range.
16	**·91**	**·78**	**·86**	**·92**	**·95**	**·94**	**·92**	**1·05**	**1·06**	**·89**	**·89**	**·81**	**Mean.**
	·26–1·61	·39–1·36	·39–2·05	·44–2·10	·35–2·01	·28–1·53	·37–1·35	·65–1·55	·38–1·68	·37–1·52	·39–1·54	·24–1·28	Range.
17	**1·03**	**·66**	**·79**	**1·04**	**1·04**	**1·01**	**1·13**	**1·25**	**1·09**	**1·13**	**1·02**	**·82**	**Mean.**
	·37–2·95	·25–1·08	·13–1·60	·34–2·11	·52–2·43	·56–1·59	·88–1·48	·76–1·99	·41–1·83	·77–1·59	·33–1·85	·36–1·15	Range.
18	**·86**	**1·12**	**1·26**	**1·07**	**·93**	**·94**	**1·10**	**1·14**	**1·11**	**1·06**	**1·09**	**·98**	**Mean.**
	·35–2·03	·62–1·79	·29–2·41	·38–2·48	·31–1·52	·33–1·23	·59–1·84	·43–1·80	·52–2·14	·40–1·82	·38–2·19	·30–2·58	Range.

TABLE 9.

Mean Magnesium (Mg) content of Pastures. (Range values included.)

Area.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	
1	**·16**	**·14**	**·15**	**·15**	**·15**	**·13**	**·13**	**·13**	**·11**	**·11**	**·14**	**·14**	**Mean.**
	·08– ·28	·04– ·29	·06– ·37	·07– ·29	·06– ·27	·06– ·40	·06– ·40	·06– ·37	·04– ·20	·03– ·33	·05 - ·39	·08– ·21	Range.
2	**·18**	**·15**	**·15**	**·16**	**·16**	**·17**	**·17**	**·13**	**·15**	**·16**	**·15**	**·16**	**Mean.**
	·07– ·50	·07– ·44	·05– ·47	·06– ·35	·06– ·34	·04– ·48	·06– ·39	·05– ·48	·03– ·37	·03– ·33	·05– ·44	·05– ·32	Range.
3	**·14**	**·15**	**·13**	**·13**	**·13**	**·12**	**·12**	**·12**	**·10**	**·11**	**·14**	**·13**	**Mean.**
	·06– ·29	·08– ·27	·05– ·20	·08– ·22	·07– ·30	·06– ·28	·05– ·27	·06– ·23	·04– ·25	·04– ·25	·08– ·25	·05– ·24	Range.
4	**·15**	**·14**	**·14**	**·14**	**·17**	**·14**	**·13**	**·12**	**·12**	**·13**	**·13**	**·14**	**Mean.**
	·08– ·21	·08– ·21	·07– ·23	·06– ·32	·05– ·33	·06– ·27	·04– ·21	·04– ·23	·06– ·24	·09– ·17	·08– ·17	·08– ·20	Range.
5	**·16**	**·15**	**·12**	**·16**	**·15**	**·13**	**·12**	**·14**	**·13**	**·15**	**·14**	**·15**	**Mean.**
	·05– ·38	·06– ·39	·06– ·26	·08– ·36	·07– ·37	·06– ·45	·06– ·23	·08– ·40	·05– ·46	·05– ·39	·06– ·32	·06– ·30	Range.
6	**·14**	**·12**	**·13**	**·12**	**·12**	**·09**	**·11**	**·12**	**·09**	**·11**	**·13**	**·16**	**Mean.**
	·07– ·24	·04– ·27	·07– ·31	·05– ·24	·05– ·24	·05– ·20	·07– ·19	·07– ·24	·03– ·17	·04– ·26	·07– ·20	·07– ·42	Range.
7	**·17**	**·17**	**·15**	**·17**	**·15**	**·13**	**·11**	**·13**	**·12**	**·11**	**·14**	**·17**	**Mean.**
	·11– ·32	·06– ·44	·08– ·38	·09– ·51	·07– ·37	·04– ·25	·06– ·18	·07– ·21	·04– ·21	·03– ·23	·06–·22	·09– ·54	Range.
8	**·13**	**·14**	**·13**	**·12**	**·13**	**·12**	**·11**	**·12**	**·11**	**·10**	**·11**	**·14**	**Mean.**
	·07– ·25	·06– ·27	·04– ·28	·06– ·21	·06– ·21	·07– ·28	·06– ·18	·07– ·17	·06– ·20	·03– ·19	·06– ·18	·08– ·28	Range.
9	**·18**	**·19**	**·24**	**·18**	**·20**	**·21**	**·16**	**·15**	**·16**	**·15**	**·18**	**·21**	**Mean.**
	·09– ·30	·07– ·62	·09– ·65	·08– ·39	·07– ·52	·06– ·65	·05– ·40	·08– ·32	·05– ·66	·05–·35	·08– ·54	·07– ·55	Range.
10	**·22**	**·22**	**·25**	**·22**	**·22**	**·21**	**·19**	**·20**	**·19**	**·17**	**·21**	**·24**	**Mean.**
	·06– ·49	·12– ·40	·07– ·54	·10– ·60	·06– ·51	·06– ·39	·08– ·39	·07– ·44	·07– ·42	·06– ·48	·06– 40	·09– ·44	Range.
11	**·23**	**·21**	**·18**	**·18**	**·17**	**·16**	**·18**	**·17**	**·16**	**·17**	**·22**	**·26**	**Mean.**
	·12– ·50	·11– ·55	·06– ·49	·10– ·54	·09– ·40	·09– ·43	·07– ·64	·07– ·60	·15– ·40	·06– ·58	·08–1·05	·11– ·57	Range.
12	**·19**	**·28**	**·23**	**·24**	**·24**	**·20**	**·23**	**·14**	**·16**	**·15**	**·21**	**·29**	**Mean.**
	·05– ·50	·10– ·69	·06– ·70	·06– ·46	·04– ·47	·06– ·58	·06– ·68	·05– ·27	·04– ·35	·06– ·40	·03– ·54	·02– ·76	Range.
13	**·37**	**·22**	**·23**	**·25**	**·35**	**·21**	**·30**	**·27**	**·16**	**·19**	**·25**	**·18**	**Mean.**
	·11–1·05	·05– ·48	·07– ·45	·09– ·51	·07– ·95	·07– ·44	·12– ·59	·10– ·57	·07– ·34	·06– ·40	·07– ·40	·09– ·31	Range.
14	**·21**	**·23**	**·30**	**·32**	**·27**	**·28**	**·26**	**·25**	**·28**	**·33**	**·24**	**·20**	**Mean.**
	·10– ·31	·07– ·59	·11– ·92	·13– ·74	·10– ·58	·11– ·48	·10– ·67	·14– ·50	10·– ·69	·14– ·99	·12– ·45	·10– ·28	Range.
15	**·41**	**·19**	**·36**	**·37**	**·26**	**·34**	**·33**	**·34**	**·38**	**·29**	**·27**	**·33**	**Mean.**
	·10– ·95	·09– ·30	·07– ·56	·18– ·60	·10– ·51	·08– ·76	·14– ·73	·17– ·68	·04– ·75	·10– ·58	·08– ·55	·11– ·56	Range.
16	**·34**	**·27**	**·26**	**·34**	**·31**	**·31**	**·35**	**·34**	**·31**	**·35**	**·30**	**·26**	**Mean.**
	·12– ·54	·10– ·69	·09 ·56	·15– ·84	·12– ·51	·10– ·61	·13– ·70	·21– ·68	·17– ·63	·12– ·60	·14– ·40	·08– ·51	Range.
17	**·35**	**·19**	**·23**	**·43**	**·31**	**·44**	**·36**	**·48**	**·47**	**·46**	**·36**	**·32**	**Mean.**
	·14– ·60	·06– ·29	·07– ·48	·16– ·73	·14– ·65	·26– ·73	·22– ·56	·25– ·74	·15– ·73	·27– ·60	·18– ·65	·13– ·48	Range.
18	**·26**	**·29**	**·33**	**·30**	**·26**	**·38**	**·32**	**·34**	**·34**	**·34**	**·32**	**·28**	**Mean.**
	·05– ·40	·13– ·45	·12– ·54	·06– ·71	·08– ·60	·13– ·70	1·0– ·57	·08– ·68	·16– ·48	·14– ·56	·14– ·67	·08– ·55	Range.

as these appear to show no definite tendency the annual average, i.e. the mean of the twelve monthly averages is taken as the criterion. The calcium figures calculated in this manner are 0·60, 0·59, 0·63, 0·86, 0·92, 1·00 and 1·05 for Areas 12, 13, 14, 15, 16, 17 and 18, respectively, while the magnesium values are 0·21, 0·25, 0·26, 0·32, 0·31, 0·37 and 0·31 in corresponding order. The calcium content of the Desert Succulent and Desert Grass pastures of Namaqualand (Area 18) in the west is thus seen to be about four times more than that of the Tall Grass pastures around Port Shepstone in the southern part of Natal on the East Coast of South Africa.

Mitchell and McClure (*loc. cit*) estimated the feed calcium requirement for growth of a Holstein-Friesian heifer weighing 800 lb. at 7·1 grams and that of a growing beef steer of the same weight at 10·4 grams. Pasture containing a minimum of 0·14 per cent. calcium on the basis of the dry matter is, therefore, necessitated by the calcium requirement for growth of a 800 lb. beef steer consuming 16 lb. dry matter per day. The necessary percentage of calcium in the feed would again be higher in the case of younger animals since on the one hand the daily feed calcium requirement itself is higher and, on the other hand, younger stock may be expected to consume less dry matter. The feed calcium requirement of a pregnant Holstein-Fresian cow weighing 1,000 lb. is given by the same authors in terms of the average for the whole gestation period as 11·8 grams per day. Also, a lactating animal of the same weight producing 2 gallons of milk per day will require 19·6 grams feed calcium including its maintenance requirement. To ingest the necessary amount of calcium the latter animal will, therefore, have to consume 16 lb. of a ration containing 0·27 per cent. calcium. Finally, the necessary calcium content of the dry ration for growing Shropshire sheep is estimated to vary between 0·11 and 0·17 per cent., depending on the age and sex of the animal. A comparison of the estimated requirements given above in terms of percentages of the dry ration with the average calcium values for South African pastures presented in Table 8 indicates that cattle or sheep grazing on these pastures are not likely to suffer from a calcium deficiency as such if milk production remains moderate. A cow producing more milk than the amount (2 gallons) stated will naturally require more calcium in its diet. The calcium content of some pastures (e.g. Area 4) may be considered inadequate to fulfil the higher demand for calcium, but, on the other hand, since the production of milk will in any case be seriously curtailed by a deficiency of nutrients such as phosphorus and protein in most pastures calcium cannot in the first place be considered a limiting factor in milk production on South African natural pastures.

