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The Endogenous Nitrogen Metabolism of Young Sheep with Reference to the Estimation of the Maintenance Requirement of Sheep.

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That the maintenance requirement of nitrogen of an animal can be measured by the total nitrogen excretion in the urine after the endogenous level is attained, is now generally accepted. On this basis, the endogenous nitrogen excretion of mature sheep was measured (Smuts and Marais 1938) and the results interpreted in relation to the maintenance requirement of protein. However, it is evident from the literature that the relationship between the endogenous nitrogen and basal metabolism established by Smuts (1935) for mature animals may also hold good for young animals. Du Bois (1916) with human beings, Deighton (1934) with pigs, Mitchell (1926) with rats, and Ritzman and Benedict (1930) with sheep, have shown that the basal metabolism of immature animals is invariably higher than that of mature animals of the same species. On the other hand, from data of Terroine (1933) with rats, it appears that the endogenous nitrogen metabolism reacts in the same way and follows the same general trend as the basal metabolism. Consequently it follows that the endogenous nitrogen metabolism, and therefore the maintenance requirement of protein for immature sheep will be greater than that already established by us for mature sheep.

In this study an effort was made to measure the endogenous nitrogen metabolism of young sheep with a view to establishing their maintenance requirement.

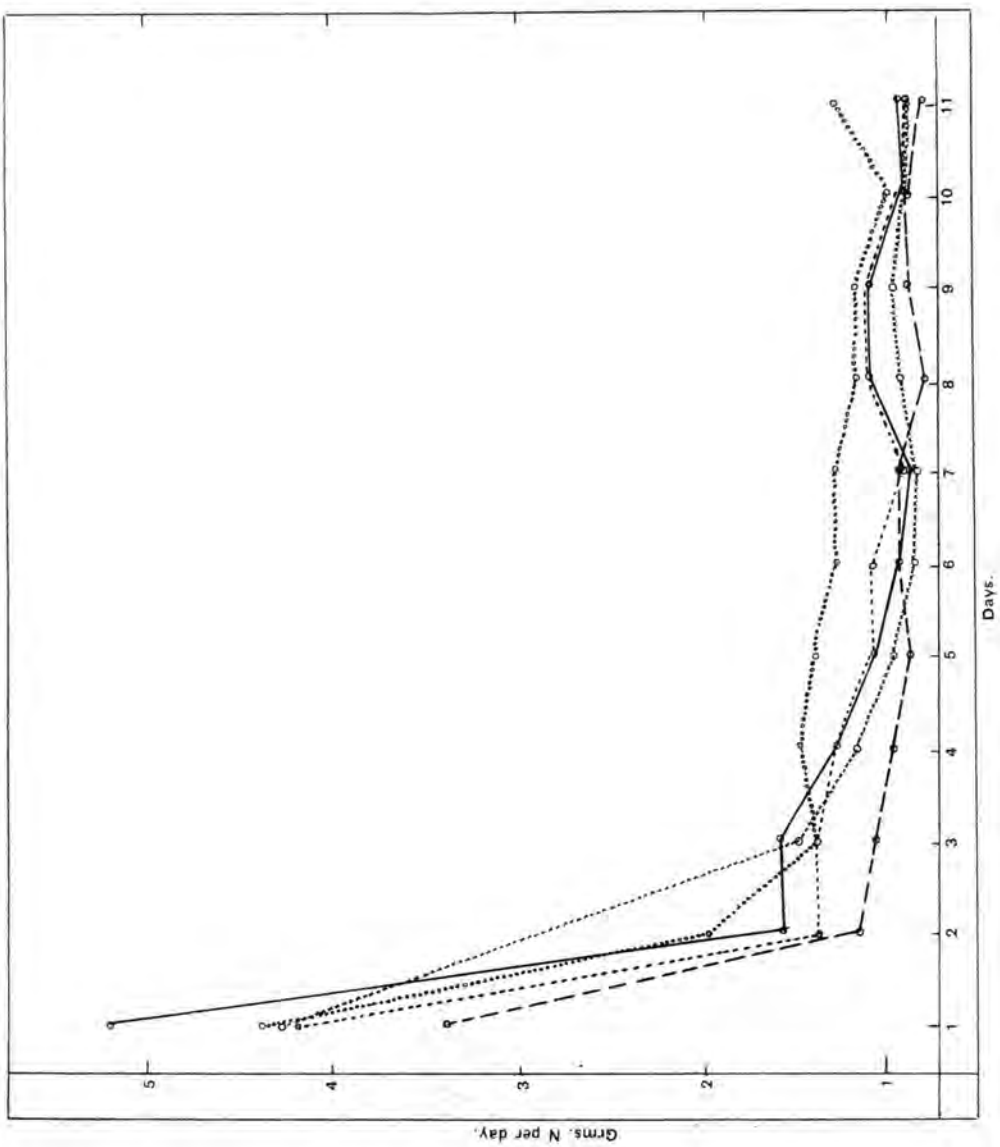
Experimental.

