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# Studies in Mineral Metabolism XXXV.

# The Role of Iodine in the Nutrition of Sheep.

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## Introduction.

Work on the feeding of KI to sheep was begun at this Institute in 1929, mainly with the object of collecting information on the advisability of incorporating iodine in licks—a custom which was then being practised on a fairly extensive scale both in this country and abroad by stockmen. The results of the first investigation (1932) suggested:—

(1) That the administration of ·02 grm. KI daily to sheep affected their weight increase adversely when the diet contained insufficient phosphorus.

(2) That on an adequate ration the iodine supplement was without effect on body weight.

(3) That reproduction was apparently interfered with and became abnormal in regard to both the gestation period and the health and vitality of the offspring, when iodine was given, irrespective of the presence or absence of sufficient phosphorus in the diet. These results might obviously have been influenced by the quantity of potassium iodide given and hence in a subsequent experiment (1935) ·002 grm. KI per head per day was given to a group of sheep, ·02 grm. to a second group and ·06 grm. to a third, while complete records were kept of the oestrous cycle of all the animals. The phosphorus intake was adequate and the same in all the groups. It was further realised that the results of the first investigation were probably complicated by the low vitamin A content of the diet which was rectified in the

subsequent work. The results of this experiment showed that oestrum was normal in all the groups and that the KI was without effect on the bodyweight of the sheep. In regard to reproduction, however, the results, although by no means as unsatisfactory as in the first investigation, left much to be desired and suggested that the protein of the basal ration of maize and hay was apparently either inadequate or too poor in quality for normal reproduction and lactation. Hence the present experiment was planned to determine the effect of iodine in the ration of sheep when only poor quality protein was available and secondly when in addition the supply of vitamin A was low or inadequate as might and often does occur under conditions of practical farming in this country.

## Details of Experiment.

The remaining 28 ewes used in the previous experiment on iodine feeding mentioned above were re-divided into four groups each consisting of seven approximately even and uniform animals. The number of animals in each group was increased to 10 with ewes of the same age and conformation as those already available.

The four groups of 10 sheep were placed on the following rations:—

| *Groups.* | *Rations.* |
|---|---|
| 1 | Hay *ad lib*, 225 grm samp and ·05 grm KI |
| 2 | Ration of group 1 plus 200 grm green feed. |
| 3 | Ration of group 2 plus 50 grm blood meal. |
| 4 | Ration of group 3 but omitting the KI |

10 grm. bonemeal were added daily to the ration of each sheep.

The management and individual feeding of the sheep were essentially the same as in the earlier work of which the details were given in the first publication (1934). The samp (maize endosperm )was almost always completely consumed and this ensured the regular ingestion of the KI which was added in solution to the maize after the latter had been weighed and placed in the feeding boxes. The green feed in groups 1, 2 and 3 was given in separate feeding boxes in the individual feeding pens in which all the sheep were placed daily at 2 p.m. and left until 8.30 a.m. the following morning. Hay was available in racks in the common run to which the sheep had free access when they were not in the feeding boxes. Water was always available in the common gravelled paddock. The experiment was continued long enough for full observations on one period of reproduction and lactation; it was started in February, 1935, and concluded at the end of February, 1936.

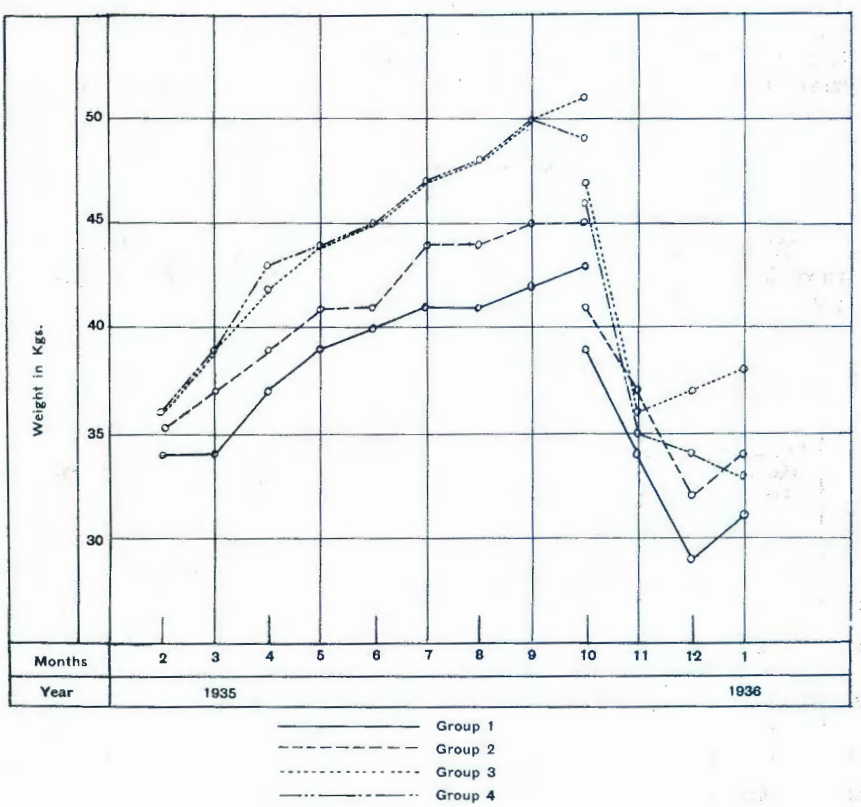
As in the previous work observations were made on weight increase, food consumption, wool production and reproduction. In view of the regularity of oestrum, previously observed, further observations were not made in regard to this matter but the ewes were served in May, 1935, when all except one became pregnant.