According to du Toit and associates (1934) it is doubtful whether a deficiency of magnesium will ever occur in the diet of animals on pasture. These authors were able to lower the magnesium content of their basal ration to 0·11 per cent., but the amount of magnesium ingested with this ration was at least five times the amount of magnesium secreted in two gallons of milk. Reference to Table 9 shows that the magnesium content of South African pastures rarely falls below 0·10 per cent.

TABLE 10.

Mean Potassium (K) Content of Pastures. (Range Values included.)

Area.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	
1	**1·40**	**1·28**	**1·15**	**1·07**	**·74**	**·58**	**·39**	**·41**	**·52**	**·72**	**1·30**	**1·37**	**Mean.**
	·79–4·02	·40–2·07	·47–4·34	·41–4·27	·27–1·65	·20–1·73	·10–1·44	·09–1·34	·13–1·62	·17–2·05	·40–2·47	·74–2·42	Rang.
2	**1·64**	**1·25**	**1·10**	**1·07**	**·88**	**·80**	**·78**	**·53**	**·75**	**1·07**	**1·21**	**1·45**	**Mean.**
	·53–3·75	·58–2·63	·29–2·40	·32–2·75	·31–2·36	·17–2·10	·14–2·45	·10–1·63	·03–2·22	·17–3·37	·36–3·33	·33–3·51	Range.
3	**1·34**	**1·19**	**·90**	**·82**	**·62**	**·53**	**·34**	**·29**	**·57**	**·62**	**1·22**	**1·34**	**Mean.**
	·52–2·66	·38–2·05	·46–1·71	·39–1·53	·23–1·07	·19–1·74	·16– ·95	·15– ·86	·12–1·96	·07–1·72	·34–2·00	·70–2·11	Range.
4	**1·03**	**·97**	**·78**	**·84**	**·65**	**·57**	**·52**	**·50**	**·64**	**·81**	**·99**	**1·32**	**Mean.**
	·33–1·63	·34–1·92	·46–1·37	·29–2·39	·35–1·22	·19–1·32	·18–2·59	·12–1·53	·21–2·12	·26–2·50	·36–2·04	·73–1·88	Range.
5	**1·33**	**1·36**	**1·00**	**1·16**	**1·04**	**·80**	**·69**	**·62**	**·79**	**·98**	**1·32**	**1·56**	**Mean.**
	·35–2·29	·39–2·60	·24–2·05	·33–2·90	·38–2·53	·28–2·17	·24–2·56	·14–1·38	·13–2·28	·13–3·56	·33–3·05	·59–3·54	Range.
6	**1·75**	**1·32**	**1·17**	**·92**	**·70**	**·58**	**·41**	**·43**	**·59**	**·86**	**1·17**	**1·84**	**Mean.**
	·80–4·22	·60–2·84	·73–2·39	·34–2·35	·30–1·46	·18–1·29	·11– ·98	·09–1·08	·14–1·96	·14–1·71	·29–2·15	1·05–4·04	Range.
7	**1·49**	**1·40**	**1·00**	**·95**	**·67**	**·49**	**·38**	**·31**	**·46**	**·55**	**1·37**	**1·61**	**Mean.**
	·87–2·59	·71–2·76	·57–1·78	·31–2·82	·11–1·65	·10–1·39	·13– ·80	·09– ·75	·06–1·98	·12–1·53	·55–2·35	·72–2·29	Range.
8	**1·55**	**1·39**	**1·15**	**·93**	**·66**	**·52**	**·37**	**·30**	**·44**	**·54**	**·92**	**1·56**	**Mean.**
	·60–2·76	·66–2·40	·43–2·63	·36–1·49	·28–1·35	·20–1·17	·18– ·79	·13– ·70	·09–1·69	09·–1·51	·20–1·90	·84–2·36	Range.
9	**1·55**	**1·42**	**1·24**	**1·06**	**·82**	**·73**	**·54**	**·48**	**·39**	**·71**	**1·45**	**1·70**	**Mean.**
	·70–2·63	·80–3·13	·55–2·70	·46–2·01	·27–2·01	·24–1·80	·11–1·03	·13–· 99	·04–1·30	·17–2·26	·21–4·56	·58–3·47	Range.
10	**1·85**	**1·89**	**1·51**	**1·47**	**1·18**	**·95**	**·84**	**·67**	**·60**	**·63**	**1·67**	**2·13**	**Mean.**
	·29–3·15	·89–3·61	·39–2·51	·61–4·45	·40–2·53	·21–1·89	·18–1·64	·25–1·10	·22–1·23	·04–1·69	·24–3·73	·52–4·03	Range.
11	**2·07**	**1·79**	**1·42**	**1·16**	**·91**	**·68**	**·73**	**·57**	**·46**	**·57**	**1·67**	**2·31**	**Mean.**
	·81–3·61	·70–3·79	·40–3·70	·45–2·36	·32–2·11	·16–2·18	·14–1·78	·14–1·64	·07–1·66	·11–2·59	·33–4·24	·86–4·15	Range.
12	**1·40**	**1·77**	**1·37**	**1·40**	**1·13**	**·79**	**·95**	**·63**	**·78**	**·71**	**·89**	**1·44**	**Mean.**
	·24–2·67	1·05–2·50	·50–2·61	·50–2·06	·31–2·01	·26–2·02	·23–2·36	·17–1·08	·33–1·28	·23–1·60	·15–1·70	·11–2·73	Range.
13	**2·28**	**1·75**	**1·52**	**1·48**	**1·61**	**·96**	**1·24**	**1·07**	**·58**	**·89**	**1·53**	**1·84**	**Mean.**
	·76–3·56	·91–2·76	·65–2·39	·85–3·12	·31–3·04	·25–1·98	·49–1·88	·38–2·45	·11– ·92	·16–1·65	·73–2·28	1·01–2·59	Range.
14	**1·82**	**1·76**	**1·72**	**1·90**	**1·67**	**1·40**	**1·27**	**1·36**	**1·50**	**1·62**	**1·80**	**1·86**	**Mean.**
	·84–2·88	·84–3·32	·94–2·87	·83–3·16	·62–3·17	·60–2·13	·42–2·25	·51–2·65	·52–2·70	·72–2·91	1·01–2·69	1·23–2·85	Range.
15	**2·09**	**1·25**	**1·68**	**1·65**	**1·39**	**1·37**	**1·66**	**1·51**	**1·64**	**1·58**	**1·39**	**1·94**	**Mean.**
	·98–5·73	·53–1·88	·62–2·70	·69–2·95	·37–2·38	·49–2·41	·85–2·83	·78–2·70	·26–5·78	·43–2·70	·60–2·40	1·08–3·17	Range.
16	**1·73**	**1·46**	**1·47**	**1·72**	**1·56**	**1·49**	**1·55**	**1·74**	**1·62**	**1·49**	**1·75**	**1·78**	**Mean.**
	1·10–2·49	·87–3·13	·54–2·16	1·14–2·50	·67–2·50	·52–2·72	·93–2·57	1·04–2·86	·86–2·77	·51–2·19	·84–3·24	·24–2·68	Range.
17	**1·17**	**1·00**	**·95**	**1·19**	**1·23**	**1·56**	**1·55**	**2·09**	**1·74**	**1·65**	**1·34**	**1·42**	**Mean.**
	·67–1·64	·56–2·07	·42–1·46	·41–1·71	·61–2·91	·83–2·12	1·31–1·79	1·13–3·16	·95–2·86	1·02–3·17	·72–1·80	·85–2·21	Range.
18	**1·38**	**1·29**	**1·36**	**1·28**	**1·25**	**1·34**	**1·33**	**1·66**	**1·77**	**1·62**	**1·05**	**1·33**	**Mean.**
	·15–2·31	·68–1·69	·75–2·70	·50–2·43	·42–2·03	·68–2·03	·92–1·90	·55–2·98	·96–2·81	·83–2·59	·49–1·65	·75–2·58	Range.

TABLE 11.

Mean Sodium (Na) Content of Pastures. (Range Values included.)