Nine young Merino wethers approximately four months of age, and weighing from 17 to 28 Kgms., were utilized. These sheep were put for 3 weeks on a standard ration containing 14 per cent. lucerne protein. After the termination of this preliminary period, they were removed to the metabolism cages and put on a nitrogen-low ration, the composition of which is the same as previously described by Smuts and Marais (1938). It was, however, found

necessary to include 10 per cent. of wheat straw and to reduce the agar to 15 per cent. in order to ensure a high enough food intake to cover the energy requirements. By this method it was possible to study the complete curve of nitrogen excretion.

Experimental Results.

Curves representing the total nitrogen excretion in the urine of the 9 sheep on a nitrogen low ration are given in graphs 1 and 2. In comparison with mature sheep kept under the same standard

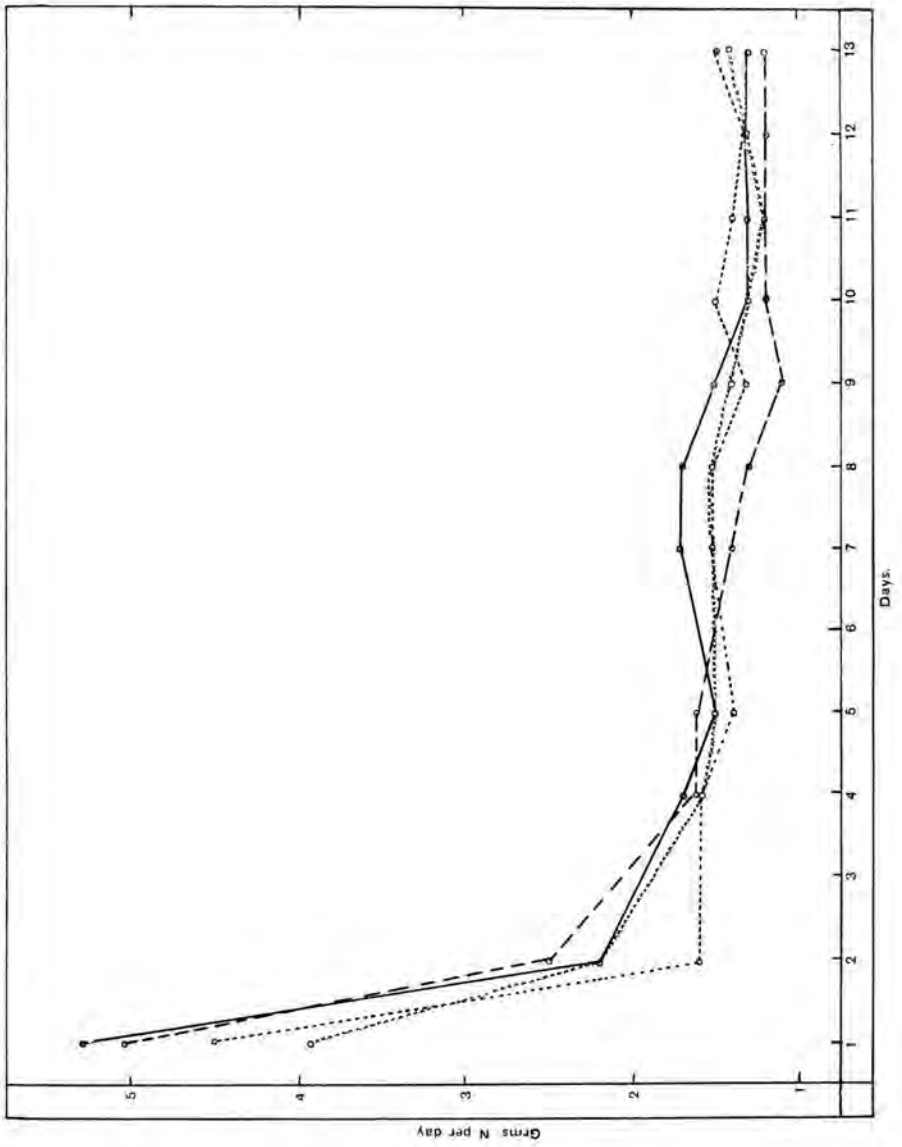


Graph 1.
Endogenous Nitrogen Excretion of Sheep on a N-low ration.

conditions of feeding, namely 14 per cent. lucerne protein, there exists a distinct difference in the nitrogen elimination, when placed on a nitrogen low ration. With mature sheep, it was noticed that after the initial sharp drop in nitrogen excretion on the first day, there was a further prominent decrease up to the eighth day. Thereafter the decrease was more gradual, and such that the

GRAPH 2.

