Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 14, *Numbers* 1 *and* 2, *January and April*, 1940.

Printed in the Union of South Africa by the
Government Printer, Pretoria.

The Utilization by Sheep of the Proteins contained in the Natural Grazing during Different Seasons of the Year.

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In a previous paper we have shown that the dry matter consumption of sheep on natural grazing during different seasons of the year is very constant when expressed per $\frac{3}{4}$ power function of the weight. On this basis it was concluded that the phenomenon of weight reduction in sheep during the winter months is not due to a lowered dry matter consumption per unit of weight, but in all probability to the nutritional state of the winter pasture. In fact it seems fairly reasonable to assume that this depleted nutritional state of winter grazing may involve nutritional deficiencies of a complex nature, and that the magnitude of these deficiencies determines the extent of weight loss in animals. Existing evidence strongly suggests the latter point of view. It is by now well established that phosphorus is deficient in winter pasture. However, the addition of phosphorus alone does not remedy the condition of weight loss during winter. This condition alone affords confirmatory evidence of the possibility of additional nutritional deficiencies. Working on the hypothesis that other deficiencies apart from phosphorus exist in winter grazing, it was decided to investigate the possibility of an existing protein deficiency.

It is clear, however, that the question of a protein deficiency can only be settled by a systematic analysis of the entire problem. In other words, definite knowledge must be available on (1) the seasonal protein content of the pasture, (2) the quantity of pasture consumed daily, (3) the biological utilization of the protein in the pasture during different seasons of the year and (4) the maintenance protein requirements of the animals. It is only when these factors are known that a final and conclusive verdict on the question of a protein shortage can be given. An extensive survey on the chemical composition of the pastures in the Union of South Africa has been inaugurated in 1932 and now concluded (1939). This report includes a detailed monthly analysis of the protein content of pastures over the Union. Furthermore the dry matter consumption as well as the maintenance protein requirements of sheep have previously been determined by the authors (1938-39). In this study attention is therefore exclusively given to the third requirement namely the biological utilization of the proteins of the pasture during the different seasons of the year.

Very little work has apparently been done on the biological value of grazing. Thus far the majority of investigations dealing with the protein utilization of grasses or grazing consist almost exclusively of nitrogen balances, and can therefore not be compared with the biological values obtained in this study. Sotola (1930) has determined the biological value of alfalfa hay, corn silage and sunflower silage with sheep. The average values for the respective feeds were 56, 94 and 67. Turk, Morrison and Maynard (1934) found a much higher biological value for lucerne hay. Their values for lucerne hay and clover hay were 79 and 81 respectively. Smuts and Marais found an average value of 59 for lucerne hay with sheep. This value agrees exceptionally well with that of Sotola. The work of Morris, Wright and Fowler (1936) on cattle is probably more directly related to this study. They determined the biological values of the proteins contained in autumn and spring grass. Their values were 76·5 for the first type of grass and 63 for the latter. It is also evident from their work that there is no difference in the biological values of dry or green grass of the same season. Bartless and co-workers (1938) studied the effect of the different methods of drying on the biological values of grass proteins. They found that the highest biological value, namely 67, is associated with a drying temperature of 300° F. At a temperature of 170° F. the biological value drops to 62. It is also clear from the work of the above authors that the quality of the proteins of grass allowed to sun-dry is decidedly diminished since the biological value under these conditions drops to 52.

Experimental.

Representative grazing cut during different seasons of the year, was utilized for these metabolism experiments. The grass was fed to five merino whethers under controlled experimental conditions. These sheep were first put on a nitrogen low diet, the composition of which was given previously, and then on a collection period of 10 days on the same ration. After this they were fed the grass for a preliminary period of 10 days, and then subjected to a collection period of the same duration. Grazing was fed without any form of supplementation except minerals to which sheep had free access under practical grazing conditions. It was realized that the present conditions of experimentation would not afford a true measure of the actual biological value of the protein contained in the respective seasonal grazings, since portion of the protein may be catabolized for energy purposes. However the main object in this investigation was to obtain a detailed picture of the biological utilization of the protein under the prevailing pastoral conditions.

Experimental Results.

In Table 1 are given the metabolism data on the natural grazing obtained during the different seasons of the year. The metabolic faecal nitrogen and the endogenous nitrogen values are representative of the nitrogen low period. These values represent the daily unavoidable nitrogen contribution of the body and do therefore not form an integral part of the undigested or unutilized portion of the grass protein.

TABLE 1.

Metabolism Data and Biological Values of Natural Grazing during Different Seasons of the Year.