Area.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	
1	**·04**	**·04**	**·04**	**·07**	**·03**	**·02**	**·03**	**·02**	**·03**	**·05**	**·05**	**·05**	**Mean.**
	tr.– ·26	tr.– ·27	tr.– ·28	tr.– ·60	tr.– ·26	tr.– ·38	tr.– ·35	tr.– ·12	tr.– ·17	tr.– ·28	tr.– ·25	tr.– ·28	Range.
2	**·20**	**·16**	**·12**	**·15**	**·14**	**·16**	**·15**	**·08**	**·17**	**·21**	**·14**	**·18**	**Mean.**
	·03– ·53	·03– ·51	·02– ·57	·02– ·47	·01– ·77	tr.–1·40	·01– ·78	·01– ·79	tr.–1 ·02	·01–1 ·12	tr.–1·07	·02– ·45	Range.
3	**·06**	**·05**	**·02**	**·05**	**·03**	**·03**	**·03**	**·02**	**·05**	**·04**	**·04**	**·07**	**Mean.**
	tr.– ·38	tr.– ·24	tr.– ·07	tr.– ·17	tr.– ·15	tr.– ·15	tr.– ·21	tr.– ·10	tr.– ·18	tr.– ·14	tr.– ·14	tr.– ·28	Range.
4	**·11**	**·13**	**·12**	**·11**	**·14**	**·10**	**·12**	**·10**	**·16**	**·18**	**·20**	**·17**	**Mean.**
	tr.– ·24	tr.– ·36	·01– ·34	tr.– ·41	·02– ·51	tr.– ·76	·01– ·42	tr.– ·28	·02– ·55	tr.– ·47	·04– ·56	·03– ·38	Range.
5	**·25**	**·18**	**·12**	**·21**	**·14**	**·17**	**·14**	**·15**	**·18**	**·16**	**·21**	**·17**	**Mean.**
	·01–1·85	tr.– ·75	tr.– ·43	·01–1·27	·01– ·42	tr.–1·42	tr.–1·25	tr.– ·82	tr.–1·59	tr.– ·94	tr.–1·64	·02– ·90	Range.
6	**·04**	**·03**	**·03**	**·03**	**·02**	**·01**	**·01**	**·02**	**·03**	**·04**	**·04**	**·07**	**Mean.**
	tr.– ·15	tr.– ·24	tr.– ·09	tr.– ·07	tr.– ·09	tr – ·04	tr.– ·07	tr.– ·08	tr.– ·07	tr.– ·27	tr.– ·32	tr.– ·36	Range.
7	**·05**	**·04**	**·04**	**·03**	**·03**	**·02**	**·02**	**·03**	**·04**	**·05**	**·03**	**·06**	**Mean.**
	tr.– ·22	tr.– ·20	tr.– ·32	tr.– ·12	tr.– ·20	tr.– ·13	tr.– ·11	tr.– ·32	tr.– ·16	tr.– ·27	tr.– ·08	tr. ·41	Range.
8	**·04**	**·04**	**·02**	**·04**	**·02**	**·01**	**·01**	**·01**	**·03**	**·02**	**·05**	**·07**	**Mean.**
	tr.– ·18	tr.– ·38	tr.– ·07	tr.– ·14	tr.– ·04	tr.– ·09	tr.– ·04	tr.– ·07	tr.– ·21	tr.– ·09	tr.– ·29	tr.– ·45	Range.
9	**·12**	**·13**	**·09**	**·14**	**·05**	**·06**	**·05**	**·04**	**·07**	**·16**	**·06**	**·18**	**Mean.**
	·02– ·48	tr.– ·69	tr.– ·58	tr.–1·06	tr.– ·20	tr.– ·29	tr.– ·20	tr.– ·15	tr.– ·45	tr.– ·40	tr.– ·17	tr.–1·02	Range.
10	**·13**	**·15**	**·13**	**·10**	**·12**	**·12**	**·07**	**·06**	**·09**	**·06**	**·15**	**·14**	**Mean.**
	tr.– ·60	·02– ·47	tr.– ·51	tr.– ·49	·01– ·55	tr.– ·28	·01– ·25	tr.– ·20	tr.– ·34	tr.– ·31	tr.– ·77	tr.– ·53	Range.
11	**·11**	**·17**	**·07**	**·06**	**·06**	**·03**	**·03**	**·03**	**·04**	**·04**	**·12**	**·12**	**Mean.**
	tr.– ·46	tr.– ·68	tr.– ·38	tr.– ·33	tr.– ·28	tr.– ·17	tr.– ·10	tr.– ·26	tr.– ·15	tr.– ·12	tr.– ·47	tr.– ·41	Range.
12	**·03**	**·04**	**·03**	**·08**	**·02**	**·04**	**·04**	**·01**	**·04**	**·02**	**·04**	**·04**	**Mean.**
	tr.– ·50	tr.– ·14	tr.– ·07	tr.– ·42	tr.– ·05	tr.– ·36	tr.– ·19	tr.– ·05	tr.– ·13	tr.– ·06	tr.– ·17	tr.– ·08	Range.
13	**·16**	**·04**	**·21**	**·18**	**·06**	**·11**	**·29**	**·11**	**·08**	**·15**	**·09**	**·24**	**Mean.**
	tr.– ·81	tr.– ·10	tr.–1·54	tr.–1·05	tr.– ·24	tr.– ·52	·02–1·35	tr.– ·33	0·2– ·46	tr.–1·10	tr.– ·13	·04–1·15	Range.
14	**·17**	**·17**	**·19**	**·19**	**·14**	**·09**	**·16**	**·48**	**·12**	**·29**	**·24**	**·25**	**Mean.**
	·02– ·95	tr.– ·54	·01–1·12	·01– ·65	tr.– ·71	·01– ·49	tr.– ·80	tr.–2·74	·03– ·49	·02–1·45	·03–1·05	·05– ·60	Range.
15	**1·21**	**·52**	**1·15**	**·85**	**·77**	**1·02**	**·85**	**1·02**	**1·52**	**·68**	**·94**	**1·45**	**Mean.**
	·03–3·20	tr.–1·76	tr.–3·96	·02–3·12	·04–3·13	·01–3·24	·01–3·07	·04–4·01	tr.–6·32	·02–2·17	tr.–3·03	·04–3·07	Range.
16	**1·24**	**·86**	**·60**	**1·11**	**1·00**	**·83**	**1·03**	**·94**	**·98**	**1·70**	**·99**	**1·25**	**Mean.**
	·02–2·44	tr.–3·98	tr.–2·03	tr.–5·40	tr.–7·60	tr.–3·11	·01–4 ·02	·01–2·52	·01–4·10	·01–9·92	tr.–2·82	tr.–4·35	Range.
17	**1·05**	**·37**	**1·05**	**1·86**	**·63**	**1·52**	**1·24**	**1·70**	**1·76**	**1·44**	**1·27**	**1·50**	**Mean.**
	·18–2·04	·12– ·86	·05–4·42	·11–4·16	·19–1·76	·09–2·54	·18–2·33	·51–4·09	·18–3·47	·36–3·25	·17–3·43	·21–3·85	Range.
18	**·85**	**1·24**	**1·14**	**1·11**	**·76**	**·76**	**·75**	**1·13**	**1·35**	**1·36**	**1·12**	**·52**	**Mean.**
	·03–3·28	tr.–5·98	tr.–4·62	·05–3·21	·04–2·50	tr.–2·06	·02–2·68	·03–4·70	·13–2·95	·08–3·74	tr.–4·31	·03–1·52	Range.

tr. = trace.

TABLE 12.

Mean Chlorine Content of Pastures. (Range Values included.)

Area.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	
1	**·33**	**·34**	**·26**	**·29**	**·18**	**·15**	**·12**	**·10**	**·17**	**·20**	**·33**	**·33**	**Mean.**
	·13–1·02	·14– ·84	·10– ·64	·09–1·65	·07– ·65	·02– ·57	·01– ·48	·01– ·29	·03– ·58	·03– ·90	·09– 77	·14– ·59	Range.
2	**·59**	**·38**	**·38**	**·37**	**·31**	**·43**	**·36**	**·21**	**·42**	**·52**	**·41**	**·47**	**Mean.**
	·10–1·80	·10–1·15	·09–1·23	·10– ·80	·09–2·08	·05–2·92	·06–1·39	·02–1·31	·01–1·97	·02–2·24	·08–1·24	·09– ·94	Range.
3	**·32**	**·25**	**·20**	**·20**	**·17**	**·16**	**·12**	**·08**	**·18**	**·16**	**·32**	**·32**	**Mean.**
	·12–1·10	·07– ·50	·09– ·59	·08– ·77	·04– ·42	·05– ·48	·02– ·49	·01– ·43	·02– ·52	·01– ·42	·07– ·70	·18– ·72	Range.
4	**·32**	**·28**	**·30**	**·25**	**·31**	**·29**	**·27**	**·22**	**·36**	**·38**	**·47**	**·45**	**Mean.**
	·14– ·60	·09– ·67	·07– ·94	·06– ·60	·07– ·76	·05–1·15	·04–1·33	·02– ·67	·07– ·93	·04–1·58	·12– ·86	·13–1·00	Range.
5	**·47**	**·39**	**·26**	**·32**	**·33**	**·29**	**·24**	**·21**	**·30**	**·31**	**·40**	**·45**	**Mean.**
	·13–1·62	·06–1·04	·05– ·68	·08– ·88	·06– ·74	·07–1·00	·03–1·02	·02– ·60	·04–1·28	·01–1·13	·07–1·61	·08–1·15	Range.
6	**·37**	**·29**	**·19**	**·17**	**·14**	**·10**	**·09**	**·09**	**·12**	**·21**	**·26**	**·34**	**Mean.**
	·11–1·62	·06– ·83	·04– ·32	·02– ·55	·04– ·36	·02– ·26	·01– ·23	·01– ·32	·02– ·56	·01– ·52	·06– ·60	·17– ·50	Range.
7	**·33**	**·35**	**·22**	**·25**	**·18**	**·13**	**·08**	**·08**	**·16**	**·14**	**·33**	**·37**	**Mean.**
	·13– ·64	·14– ·87	·06– ·45	·06 ·93	·03– ·63	·02– ·44	·02– ·27	·01– ·33	·02– ·64	·02– ·76	·13– ·56	·16– ·66	Range.
8	**·32**	**·28**	**·26**	**·20**	**·14**	**·10**	**·08**	**·06**	**·12**	**·09**	**·21**	**·32**	**Mean.**
	·10– ·56	·07– ·63	·07– ·90	·05– ·42	·07– ·35	·03– ·27	·02– ·15	·01– ·17	·02– ·43	·01– ·46	·03– ·43	·14– ·67	Range.
9	**·42**	**·37**	**·32**	**·30**	**·22**	**·21**	**·15**	**·14**	**·24**	**·18**	**·31**	**·47**	**Mean.**
	·14–1·08	·15–1·11	·10– ·99	·04– ·80	·04– ·69	·06– ·48	·06– ·50	·01– ·48	·02–1·70	·02– ·73	·07– ·75	·07–1·34	Range.
10	**·48**	**·48**	**·40**	**·37**	**·31**	**·30**	**·23**	**·20**	**·22**	**·16**	**·41**	**·54**	**Mean.**
	·08– ·79	·27– ·95	·04– ·80	·10– ·80	·04–1·24	·03–1·17	·03– ·15	·04– ·58	·04– ·62	·02– ·54	·06–1·11	·16–1·73	Range.
11	**·38**	**·47**	**·34**	**·33**	**·23**	**·19**	**·18**	**·11**	**·12**	**·11**	**·38**	**·50**	**Mean.**
	·12– ·81	·11–1·09	·06– ·82	·09– ·81	·07– ·80	·02– ·67	·02– ·57	·01– ·36	·01– ·38	·01– ·45	·04– ·68	·09– ·93	Range.
12	**·23**	**·37**	**·27**	**·23**	**·23**	**·15**	**·17**	**·12**	**·14**	**·11**	**·16**	**·30**	**Mean.**
	·03– ·48	·08– ·71	·07– ·67	·09– ·38	·05– ·50	·03– ·36	·06– ·40	·04– ·31	·02– ·33	·01– ·32	·02– ·47	·02– ·54	Range.
13	**·39**	**·39**	**·45**	**·34**	**·38**	**·30**	**·33**	**·29**	**·12**	**·24**	**·48**	**·47**	**Mean.**
	·14– ·63	·05– ·66	·13–1·35	·09–1·03	·05– ·83	·05– ·87	·04– ·81	·02– ·60	·02– ·22	·02– ·74	·17– ·96	·19–1·04	Range.
14	**·45**	**·41**	**·25**	**·34**	**·32**	**·25**	**·27**	**·44**	**·24**	**·31**	**·39**	**·40**	**Mean.**
	·11–1·05	·11– ·89	·07– ·40	·13– ·95	·08–1·08	·15– ·49	·04–1·02	·03–1·87	·08– ·88	·09– ·78	·15– ·68	·23– ·82	Range.
15	**1·44**	**·40**	**1·06**	**·78**	**·56**	**·63**	**·74**	**·88**	**1·59**	**·74**	**·70**	**1·02**	**Mean.**
	·26–3·80	·11–1·68	·16–2·82	·18–2·62	·15–1·84	·09–2·76	·09–2·66	·15–3·50	·07–9·02	·03–2·29	·07–2·05	·15–3·18	Range.
16	**1·02**	**·43**	**·61**	**·71**	**·79**	**·65**	**·73**	**·59**	**·64**	**1·72**	**·67**	**·79**	**Mean.**
	·15–2·49	·10–1·05	·07–1·89	·12–2·32	·13–5·96	·06–3·06	·08–2·39	·08–1·47	·01–1·47	·04–17·10	·14–2·40	·14–2·40	Range.
17	**·97**	**·30**	**·82**	**1·36**	**·92**	**1·58**	**1·50**	**2·20**	**1·94**	**1·58**	**1·58**	**1·55**	**Mean.**
	·22–2·60	·12– ·58	·12–1·86	·08–3·94	·16–5·06	·33–3·53	·43–3·67	·53–6·40	·36–4·48	·65–3·29	·09–5·30	·38–5·14	Range.
18	**1·07**	**·82**	**·71**	**·89**	**·52**	**·66**	**·73**	**1·12**	**1·03**	**1·17**	**1·09**	**·46**	**Mean.**
	·32–5·80	·06–3·95	·11–3·45	·06–3·49	·08–3·18	·13–2·15	·07–3·67	·13–4·19	·19–2·78	·20–4·12	·11–5·22	·17– ·97	Range.