Endogenous Nitrogen Excretion of Sheep on a N-low ration.



endogenous level was only reached round about the 14th day. With young sheep, as will be seen from the graphs, the position is very different. There is in each case the characteristic sharp drop in the nitrogen excretion the first day, with a very gradual reduction up to the 5th or 6th day, when in nearly every case the endogenous level is attained. From there onwards the curve representing the daily urinary nitrogen almost assumes a straight line representing a very constant output. Thus there appears to be a distinct difference in the amount of nitrogen stored by the actively growing sheep and the non-growing or mature sheep. Such a difference may be expected on the basis that the growing animal needs in addition to its maintenance requirement, a substantial portion of the available nitrogen for tissue synthesis, leaving thus a much smaller fraction of the total nitrogen intake for reservation. This statement is endorsed by the fact that mature sheep on an 8 per cent. lucerne protein ration for 3 months, attain their endogenous level after 6 days on a nitrogen low ration, in comparison with 14 days after a 14 per cent. lucerne protein ration. This indicates, that at the higher level of protein feeding almost twice as much nitrogen was available for storage as at the lower level.

The endogenous nitrogen per unit weight in accordance with the general view, is higher for young sheep than for mature ones. The average figure recorded by us for mature sheep is ·041 grms. per Kg. weight, while for immature sheep the average figure obtained in this study is ·051 grms. per Kg. Expressed on the basis of utilizable protein these figures per 100 lb. weight become 11·6 grms. and 14·4 grms. protein.

In trying to find a general method for estimating the protein requirements for maintenance, it was stated in an earlier paper [Smuts and Marais (1938)] that the formula adopted by Smuts (1935) for the prediction of the protein requirements of mature animals of different species could be applied to sheep. However, after assembling all the data thus far obtained on the endogenous nitrogen excretion of sheep, it was found that the percentage deviation from the determined values by the application of the above formula could be decreased considerably by the introduction of a different constant. In Table 1 the data pertaining to the endogenous nitrogen determinations are tabulated. From these figures a value for k in the formula $P = kW^{\cdot 734}$ has been established. As will be seen, the same value for k was obtained for mature and young sheep. This value was then introduced into the formula and the utilizable protein predicted, as shown in column 6. In column 7 the percentage deviation has been determined. For mature sheep this deviation is only $\pm 2{\cdot}5$ per cent., and with young sheep $\pm 5{\cdot}4$ per cent. The magnitude of these deviations is considered exceptionally small and much less than the deviation when the general formula $P = {\cdot}88\ W^{\cdot 734}$ for different species is applied. Consequently the new formula $P = {\cdot}74\ W^{\cdot 734}$ appears to be better applicable for the estimation of the protein requirements for maintenance of mature as well as young sheep. In this formula P equals utilizable protein and W weight in Kgm.

TABLE 1.

Formula for Predicting the Endogenous Nitrogen (Protein) of Sheep.

Animal No.	Weight in Kgm.	End. N. as Determined.	End. N. Expressed as Protein.	Value k in $P = kW^{\cdot 734}$	End Protein $P = \cdot 74\ W^{\cdot 734}$	Percentage Deviation from Value.
			MATURE SHEEP.			
1	44·5	2·03	12·69	·78	11·99	− 5·5
2	40·0	1·81	11·34	·75	11·09	− 2·2
3	37·7	1·72	10·75	·75	10·62	− 1·2
4	42·0	1·84	11·50	·74	11·50	− 0·0
5	39·0	1·72	10·75	·73	10·89	+ 1·3
7	40·0	1·76	11·00	·73	11·09	− 0·8
8	44·0	1·79	11·19	·70	11·90	+ 6·4
9	50·0	2·01	12·56	·72	13·07	+ 4·06
10	40·0	1·75	10·95	·73	11·09	+ 1·3
		Average...	—	·74	—	± 2·5
			YOUNG SHEEP.			
1A	17	·907	5·67	·71	5·92	+ 4·4
2A	20	1·02	6·38	·70	6·67	+ 4·5
3A	22	1·00	6·25	·65	7·15	+14·4
4A	18	·930	5·81	·70	6·17	+ 6·2
5A	23	1·20	7·48	·75	7·39	− 1·2
6A	22	1·23	7·69	·80	7·15	− 7·0
8A	26	1·34	8·38	·77	8·09	− 3·5
9A	25	1·33	8·34	·79	7·86	− 5·4
10A	28	1·40	8·75	·76	8·54	− 2·4
		Average...	—	·74	—	± 5·4
		Average of Total.....		·74	—	± 4·4