Grazing July, 1938 (0·49 *per cent. N*).

Animal No.	Average Weight.	Grass Consumption.	Dry Matter Intake.	Nitrogen Intake.	Nitrogen in Faeces.	Metabolic Faecal Nitrogen.	Absorbed Nitrogen	Nitrogen in Urine.	Endogenous Nitrogen.	Food Nitrogen Retained.	Biological Value.	Nitrogen Balance.	Apparent Digestibility.	True Digestibility.
	Kgm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.			Per cent.	Per cent.
1.....	46	487	448	2·39	2·66	1·88	1·61	2·46	2·12	1·27	79	−2·73	0·0	67
2.....	45	463	426	2·27	2·70	1·96	1·53	2·18	1·92	1·27	83	−2·61	0·0	67
3.....	42	469	431	2·30	2·01	1·81	2·10	2·34	1·98	1·74	82	−2·05	12·0	91
4.....	50	459	422	2·25	2·46	2·15	1·94	2·14	1·85	1·65	85	−2·35	6·0	86
5.....	42	411	378	2·01	2·35	1·81	1·47	2·09	1·88	1·26	86	−2·43	0·0	73
									Average.....		83	—	2	77
Grazing October, 1938 (1·44 *per cent. N*).														
38248.....	56	650	600	9·36	3·54	2·08	7·90	5·17	2·23	4·96	63	0·65	62	84
49612.....	53	769	723	11·07	4·83	2·89	9·13	6·06	2·52	5·59	61	0·18	56	82
38252.....	44	500	470	7·20	2·90	2·16	6·46	4·23	1·89	4·12	64	0·07	60	90
38243.....	48	640	602	9·22	3·73	2·40	7·89	4·79	1·73	4·83	61	0·70	60	86
39292.....	52	662	622	9·53	3·83	2·49	8·19	5·09	1·92	5·02	62	0·61	60	86
									Average.....		62	—	60	85
Grazing January, 1939 (1·17 *per cent. N*).														
38248.....	32	554	515	6·48	3·09	2·47	5·86	3·22	1·15	3·79	65	0·17	52	90
49612.....	52	809	752	9·47	4·81	3·53	8·19	4·27	2·29	6·21	76	1·39	49	86
38252.....	42	616	573	7·21	3·75	2·63	6·09	3·27	1·81	4·63	76	0·19	48	84
38240.....	44	744	692	8·70	4·09	2·90	7·51	3·74	2·02	5·79	77	0·87	53	86
39290.....	45	504	469	5·90	2·67	2·39	5·62	3·33	1·67	3·96	71	0·10	55	95
									Average.....		74	—	51	88
Grazing April, 1939 (0·73 *per cent. N*).														
38248.....	43	473	430	3·45	2·96	2·45	2·94	1·73	1·20	2·41	82	−1·24	14	85
49612.....	46	500	455	3·65	3·24	2·96	3·37	2·18	1·52	2·71	80	−1·77	11	92
38252.....	41	469	427	3·42	2·93	1·92	2·41	1·85	1·57	1·83	76	−1·36	14	71
38240.....	41	499	454	3·64	3·15	2·59	3·08	1·73	1·64	2·99	97	−1·24	13	85
38249.....	40	358	326	2·61	2·39	2·15	2·37	1·69	1·12	1·80	76	−1·47	8	99
									Average.....		82	—	12	86

During July, when the nitrogen content of the grazing is as low as 0·49 per cent., the total intake of this element is comparatively speaking also very low. The total intake of nitrogen for the five sheep varies from 2·39 to 2·01 grams per day. Except for sheep 3, the nitrogen excretion in the faeces is in every case greater than the nitrogen intake. Superficially these values would indicate that none of the grass protein is digested as illustrated under the apparent digestibility. However, if that portion of the faecal nitrogen, arising from the body is subtracted from the total faecal nitrogen, it will be seen that in reality 77 per cent. of the protein contained in the grazing during July is digested.

Schneider has shown that the metabolic faecal nitrogen consists of two portions, namely that which is proportional to the dry matter intake and a second portion which is dependent on the weight or in other words of endogenous nature. The second portion would, therefore, become more prominent under submaintenance conditions as is reflected in practice on grazing during the winter. Due to the relatively low intake of protein during the winter months, the metabolic faecal nitrogen becomes more prominent, and makes up a larger proportion of the total faecal nitrogen than during summer conditions, when the protein intake exceeds the maintenance requirements.