(4) Potassium, Sodium, and Chlorine.

The remarks made earlier in this discussion with reference to the trend of the phosphorus and protein averages of pastures in the course of the year may with equal justification be applied to the monthly averages for potassium and chlorine given in Tables 10 and 12, and to a lesser extent to the sodium figures given in Table 11.

Commencing with the averages for samples composed almost exclusively of grasses an inspection of the relevant tables reveals that potassium and chlorine reach their highest levels in the dry matter of the grasses in November, December or January corresponding with the months of highest rainfall and the period of most active growth. After January as the rainfall becomes less and the grasses tend to mature, the percentages of these constituents undergo a gradual decrease until the lowest levels for the year are reached during the dry and cold winter months—June, July and August, after which a gradual increase to the peak values mentioned above sets in. Sodium figures fluctuate somewhat irregularly from month to month but in general the tendency for lower values during the dry winter months as compared with the rainy season when values are higher is nevertheless apparent. Maximum average monthly figures for potassium in Areas 1 to 12 vary between 1·32 and 2·31 per cent., and for chlorine between 0·32 and 0·59 per cent. The corresponding minimum averages obtaining during winter range from 0·29 to 0·63 and 0·06 to 0·22 for potassium and chlorine, respectively.

The range values given above for the highest and lowest figures obtained for the pastures of Areas 1-12 serve to indicate that there are differences in the monthly averages of the pastures of individual areas in respect of potassium and chlorine. Thus the lowest average maximum figure for potassium occurs in the samples for December collected in Area 4, while Areas 3, 7 and 8 show the lowest average minimum values for potassium. On the other hand the pastures in Areas 6, 9, 10 and 11 are on the whole somewhat richer in potassium than any of the other areas from No. 1 to 12. Chlorine values, again, are highest both in regard to average minimum and maximum values in the pastures of Areas 2, 5, 9 and 10, while Areas 1, 3, 7 and 8 may be considered to be poorest in this constituent.

The grassland pastures are considered to be generally poor in sodium. In Areas 1, 3, 6, 7, 8 and 12 maximum values never exceed 0·08 per cent., while in the dry winter months they drop on an average as low as 0·01 per cent. A slight improvement is shown in the average sodium figures for Areas 9, 10 and 11 in the Parkland region of the Transvaal, while an appreciable increase in the figures for Areas 2 and 4, bordering on the coast of Natal, and Area 5 in the south-eastern part of the Cape is indicated. In Area 2 the average monthly figure drops only once (in August) below 0·10 per cent., ranging for the other months between 0·12 and 0·20 per cent. In Areas 4 and 5 the monthly averages vary between 0·10 and 0·20 per cent. and 0·14 and 0·25 per cent. respectively.

Passing from the all-grass or predominantly-grass pasture areas to the grass-bush or all-bush pastures of the Desert Shrub and Desert Succulent regions the percentage contents and monthly fluctuations

of the three constituents under discussion undergo certain changes. To commence with potassium, although there is a tendency for this element to be lower during the months of least rainfall, it remains comparatively high throughout the year in the pastures of Areas 13 to 18. In fact, except for the months June, September and October in Area 13 potassium figures never drop below 1·00 per cent. and about 70 per cent. of figures range from 1·40 to 2·00 per cent. Sodium and chlorine figures fluctuate on the whole in a most irregular manner but never drop to the low levels indicated for some of the grassland areas. The pastures of Areas 13 and 14 do not differ much in sodium and chlorine content from those in Area 5. In the pastures of the remaining four areas, viz. Nos. 15, 16, 17 and 18 of the Desert Shrub and Desert Succulent regions both sodium and chlorine figures are on the whole exceptionally high. More than 60 per cent. of the average monthly sodium values range from 1·00 to 1·86 per cent., while only about 6·0 per cent. of the values drop below 0·60 per cent. sodium. Also, the great majority of chlorine figures exceed 0·70 per cent. and some of these rise to as high as 2·20 per cent. in the dry matter of the pastures.

The grasses have been shown to be on the whole extremely poor in sodium throughout the year, while chlorine values also are somewhat low, especially during the dry winter months. The higher values obtained for both elements in the pastures of Areas 15, 16, 17 and 18 must therefore be ascribed to the shrubs and other herbaceous plants present in the samples from these areas. However, that shrubs or bushes are not always rich in sodium and chlorine is soon realised from an inspection of the tables in the appendix giving the analyses of individual samples from Areas 12, 13, and 14 where many " bush " and " bush and grass " samples were collected.

From remarks made in the oft quoted bulletin by Mitchell and McClure (*loc. cit*) it appears that 25·0 grams of potassium daily is more than enough to carry calves through growth and gestation. Also, in the light of work done at this Institute [Theiler *et al* (1927), du Toit *et al* (1934)] it would seem that 32·0 grams of potassium is adequate for the production of 2 gallons of milk daily, although 18·0 grams are secreted in the milk. The requirements of growing cattle for sodium and chlorine are considered very low, about 1·5 grams of sodium and less than 5·0 grams of chlorine per day being taken to be sufficient. Finally, it was provisionally suggested that 14·0 grams of chlorine was sufficient to provide for the daily secretion of 2 gallons of milk and that this amount would also be enough for growth and gestation. 11·0 Grams of sodium apparently sufficed for the normal production of the same amount of milk per day.

Assuming again an average dry matter consumption of 16 lb. per day it would mean that the dry matter of the ration of a cow producing 2 gallons of milk per day should contain 0·45 per cent. potassium and that of a growing bovine 0·34 per cent. Reference to Table 10 showing the average potassium content of South African pastures indicates that the probability of a potassium deficiency in animals grazing on these pastures is indeed remote.

TABLE 13.

MEAN CRUDE FIBRE CONTENT OF PASTURES (RANGE VALUES INCLUDED).