In Table 2 the utilizable protein, digestible protein, and the minimum energy requirements (basal metabolism), have been predicted. The utilizable protein is directly calculated by means of the above equation, while the digestible protein is calculated from

TABLE 2.

Prediction of Maintenance Requirement for Protein for Sheep.

Weight in Kgm.	Weight in lb.	Utilizable Protein ($P = 74W^{\cdot 734}$)	Digestible Protein.	Basal Metabolism. Cal/day.	Basal Metabolism Cal/per Kgm.
15	33	5·40	10·80	432	29
20	44	6·67	13·34	534	27
30	66	8·94	17·88	715	24
35	77	10·06	20·12	805	23
40	88	11·09	22·18	887	22
45	100	12·10	24·20	968	22
50	110	13·07	26·14	1,046	21

the utilizable protein by assuming a biological value of 50. The latter assumption naturally provides for a fair margin of safety, since at maintenance level we have not experienced a biological value as low as 50.

The basal metabolism is calculated by assuming that the relationship of 2 mgm. endogenous nitrogen or 12·5 mgm. protein is equivalent to one Calorie of basal heat.

It is interesting to note that the digestible protein requirement as predicted by the general equation of $P = \cdot 88\ W^{\cdot 731}$ for a 100 lb. sheep is 29 grams, by the new equation 24 grams, and according to Armsby (1917) 27 grams. Naturally Armsby's figure holds good for any ration, while the figure obtained in this study will be greater or smaller depending on the biological value of the feed.

The basal metabolism in column 5 and expressed per Kg. weight in column 6 is interesting in view of the fact that it allows for an easy means of predicting the minimum energy requirement. A 100 lb. sheep according to our calculations would have a basal metabolism of 22 Calories per Kg. weight. This figure coincides with the average value of the W-W wethers, W 2-5, W2-41, W 2-12 and W 2-6 of Lines and Pierce (1931). Their average value for the four sheep weighing from 41 to 52 Kgms. is 22 calories per Kgm. Ritzman and Benedict (1930) obtained an average value of 27 calories per Kg. which is slightly higher than our figure. These sheep, however, were measured for their basal metabolism 18 to 37 hours after withdrawal of food and may probably not have reached the post absorptive condition. Armsby (1917) on the other hand, basing his calculations on the work of Henneberg and Kellner, arrived at a value of 16 calories per Kg.

For the EE lambs of 5 months of age, Lines and Pierce (1931) obtained an average value of 36 calories per Kg. This value is higher than our predicted value of 29 calories. However, it appears from the work of the above authors that the nutritional level of the animal or the seasonal changes in pasture may effect the basal metabolism. The seasonal effect is claimed to be due to the change in protein content. These factors may therefore partly be responsible for our lower endogenous nitrogen and consequently a lower predicted figure for the basal metabolism, since our sheep were kept on a low level of protein for a considerable time.

From the basal metabolism figures of Lines and Pierce (1931), and Ritzman and Benedict (1930), and our calculated values from the endogenous nitrogen, it appears that a very definite relationship exists between the basal metabolism and the endogenous nitrogen metabolism in sheep. Such a relationship would in future be of considerable value in assessing the value of either of these entities once the magnitude of one is known.

Summary and Conclusions.

In a study on the endogenous nitrogen excretion of immature sheep, it was found that young sheep reach their endogenous level on the 6th day, after having been on a standard ration of 14 per cent. lucerne protein. The endogenous nitrogen excretion was found

to be higher than in mature sheep, the average value for 4 months old wethers being ·051 grms. per Kg. A formula for estimating the maintenance requirement of sheep was devised and its application tested. It was also shown that the basal metabolism of sheep can be predicted from the endogenous N, and that the figures arrived at agree very well with the values reported in the literature.

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