Sheep under winter conditions of grazing as represented by our July figures utilize the absorbed nitrogen with great efficiency as shown by the biological value of 83. This can be expected since these animals are definitely on a very low level of protein intake. The absorbed nitrogen is in most cases insufficient to supply the daily unavoidable losses of the body resulting from the endogenous protoplasmic activity. The result is that these sheep are continuously labouring under a complete negative nitrogen balance, as indicated in the Table.

When grazing conditions improve in the early summer with the coming of the first rains, the nitrogen content of the pasture responds immediately and attains an average value of 1·44 per cent., as shown by the October figures. Concomitant with this marked improvement in the protein content of the pasture there is also an equally marked change in the nitrogen metabolism of the sheep. The total nitrogen intake increases from approximately 2·3 grams in July to approximately 9·2 grams in October. The apparent digestibility during the month is 60 and the true digestibility 85. The absorbed nitrogen available for utilization is now about five times as great as during July conditions; and very decidedly above the maintenance requirement of the animals. Consequently the nitrogen is not utilized with such efficiency as during July, when the level of intake was very much lower and a protein shortage existed. The biological value obtained under October conditions is 60, which is not comparable to that of July, due to the difference in level of protein intake. However, it is clear that sheep during this season of the year is in a complete positive nitrogen balance. In fact it is doubtful if mature sheep could utilize a higher level of intake than that of October grazing to any greater advantage.

During January the nitrogen content of the pasture which has reached a more advanced state of growth has dropped to 1·17 per cent. This intake of nitrogen is, as will be seen from the metabolism data, adequate for the normal protein requirements of adult merino sheep. The protein contained in the grazing during this month is digested to the same extent as that of October. The average apparent digestibility is 51 and the true digestibility 88. Due to the slight decrease in protein content of the January pasture in comparison with that of October, there is naturally a more efficient utilization of the element during January. The average biological value is 74, compared with 62 during October.

In April, when the grazing has almost approached the winter state, its nitrogen content has dropped rapidly and averages 0·73 per cent. Nevertheless it is still slightly better than the July grazing, which represents grazing conditions during mid-winter. During April the total faecal nitrogen very nearly approaches that of the total nitrogen intake. The apparent digestibility of 12 per cent. is, however, still better than the 2 per cent. obtained under July conditions. It is evident that under April conditions of grazing, the protein intake has again dropped below maintenance level. Consequently efficient utilization is made of the meagre quantities of absorbed nitrogen, as is witnessed by the average biological value of 82 obtained for that period. As would be expected from the analysis of the metabolism data, sheep are definitely in a negative nitrogen balance.

Discussion.

A few points of practical and scientific interest arise from a consideration of the data. Firstly there appears to be a striking correlation between the nitrogen content of the pasture, the apparent digestibility and the biological value. In the former case the relationship appears to be direct or linear, while in the latter case the biological value appears to be inversely related to the protein content. Thus with a nitrogen content of 0·49 per cent., the apparent digestibility is 2 per cent. ond the biological value 83. With a nitrogen content of 0·79 per cent., the apparent digestibility is 12 per cent. and the biological value 82. In January the nitrogen content is 1·17, the apparent digestibility 51 and the biological value 74, while these figures in the above order is 1·44 per cent., 60 per cent. and 62 for October. From this relationship it appears possible to arrive at average figures for digestibility and biological value, if the protein content of the pasture is known.

Secondly it is interesting to note that during periods when the protein content of the grazing is low, the metabolic faecal nitrogen represents a greater proportion of the total faecal nitrogen than during periods of higher protein intake. It is believed that the endogenous portion of the metabolic faecal nitrogen, which is assumed to be constant per unit of weight, becomes more evident, as Schneider has shown under submaintenance conditions.

Thirdly, it is evident from the metabolism data, that although sheep utilize the protein of the grazing in April and July with great efficiency, the total intake of this element is nevertheless inadequate

to supply the maintenance needs of mature sheep. From October to January, however, there is no shortage of protein in the pasture. In fact the grazing during these months supply ample protein for maintenance and growth. From a practical animal husbandry point of view it is, therefore, essential that the protein deficiency prevalent in the grazing from April to September be scientifically and economically rectified.

Summary and Conclusions.

By means of controlled metabolism experiments it was shown that the biological value of the proteins in the natural grazing of the Transvaal varies according to the season of the year. During April the average biological value is 82, and during July the value obtained is 83. When the nitrogen content of the pasture increases, the biological value decreases. In October the average biological value is 62, and in January 74.

It has been shown by means of the above data that there is a protein deficiency in the pasture during the entire winter, starting in April and concluding round about August or September.

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