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	
1	**36·5**	**37·6**	**36·2**	**36·0**	**35·3**	**36·8**	**37·5**	**38·1**	**36·9**	**36·6**	**35·5**	**36·4**	**Mean.**
	27·6–	32·3–	31·5–	26·8–	28·9–	28·5–	31·3–	28·8–	30·4–	29·0–	27·8–	29·4–	Range.
	42·8	43·5	41·3	48·7	44·5	42·6	43·7	44·5	46·5	44·0	43·0	43·1	
2	**37·4**	**38·0**	**37·1**	**36·8**	**36·8**	**37·0**	**36·9**	**38·9**	**37·3**	**36·6**	**36·9**	**36·1**	**Mean.**
	30·4–	26·0–	31·5–	31·1–	31·9–	29·9–	25·2–	31·0–	30·3–	28·7–	28·4–	27·7–	Rang.
	45·3	43·3	42·5	44·5	44·0	42·7	41·5	46·8	44·1	45·4	42·9	41·2	
3	**36·6**	**36·2**	**35·7**	**34·8**	**35·1**	**35·9**	**36·4**	**36·6**	**35·9**	**35·3**	**34·8**	**35·0**	**Mean.**
	32·9–	31·4–	27·9–	26·4–	30·4–	30·7–	30·5–	31·6–	30·3–	27·8–	30·3–	29·5–	Range.
	40·3	45·1	42·0	40·2	40·0	40·7	41·7	43·8	40·8	40·5	40·3	40·9	
4	**35·4**	**36·5**	**37·4**	**35·0**	**37·4**	**36·3**	**36·1**	**37·4**	**36·4**	**36·4**	**35·5**	**36·0**	**Mean.**
	32·7–	32·6–	32·6–	30·2–	32·9–	31·4–	31·9–	33·4–	30·6–	32·3–	31·5–	32·7–	Range.
	39·6	41·4	44·1	40·8	43·1	41·4	39·8	43·3	41·6	41·5	39·8	38·9	
5	**34·7**	**33·6**	**34·6**	**33·1**	**34·9**	**34·4**	**35·2**	**35·2**	**34·9**	**33·5**	**34·2**	**33·2**	**Mean.**
	27·8–	24·8–	27·5–	20·6–	29·3–	26·7–	27·9–	26·4–	30·7–	25·5–	25·5–	23·6–	Range.
	40·9	43·2	40·9	39·6	41·3	39·5	40·1	40·7	46·2	40·5	42·7	46·0	
6	**34·1**	**34·6**	**35·3**	**33·7**	**35·5**	**35·0**	**35·7**	**35·7**	**34·6**	**34·0**	**33·8**	**32·8**	**Mean.**
	24·8–	25·2–	31·3–	28·5–	30·0–	29·7–	31·9–	33·1–	29·5–	21·4–	21·4–	22·7–	Range.
	43·5	41·3	41·6	38·8	40·6	43·0	41·3	41·8	39·8	40·4	37·5	37·5	
7	**36·5**	**35·1**	**35·9**	**34·5**	**35·7**	**37·2**	**37·6**	**37·9**	**37·4**	**36·1**	**34·4**	**35·0**	**Mean.**
	29·3–	31·2–	27·8–	29·3–	30·2–	32·3–	31·4–	31·8–	28·2–	29·2–	27·4–	20·7–	Range.
	43·2	39·8	42·5	39·8	42·1	46·0	41·9	44·7	43·5	43·8	41·8	42·0	
8	**35·6**	**34·8**	**34·9**	**34·6**	**34·8**	**36·0**	**36·6**	**35·9**	**34·5**	**34·2**	**35·9**	**33·9**	**Mean.**
	30·0–	30·2–	30·4–	29·3–	28·6–	31·4–	30·7–	31·7–	31·3–	31·4–	29·5–	26·0–	Range.
	41·9	40·0	40·1	40·3	42·0	42·7	41·4	41·2	38·2	42·7	42·1	42·8	
9	**37·0**	**35·0**	**35·2**	**35·9**	**35·9**	**35·9**	**37·4**	**37·9**	**37·0**	**34·7**	**34·0**	**34·4**	**Mean.**
	30·7–	24·5–	28·8–	30·1–	26·5–	29·1–	28·3–	31·8–	29·3–	21·2–	23·2–	27·7–	Range.
	42·3	40·4	42·5	42·2	41·0	42·2	45·5	45·5	43·2	41·2	40·3	40·1	

TABLE 13 (*continued*).

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	
10	**36·1**	**35·7**	**35·4**	**34·6**	**35·7**	**36·6**	**36·5**	**37·8**	**38·5**	**37·1**	**33·2**	**34·8**	**Mean.**
	27·4–	21·8–	28·9–	26·3–	29·4–	28·2–	29·1–	31·2–	32·9–	23·3–	22·7–	24·0–	Range.
	41·4	43·3	43·6	40·7	41·3	45·1	51·6	43·7	44·5	44·1	40·3	41·9	
11	**34·0**	**34·6**	**35·5**	**34·1**	**34·5**	**35·9**	**36·4**	**37·1**	**36·2**	**35·2**	**32·8**	**33·1**	**Mean.**
	27·2–	29·3–	27·6–	25·5–	26·6–	28·4–	27·6–	30·2–	35·0–	21·2–	24·0–	28·3–	Range.
	41·5	39·3	40·3	40·3	40·6	44·2	42·8	43·5	43·4	41·4	40·9	42·5	
12	**35·8**	**34·1**	**36·0**	**34·3**	**36·8**	**36·0**	**35·7**	**37·5**	**36·3**	**36·3**	**35·0**	**34·1**	**Mean.**
	25·2–	23·8–	25·2–	26·9–	32·3–	23·9–	27·4–	32·5–	31·5–	28·8–	25·6–	26·5–	Range.
	44·1	39·6	43·2	38·9	40·8	43·2	42·0	41·0	39·8	40·9	39·2	42·2	
13	**32·8**	**34·7**	**33·8**	**32·4**	**32·3**	**33·9**	**32·0**	**34·5**	**35·6**	**32·2**	**30·8**	**32·6**	**Mean.**
	25·6–	32·0–	30·1–	24·1–	23·6–	30·3–	25·1–	20·2–	28·8–	25·1–	24·3–	28·7–	Range.
	42·2	37·0	36·6	38·6	39·2	38·7	38·3	40·4	38·7	40·8	37·2	38·5	
14	**36·5**	**33·3**	**34·9**	**30·9**	**34·9**	**32·3**	**35·4**	**34·2**	**34·9**	**32·9**	**34·5**	**33·6**	**Mean.**
	29·4–	27·6–	25·5–	24·4–	28·8–	28·3–	24·6–	28·9–	24·5–	26·2–	29·4–	28·1–	Range.
	44·2	37·7	43·6	36·2	39·7	37·3	43·9	42·1	44·3	44·1	43·9	37·8	
15	**32·3**	**35·7**	**32·2**	**32·4**	**36·6**	**31·8**	**34·4**	**33·0**	**28·7**	**34·4**	**34·7**	**29·8**	**Mean.**
	21·2–	29·0–	23·3–	22·1–	27·1–	19·5–	21·0–	23·9–	18·5–	28·5–	22·3–	24·3–	Range.
	42·8	43·8	40·2	39·6	44·7	39·6	46·6	41·4	38·0	45·7	48·2	36·6	
16	**33·7**	**35·9**	**37·8**	**32·5**	**33·4**	**32·1**	**32·0**	**31·4**	**32·6**	**32·8**	**31·5**	**34·3**	**Mean.**
	27·0–	24·6–	26·5–	23·8–	21·2–	25·3–	22·6–	24·8–	23·4–	20·1–	24·5–	24·6–	Range.
	40·4	44·3	45·9	40·5	41·0	41·0	40·1	41·5	42·8	42·0	36·1	42·6	
17	**36·5**	**39·3**	**37·7**	**34·2**	**37·3**	**33·0**	**35·1**	**29·8**	**33·6**	**34·1**	**33·3**	**35·3**	**Mean.**
	30·8–	25·5–	32·9–	21·6–	23·8–	21·7–	31·2–	24·0–	27·0–	26·4–	26·1–	28·4–	Range.
	51·8	48·2	43·3	49·0	43·3	43·8	39·1	39·7	39·7	44·4	42·1	39·9	
18	**37·9**	**35·2**	**37·6**	**34·1**	**36·0**	**33·9**	**35·4**	**33·3**	**31·8**	**33·6**	**35·9**	**35·4**	**Mean.**
	32·6–	24·5–	26·3–	26·0–	31·2–	24·6–	30·2–	25·1–	25·7–	27·9–	27·6–	30·5–	Range.
	41·6	42·2	42·9	42·6	40·0	42·4	42·4	44·6	36·8	40·3	41·0	43·5	

Similarly, the necessary percentages of sodium and chlorine in the ration of growing cattle should be 0·02 and 0·07 per cent., and in that of cows secreting 2 gallons of milk daily 0·15 and 0·19 per cent., respectively. An inspection of the relevant tables describing the average percentages of sodium and chlorine in our pastures reveals that the requirements of growing cattle for chlorine will at all times be met by 16 lb. of pasturage, while in some areas and then only for a few months during the dry season the chlorine intake on veld alone will not be sufficient for the production of 2 gallons of milk. On the whole sufficient sodium will be ingested with 16 lb. of pasturage (dry matter basis) for the requirements of growing cattle. The sodium content of especially the grassland pastures are extremely low (0·01 per cent. of the dry matter) during winter, lower, therefore, than the necessary percentage for normal growth. But, since growth is in any case greatly retarded by a deficiency of other factors (phosphorus and protein) the deficiency of sodium during the said period may not in itself be considered serious. On the other hand, if the estimated sodium requirement in terms of a percentage of the ration of a cow producing 2 gallons of milk daily is considered in relation to the sodium figures given in Table 11 a serious sodium deficiency is seen to occur in the pastures of the Grassland Areas 1, 3, 6, 7, 8 and 12 throughout the whole year and in those of Areas 9, 10 and 11 during winter. In all other areas the pastures contain sufficient sodium for the requirements of lactating animals.

(5) Crude Fibre and Soluble Ash.

The percentage content and variation of the individual constituents of the ash of the pasture samples from month to month discussed in the preceding pages should naturally be reflected in the figures for the total soluble ash given in Table 14. Individual constituents present in the greatest amount and subject to the greatest fluctuations will largely determine the content and variation in the average values for soluble ash. That this is so is evident from a study of the average percentages for individual constituents and soluble ash given in Tables 2 and 3, Tables 8 to 12, and Table 14, respectively.

Average monthly figures for crude fibre, the last of the list of constituents determined, are presented in Table 13. A glance at these figures does not reveal marked differences in the crude fibre content of the pastures in one area from another, nor in the monthly figures of any one area, the range of variation for all the months of the year and all the areas being approximately 30·0 to 38·0 per cent. Closer examination of the data, however, justifies reference to a few minor differentiating features in the crude fibre content of pastures in the course of the year and in the various areas. In the first place, though fluctuating most irregularly reaching in percentage amount during some months the higher limit indicated above for the pastures of the country as a whole, the crude fibre figures for the areas in the Desert Shrub and Desert Succulent regions are somewhat lower than those for areas in the Grassland regions. Dividing the 18 areas into three groups, viz. Nos. 1-12 (grass), Nos. 13-16 (desert shrub), and

Table 14.

Mean Soluble Ash Content of Pastures (Range Values included).

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
1	**3·11**	**2·91**	**2·87**	**2·82**	**2·20**	**1·97**	**1·70**	**1·69**	**1·93**	**2·26**	**3·05**	**3·16**	**Mean.**
	1·94–	1·82–	1·92–	1·62–	1·32–	0·90–	0·94–	0·93–	1·00–	0·95–	1·60–	1·94–	Range.
	9·68	4·48	8·83	9·28	4·08	4·59	3·33	3·64	3·46	4·78	6·10	5·36	
2	**3·95**	**3·24**	**2·95**	**2·98**	**2·66**	**2·79**	**2·87**	**1·91**	**2·71**	**3·42**	**3·07**	**3·61**	**Mean.**
	1·40–	1·74–	1·11–	1·24–	1·42–	1·16–	1·19–	0·92–	0·94–	0·78–	1·25–	1·83–	Range.
	9·21	8·68	6·07	7·72	7·64	8·62	8·00	6·40	8·56	8·60	8·36	7·02	
3	**2·97**	**2·69**	**2·41**	**2·25**	**1·96**	**1·98**	**1·66**	**1·54**	**1·96**	**2·01**	**3·03**	**3·05**	**Mean.**
	1·71–	1·59–	1·44–	1·46–	1·39–	1·21–	1·15–	1·02–	1·09–	0·89–	1·78–	1·88–	Range.
	5·10	4·39	3·91	3·91	3·08	3·88	3·55	3·55	4·30	3·86	4·90	6·42	
4	**2·55**	**2·47**	**2·30**	**2·40**	**2·35**	**2·19**	**2·12**	**1·88**	**2·36**	**2·52**	**2·85**	**3·08**	**Mean.**
	1·66–	0·27–	1·31–	1·40–	1·27–	1·54–	1·37–	0·89–	0·97–	1·07–	1·59–	1·70–	Range.
	3·93	4·36	4·48	4·94	4·37	4·56	6·08	3·93	7·04	6·83	4·85	4·48	
5	**3·85**	**3·78**	**2·79**	**3·41**	**3·20**	**2·92**	**2·55**	**2·55**	**2·77**	**3·03**	**3·59**	**3·96**	**Mean.**
	1·45–	1·77–	1·31–	1·72–	1·70–	1·35–	1·10–	1·21–	1·05–	1·08–	2·42–	1·93–	Range.
	10·03	8·72	5·25	9·78	7·28	9·28	7·20	7·19	10·18	9·62	9·72	8·42	
6	**3·72**	**3·09**	**2·86**	**2·43**	**2·29**	**1·98**	**1·69**	**1·89**	**2·04**	**2·58**	**2·86**	**4·27**	**Mean.**
	2·23–	1·34–	1·79	1·60–	1·10–	1·11–	1·13–	1·18–	1·17–	1·18–	1·64–	2·13–	Range.
	8·66	10·2	6·40	5·02	5·10	3·83	2·58	3·99	4·01	6·04	4·98	11·7	
7	**3·32**	**3·22**	**2·68**	**2·53**	**2·05**	**1·88**	**1·65**	**1·69**	**1·87**	**2·06**	**3·19**	**3·57**	**Mean.**
	2·04–	2·10–	1·71–	1·50–	1·31–	0·63–	1·19–	1·10–	1·06–	1·14–	1·56–	2·32–	Range.
	6·36	8·80	4·71	6·72	4·37	3·67	2·62	3·17	3·67	4·24	5·48	5·40	
8	**3·30**	**3·02**	**2·82**	**2·52**	**2·13**	**2·00**	**1·85**	**1·76**	**1·96**	**2·06**	**2·52**	**3·58**	**Mean.**
	1·51–	1·60–	1·65–	1·37–	1·53–	1·24–	1·30–	1·01–	1·27–	1·23–	1·47–	2·30–	Range.
	5·49	4·82	4·95	3·70	5·24	3·73	3·03	3·28	3·72	3·85	3·57	5·94	
9	**3·73**	**3·68**	**3·91**	**3·05**	**2·76**	**3·24**	**2·26**	**2·00**	**2·76**	**2·51**	**3·65**	**4·35**	**Mean.**
	1·38–	1·62–	1·70–	1·57–	1·50–	1·00–	1·25–	0·94–	1·01–	1·12–	1·21–	2·13–	Range.
	6·86	1·11	10·15	5·04	7·58	10·1	4·68	3·34	17·1	5·16	10·6	10·4	

TABLE 14 (*continued*).

Area.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	
10	**4·45**	**4·58**	**4·33**	**3·96**	**3·50**	**3·20**	**3·00**	**2·83**	**2·56**	**2·95**	**4·80**	**5·32**	**Mean.**
	1·40–	2·15–	1·85–	1·56–	1·33–	0·98–	1·07–	1·20–	1·29–	1·12–	1·30–	1·75–	Range.
	8·02	8·08	6·15	11·08	6·74	5·66	6·06	6·45	4·83	8·54	9·50	9·03	
11	**4·81**	**4·45**	**3·47**	**3·08**	**2·77**	**2·56**	**2·73**	**2·38**	**2·36**	**2·46**	**4·33**	**5·55**	**Mean.**
	2·47–	1·98–	1·95–	1·82–	1·42–	1·28–	1·27–	1·16–	1·14–	1·25–	1·38–	2·40–	Range.
	8·06	10·0	9·85	8·10	5·40	5·60	6·18	7·30	6·03	7·70	9·06	8·38	
12	**4·13**	**5·01**	**4·16**	**4·27**	**3·61**	**3·07**	**3·86**	**2·65**	**2·74**	**2·75**	**3·37**	**4·84**	**Mean.**
	1·32–	2·65–	1·66–	1·45–	1·29–	1·12–	1·00–	0·98–	1·32–	1·44–	0·95–	0·78–	Range.
	11·30	8·58	10·3	8·05	6·08	8·82	11·3	6·46	4·40	5·93	6·62	10·54	
13	**6·58**	**4·54**	**4·36**	**4·71**	**5·62**	**3·65**	**4·88**	**4·54**	**2·88**	**3·58**	**4·60**	**4·91**	**Mean.**
	1·90–	2·20–	1·77–	2·32–	1·29–	1·18–	2·27–	1·59–	1·42–	1·06–	2·09–	2·58–	Range.
	15·52	5·58	9·28	10·00	12·22	5·96	8·38	7·73	4·84	7·52	8·61	8·61	
14	**5·08**	**4·77**	**5·28**	**5·70**	**4·98**	**4·92**	**4·60**	**5·11**	**4·90**	**5·57**	**5·23**	**4·87**	**Mean.**
	2·58–	2·37–	2·42–	2·48–	2·23–	2·19–	2·18–	2·07–	2·00–	2·30–	2·71–	3·20–	Range.
	8·66	9·00	10·55	8·88	8·96	7·44	8·15	12·20	8·70	10·63	7·36	5·71	
15	**9·10**	**5·46**	**8·20**	**7·55**	**6·30**	**6·96**	**7·46**	**7·65**	**10·04**	**6·41**	**7·24**	**9·37**	**Mean.**
	3·08–	2·34–	2·46–	3·82–	2·42–	1·97–	2·97–	3·84–	1·25–	1·82–	1·84–	2·53–	Range.
	15·54	8·90	15·83	14·95	13·98	14·18	16·30	17·90	27·20	13·15	15·10	14·22	
16	**8·80**	**6·71**	**6·42**	**8·23**	**8·16**	**7·17**	**8·11**	**7·90**	**8·33**	**9·46**	**7·69**	**8·53**	**Mean.**
	2·46–	2·81–	2·55–	2·05–	2·34–	1·83–	2·62–	2·36–	1·76–	1·76–	3·58–	1·49–	Range.
	14·60	17·35	12·43	21·44	30·15	14·48	12·28	16·50	35·40	35·40	14·04	18·78	
17	**7·91**	**4·28**	**6·27**	**9·83**	**6·94**	**9·52**	**9·21**	**11·05**	**11·30**	**9·91**	**8·67**	**8·87**	**Mean.**
	2·87–	2·05–	1·23–	2·19–	3·80–	5·17–	6·00–	6·81–	3·65–	6·33–	4·02–	3·43–	Range.
	12·27	7·00	16·10	16·30	18·48	15·27	13·45	19·80	19·30	15·18	14·90	16·78	
18	**6·97**	**8·36**	**8·97**	**7·63**	**6·45**	**6·78**	**7·33**	**8·28**	**9·29**	**9·00**	**7·77**	**5·99**	**Mean.**
	1·33–	3·95–	2·83–	2·03–	1·89–	2·19–	3·37–	1·98–	4·34–	3·13–	2·33–	1·93–	Range.
	17·65	24·00	18·65	17·30	13·25	12·00	16·67	18·75	18·90	16·60	18·36	10·07	

No. 17 and 18 (desert succulents and desert grass), and calculating monthly mean values for each group from the averages in Table 13 results in annual ranges of variation of 34·6-37·2, 32·1-34·9, and 31·6-37·2 per cent. crude fibre for the three groups, respectively. The calculated mean values given in Table 15 show the irregular fluctuations previously referred to. However, in the case of the Desert Succulent region values tend to be lower during the winter than during the summer months. Reference to Tables 2 and 3 reveals that both phosphorus and protein values, especially in Area 17, are higher during winter than in summer, indicating herbage at a younger stage of growth for the winter months, and this circumstance again being responsible for the lower crude fibre values as indicated above.

The mean figures for crude fibre for the grass pastures of Areas 1-12 given in Table 15 and presented graphically in Figure 6 together with the corresponding mean protein curve to be referred to anon show a fairly well-defined seasonal tendency which applies more or less to each of the individual grassland areas. The mean figure is highest in August and then falls gradually to a minimum value for the year in November and December. After being at a slightly higher level during January, February, and March the mean value drops to a second minimum in April after which it steadily rises to the maximum in August referred to above. This curve representing the mean crude fibre content of grass pastures from January to December indicates in general that in winter when the veld, as has been shown, is poorest in the essential nutrients, phosphorus and protein, it is at the same time more fibrous and consequently less palatable than in the summer when the percentage content of the nutrients mentioned are at their highest levels for the year. Furthermore, the curve obtained from the analyses of samples collected by following animals is considered to be a fairly true reflection of the manner in which one would anticipate how the grazing animal would select its food from the available pasturage as the purely physical condition thereof changes in the course of the year. In August practically all grasses are brown and dried out; the animal has no option and has to select its food from such pastures. The ingestion of pasture of a fibrous nature is inevitable. From September the temperature rises, rains begin to fall in light showers (c.f. Table 1) and a small amount of green succulent growth becomes available to the animal, not, however, sufficient to fulfil its requirements; it still has to graze on the old growth as well. The amount of new growth in the meantime increases with increasing rainfall until in November or December the animal will be grazing on green pasture only. A gradual decrease in the fibre content of the ingested food from August to December may thus be expected on natural pastures which have not been burnt earlier in the year. Except where a scientific system of pasture management is practised or where the pasture is overgrazed, the grazing animal will not be able to prevent the fast growing grasses from reaching the seeding stage of growth during the rapidly growing season of the year. While the pasture is still in a green and succulent state the animal will graze during January, February, and March freely on these flowering and seeding grasses which nevertheless contain a higher percentage of fibrous material than was the case in November and December. In

TABLE 15.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Grasslands	35·8	35·5	35·8	34·8	35·7	36·1	36·6	37·2	36·3	35·5	34·7	34·6
Desert shrub	33·8	34·9	34·7	32·1	34·2	32·5	33·5	33·3	33·0	33·1	32·9	32·6
Desert succulent	37·2	37·2	37·2	34·2	36·7	33·5	35·3	31·6	32·7	33·9	34·6	35·4

TABLE 16.

Mean Ca and P Contents and Ca : P Ratios of Pastures.

	Areas 1, 2, 3, 4, 7 and 8.			Areas 5 and 6.			Area 10.			Areas 9, 11 and 12.			Areas 13 and 14.			Areas 15 and 16.			Areas 17 and 18.		
	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.	Ca.	P.	Ca/P.
January	·28	·124	2·26	·33	·155	2·13	·40	·161	2·48	·40	·141	2·84	·55	·217	2·53	·83	·155	5·36	·95	·102	9·31
February	·28	·112	2·50	·35	·148	2·36	·44	·157	2·80	·44	·136	3·23	·47	·187	2·51	·82	·144	5·70	·89	·109	8·17
March	·30	·104	2·88	·34	·128	2·66	·49	·144	3·40	·51	·118	4·32	·54	·174	3·10	·84	·160	5·25	1·03	·100	10·30
April	·30	·102	2·94	·37	·130	2·85	·50	·126	3·97	·48	·108	4·44	·73	·196	3·72	·92	·155	5·94	1·06	·105	10·10
May	·31	·083	3·73	·36	·119	3·02	·46	·126	3·65	·49	·083	5·90	·76	·164	4·63	·87	·150	5·80	·99	·132	7·50
June	·30	·076	3·95	·34	·110	3·09	·49	·122	4·02	·53	·077	6·88	·66	·146	4·52	·90	·143	6·29	·98	·131	7·48
July	·31	·072	4·30	·34	·098	3·47	·50	·111	4·51	·51	·077	6·62	·74	·169	4·38	·91	·169	5·38	1·12	·132	8·48
August	·28	·066	4·24	·36	·094	3·83	·54	·106	5·09	·44	·060	7·33	·63	·153	4·12	1·02	·168	6·07	1·20	·148	8·10
September	·29	·078	3·72	·34	·099	3·44	·43	·080	5·38	·48	·055	8·72	·61	·128	4·77	·98	·158	6·20	1·10	·147	7·48
October	·27	·094	2·87	·35	·130	2·69	·43	·093	4·63	·41	·088	4·66	·62	·152	4·08	·89	·143	6·22	1·10	·135	8·15
November	·27	·123	2·19	·34	·139	2·45	·54	·189	2·86	·46	·115	4·00	·61	·180	3·39	·85	·144	5·90	1·06	·092	11·52
December	·29	·131	2·21	·36	·185	1·94	·49	·183	2·68	·52	·143	3·64	·43	·191	2·25	·84	·158	5·32	·90	·114	7·90

April the grasses begin to dry out, some becoming hard and fibrous, with the result that the animal is bound to be more selective in its choice of food than during the previous months; long fibrous stems with partially dry seedheads will be avoided and for a short time the material consumed may be expected to be less fibrous than that ingested in say, January. However, with practically no more rain falling and with the onset of the cold winter months the grasses turn brown and become dry, so that the animal is in an ever increasing degree dependent on dry, mature pasturage from May to August, a circumstance which will naturally result in an increase in the fibre content of the food consumed during the said period. That the curve (Fig. 6) representing the changes in the fibre content of the samples collected in the grass areas (Nos. 1-12) conforms in general to the known seasonal chemical and physical changes of grasses but more so to the highly probable method by which the animal will selt:t its food from the available pasturage as outlined above is taken as a strong indication that the samples collected for this mineral survey are representative of the food actually selected by animals under grazing conditions on natural veld.

In connection with the relatively small variation in the crude fibre figures in the course of the year, for instance 34·6 per cent. for December to 37·2 per cent.for August it should be pointed out that " whilst . . . the actual figure for crude fibre may be of a similar magnitude in two different herbage samples, the changes taking place in the structural material of plants with age will result in decreased digestibility of the crude fibre " (Louw, 1938). In terms of digestibility crude fibre the seasonal fluctuations for this constituent in the pastures would thus be much greater than those indicated by the figures in Table 15.

(6) Interrelationship of some Constituents.

In view of what has been said when discussing the results it may be expected that a fairly close correlation exists among some of the constitutens determined, especially in the case of samples composed exclusively or predominantly of grasses. The following correlation coefficients calculated from the average monthly figures for the samples from three of the eighteen areas are representative of grass and of desert shrub veld:—

Correlation Coefficients.

	Grass	*Desert Shrub.*	
	Area 1.	*Area* 14.	*Area* 16.
P and protein	+ ·97	+ ·66	+ ·32
P and Cl	+ ·92	+ ·65	- ·30
P and K	+ ·97	+ ·81	+ ·12
Protein and K	+ ·92	+ ·76	+ ·55
Protein and Cl	+ ·92	+ ·35	- ·29
K and Cl	+ ·98	+ ·43	- ·09
Na and Cl	+ ·69	+ ·59	+ ·88

These coefficients show for Area 1 (grassveld) almost perfect correlation for the constituents as tabulated, with the exception of sodium which, however, still shows quite a significant correlation with chlorine. On the other hand, in Area 16 where samples composed of bushes predominated the only close correlation is that between sodium and chlorine, all other correlations being insignificant. Area 14 where the samples analysed may be divided into about equal numbers of grass samples and samples composed of bushes takes an intermediate position with regard to the correlation coefficients of the constituents. The coefficients range, in fact, from an insignificant (K and Cl) to a fairly close correlation (P and K). The inverse relationship between crude fibre and crude protein referred to in a previous publication (du Toit *et al*/1935/) has been statistically established by the calculation of the correlation coefficient of the mean monthly figures for these constituents in the grassveld region as a whole (Areas 1 to 12). These mean values are presented graphically in Fig. 6 and the coefficient calculated, viz. $-0{\cdot}77$ shows a fairly close negative correlation.

Since it plays under certain circumstances such an important rôle in the mineral nutrition of farm animals it will be of interest to devote some space to a consideration of the calcium-phosphorus ratio in conjunction with the percentage amount of these elements in the pasture samples in the course of the year and in different regions of the Union. For this purpose the eighteen areas have been grouped as indicated in Table 16, those somewhat similar in regard to the calcium and phosphorus contents of their pastures falling within the same group. From the average figures for calcium and phosphorus in Tables 2 and 8 those given in Table 16 for sets of areas have been calculated.

As may be expected in view of the seasonal fluctuations of calcium and phosphorus previously discussed the proportion of calcium to phosphorus is greatest during the dry winter months in all grass pastures. In the first group (Areas 1 to 4, 7, and 8) the ratio increases from $2{\cdot}19$ in November to a maximum of $4{\cdot}30$ in July. Areas 5 and 6 with higher figures for both elements, show somewhat lower minimum and maximum calcium-phosphorus ratios than the first group of areas. The calcium figures for the two sections, Area 10 and Areas 9, 11 and 12, of the Parkland region are practically the same, but owing to better phosporus values in the pastures of Area 10 the proportion of calcium to phosphorus in this area varies from $2{\cdot}48$ to $5{\cdot}38$ as against a minimum of $2{\cdot}84$ and a maximum of as high as $8{\cdot}72$ in the pastures of Areas 9, 11 and 12.

In spite of calcium values about twice as high as those for the grass areas in the first group, the ratios of this element to phosphorus in Areas 13 and 14 are very similar to those in the said group of grass pastures, ranging from $2{\cdot}25$ to $4{\cdot}77$. Ratios in the pastures of Areas 15 and 16 remain high throughout the year, fluctuating from $5{\cdot}25$ to $6{\cdot}29$, while the highest proportions of calcium to phosphorus, viz., $7{\cdot}48$ to $11{\cdot}52$, occur in the Desert Succulent and Desert Grass pastures (Areas 17 and 18) of the North-Western Cape.

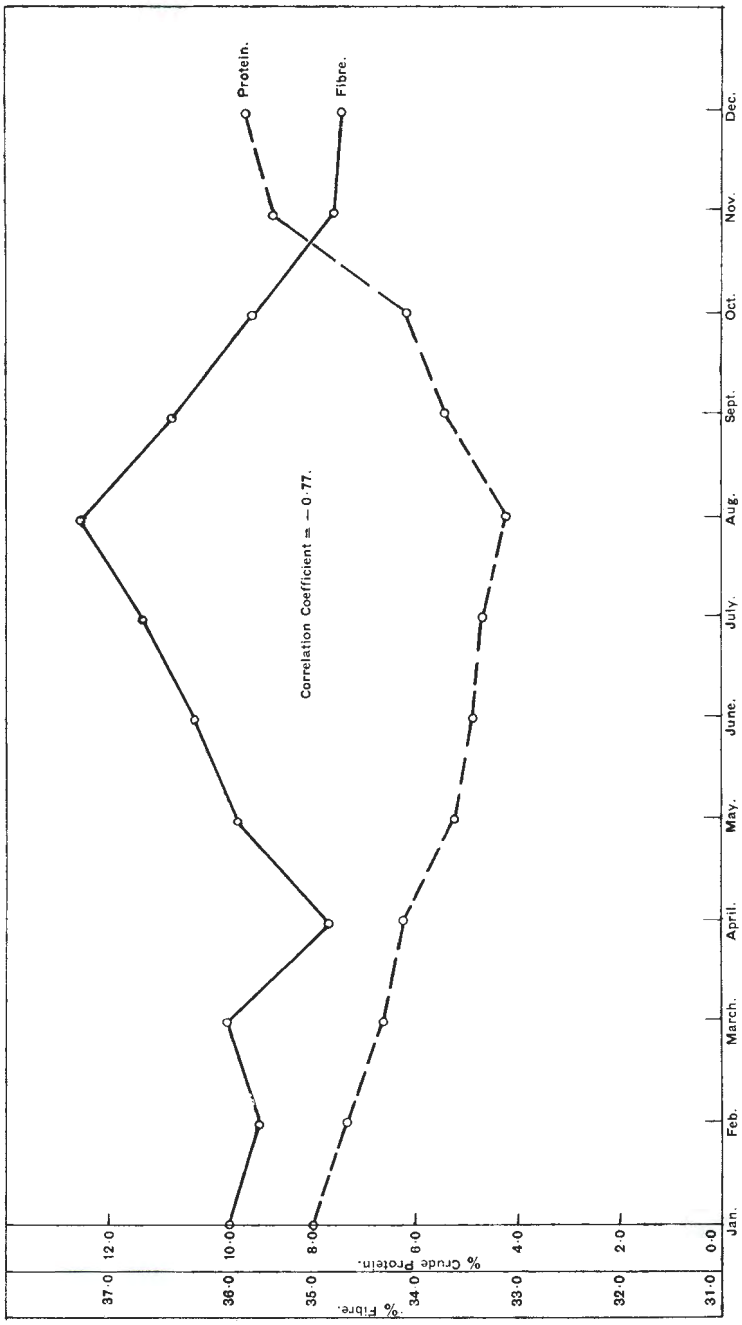


Fig. 6.—Showing the seasonal variations in the mean crude protein and crude fibre contents of the natural grass pastures of areas 1-12.

It is doubtful whether the ratios of calcium to phosphorus are sufficiently unfavourable to have any determinable effect on the growth of animals under conditions of practical farming except perhaps during periods of acute phosphorus deficiency. Under such conditions, rectifying the phosphorus deficiency would be the first concern, which then automatically improves the ratio problem. There can be no doubt that an unfavourable ratio of calcium to phosphorus, especially when the latter is present in insufficient amounts, as is almost invariably the case throughout winter in South African pastures, enhances the bad effects of the phosphorus deficiency considerably, but it has not been possible to show that ranching cattle receiving a phosphatic supplement in accordance with their needs were effected significantly by increasing the calcium-phosphorus ratio of their intake from 3·4:1 to 10:1. This is fortunate, as the use of most phosphatic supplements in practice, such as bone-meal, precipitated calcium phosphate, degelatinized bone-flour, etc., would increase the calcium intake of stock which is usually already considerably in excess of the phosphorus contained in the pasture eaten . Calcium-free supplements, such as sodium phosphate, would be preferable, but their use for feeding is almost prohibited by their cost. It is considered, however, that taking the pastures throughout the year and the variation of their calcium-phosphorus ratios from approximately normal values during the periods of active growth to unfavourable ratios during periods of food scarcity, such as drought and winter, in summer rainfall areas when phosphatic supplements are usually given and incidentally improvement of the ratio brought about, what appears to be a periodically unfavourable ratio, is without practical effect on animals entirely dependent on pasture for their food supply. At all events, it was not possible to demonstrate any effect on growth and blood phosphorus in the case of growing cattle that were running on pasture and receiving a calcium and phosphorus supplement daily to ensure a Ca:P ratio of 10:1 of their feed for a period of two years.

IV. GENERAL SUMMARY AND CONCLUSIONS.

A final report is submitted on work started in 1930 on the mineral content and feeding value of South African natural pastures.

In the course of two successive years close on five thousand samples of natural pasturage were collected by following grazing animals on farms situated all over the Union of South Africa and forwarded to Onderstepoort, where they were chemically analysed. The object in following animals while the samples were being collected was to ensure that such samples were as closely as possible representative of what the animals actually consumed on the day of collection. All samples were analysed for crude protein, crude fibre, silica-free ash, phosphorus, calcium, magnesium, potassium, sodium, and chlorine.

For the purpose of discussing the results obtained the country as a whole has been divided into eighteen different areas and tables giving the average composition from month to month of the pastures in each area separately constructed.

The following is a brief summary of the results obtained.

(1) The chemical composition of grass pastures differs in many respects considerably from that of bush pastures. Especially is this the case in connection with the changes to which the composition of pastures are subject with changing meteorological conditions from January to December.

(2) Bush pastures are on the whole richer in all the constituents determined than are grass pastures. Another distinguishing feature in the two veld types is the difference in chemical composition between winter and summer pasturage: whereas the former type shows only minor fluctuations in the course of the year, the difference in the percentage contents of certain constituents during winter and summer are considerable in the case of grass pastures.

(3) Qualitative differences in the pastures of specific regions within any one of the two main veld types are also encountered.

(4) Expressed as percentages of the dry matter the phosphorus content of grass pastures is 0·12-0·17 during summer and 0·05-0·07 during winter. In the pastures composed mainly of bushes this constituent varies between 0·11 and 0·20 per cent. Crude protein values of the grass pastures fall from 7·0-9·0 per cent. in summer to 3·3-4·0 per cent. in winter, while the percentage of this constituent in those pastures composed mainly or wholly of bushes varies between 7·0 and 10·0 in the course of the year.

(5) Calcium and magnesium values show only minor seasonal variations. Differences in the percentage contents of these constituents are, however, appreciable in the pastures of one region as against those of another. Expressed as an annual mean the variation in the calcium and magnesium contents of grass pastures in different regions are 0·25-0·48 per cent. and 0·12-0·21 per cent., respectively. Similarly, the calcium and magnesium averages for bush pastures are 0·60-1·05 per cent. and 0·21-0·37 per cent., respectively, depending on the region.

(6) Maximum potassium and chlorine values occurring during summer in the grass pastures are 1·32-2·31 per cent. and 0·32-0·59 per cent., respectively. During winter the former constituent varies between 0·29 and 0·63 per cent. and the latter between 0·06 and 0·22 per cent. in the grass pastures of different regions. Sodium average figures fall from a maximum of 0·08 per cent. to a minimum of only 0·01 per cent. in some grass pastures while in others these values vary between 0·10 and 0·25 per cent. in the course of the year.

(7) The percentage potassium remains comparatively high throughout the year in most bush pastures. Values seldom are below 1·00 per cent., while most figures fluctuate between 1·40 and 2·00 per cent. Sodium and chlorine averages are exceptionally high in

some of the pastures composed mainly of bushes. Thus, for the greater part of the year figures for sodium are 1·00-1·86 per cent., and chlorine values exceed 0·70 per cent.

(8) Crude fibre averages are lowest in pasture at the younger stages of growth, the mean annual variation is 34·6-37·2 per cent. for grass pastures and 32·0-35·0 per cent. for bush pastures.

(9) Calcium-phosphorus ratios ranging from 2·00:1 to 11·60:1 occur in the dry matter of South African pastures.

(10) Judged by the estimated requirements of cattle and sheep for growth all South African natural pastures, composed mainly or wholly of grasses are deficient in phosphorus, crude protein and, in certain areas, sodium for a period ranging from five to nine months of the year, depending on the area. There are indications that in certain of these regions the pasture may be deficient in phosphorus throughout the year. Furthermore, on the basis of the average values for phosporus these grass pastures contain at no time of the year sufficient of this nutrient to provide in the requirement for an additional function (e.g., gestation or lactation) of the animal, superimposed on growth.

(11) Provided sufficient food is available an intake of phosphorus, crude protein or sodium below the optimum requirements for growth will seldom occur on pastures composed mainly of bushes.

(12) The requirements of calcium, magnesium and potassium for growth and moderate milk production will at all times be met by the amounts of these constituents present in South African pastures. Especially is the danger of a potassium and magnesium deficiency extremely remote.

(13) The pastures of the Union are at no time deficient in chlorine. A cow producing two gallons of milk may, however, not ingest sufficient of this constituent on the winter pastures of some of the grassland regions.

Since, unlike phosphorus or calcium, the reserves of which in the animal's body may tide it over a long period of inadequate intake without appreciably affecting its productive performance, protein undernourishment may immediately limit production or prevent it entirely, the low level of this constituent existing for several months in each year in most natural pasturages must be considered the limiting factor in the productivity of both cattle and sheep in this country. This and other deficiencies occurring simultaneously in the diet will result in a generally lowered metabolic rate and this condition again may be responsible for the circumstance that symptoms characteristic of an individual mineral deficiency such as phosphorus are not manifested under practical conditions of farming to the extent which a consideration of the average phosphorus content of our pastures, as reflected in this report, in relation to the estimated requirement of the animal for this constituent, would lead one to expect.

In conclusion it may be stated that from a study of the data presented in these pages it seems justified to infer that the practice of feeding phosphorus supplements in certain areas, advocated by this

Institute for almost twenty years may with great advantage to the cattle and sheep industries be adopted in the greater part of the country and for the greater part of the year. Also, it is clear that the extreme deficiency of protein in our grass pastures during winter is a problem of equal, if not greater, importance than that of phosphorus deficiency. If the advantages which have been proved to result from a phosphorus supplement such as bonemeal are an indication of what may be expected from rectifying other deficits in our natural pasture the improvement or supplementation of winter pasture with the object of increasing the protein intake of animals should greatly benefit the cattle and sheep industries of this country.

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