## Results.

### (1) *Bodyweight.*

The sheep were weighed at monthly intervals and the average weights per group are given in figure 1 below. The weight of the non-pregnant ewe in group 4 is not included in the curve for that group.

Figure 1.




In order to compare the effects of lambing on bodyweight in the different groups the weights of all the sheep just prior to lambing were averaged for the separate groups and the averages plotted on the same ordinate. By this means the curves are more directly comparable as the gestation periods of all the sheep but one, which was not pregnant, and the lactation periods of those that reared lambs are made to synchronize. The effect of shearing is indicated by a perpendicular drop in the curves of October, 1935.

A glance at Figure 1 indicates that groups 3 and 4 receiving a protein supplement of 50 grms. bloodmeal daily differed significantly from the other two groups in weight. As no difference in bodyweight existed between these two groups prior to lambing, however, their more rapid increase in weight cannot be associated with the KI supplement which only one of the two groups was receiving but with the greater nutritive value of the blood meal diet. Group 4 was apparently more adversely affected by lambing and lactation than group 3 but this is readily explained by the fact that the former group reared 8 lambs and the latter only 5, which would naturally favour weight increase in group 3 subsequent to lambing. When groups 1 and 2 are compared it would seem that the presence of greenfeed in the latter group had no noticeable effect on weight increase at any stage of the experiment. When the post parturition periods of all four groups are compared it is seen that the weights of the animals in group 4, which reared the largest number of lambs, continued to drop, while the others showed an earlier recovery.

### (2) *Weight of Lambs.*

Weekly body weights of the lambs were taken as these might serve to indicate the milk production of the ewes. The weights are given in Table 1 below:—

*Group I.*

TABLE 1.

| No. of Ewe. | Gestation Period. Days. | Sex of Lamb. | Weights of Lambs. | | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | Birth Wt. | 14th Day. | 21st Day. | 50th Day. | |
| | | | lb. | lb. | lb. | lb. | |
| 32900. | 153 | Ewe | 7 | — | — | — | Died two days after birth. |
| 41795. | 154 | Ram | 6 | — | — | — | Died one day after birth. |
| 32917. | 149 | Twin Ewes | 5 | — | — | — | Died one day after birth. |
| | | | 3·5 | — | — | — | |
| 32916. | 149 | Ewe | 6 | 9·5 | 10·5 | 15 | |
| 41825. | 147 | Ram | 5·8 | — | — | — | Died one day after birth. |
| 32888. | 151 | Ewe | 7·5 | — | — | — | Died one day after birth. |
| 41787. | 150 | Ewe | 7 | 15 | 17 | 22·5 | |
| 32885. | 149 | Ram | 6 | — | — | — | Died three days after birth. |
| 32905. | 146 | Ram | 5 | — | — | — | Died three days after birth. |
| 32889. | — | — | — | — | — | — | Ewe died at beginning of experiment. |
| | TOTAL..... | | 38·8 | 24·5 | 27·5 | 37·5 | |
| | AVERAGE..... | | 5·9 | 12·3 | 13·8 | 18·7 | |

*Group II*

| No. of Ewe. | Gestation Period. Days. | Sex of Lamb. | Weights of Lambs. | | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | Birth Wt. | 14th Day. | 21st Day. | 50th Day. | |
| | | | lb. | lb. | lb. | lb. | |
| 32887. | 149 | Ram | 6·5 | 9·5 | 11 | 16 | — |
| 32902. | 150 | Ram | 6·5 | 16·5 | 16·5 | 22·5 | — |
| 41693. | 151 | Ewe | 5·5 | — | — | — | Died one day after birth. |
| 41868. | 147 | Ram | 6·5 | — | — | — | Died two days after birth. |
| 32911. | 151 | Ram | 9 | — | — | — | Born dead. |
| 32896. | 151 | Ewe | 7·5 | 13·5 | 15 | 22 | — |
| 31817. | 151 | Ewe | 6·8 | 13·5 | 15 | 19 | — |
| 32893. | 153 | Ewe | 7 | 13 | 15·5 | 22 | — |
| 32891. | 152 | Ram | 7·5 | 9·8 | 10·5 | 15·0 | — |
| 32906. | — | Ewe | 7·2 | 15·5 | 16·5 | 21·5 | — |
| | TOTAL..... | | 70 | 91·3 | 100·0 | 138·0 | |
| | AVERAGE..... | | 7 | 13·0 | 14·3 | 19·7 | |

*Group III*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 32904. | 148 | Ram | 7·5 | 17·0 | 19·0 | 22·5 | — |
| 32895. | 150 | Ram | 8·4 | — | — | — | Died one day after birth. |
| 32907. | 153 | Ewe | 7·0 | — | — | — | Died two days after birth. |
| 41698. | 150 | — | 8·5 | — | — | — | Born dead. |
| 41789. | 152 | Ewe | 8·5 | 15·0 | 18·5 | 235· | — |
| 41881. | 167 | Ewe | 6·5 | 8·0 | 8·5 | — | — |
| 32903. | 150 | Ram | 7·5 | 15·0 | 17·0 | 23·5 | — |
| 32894. | 149 | Ram | 8·0 | 13·0 | 14·5 | 18·0 | — |
| 32894. | 149 | Ram | 8·0 | 13·0 | 14·5 | 18·0 | — |
| 32908. | 156 | Ram | 8·5 | — | — | — | Born dead. |
| | TOTAL..... | | 70·4 | 68·0 | 77·5 | 85·5 | |
| | AVERAGE..... | | 7·8 | 13·6 | 15·5 | 21·8 | |

*Group IV*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 32886. | 154 | Ewe | 7·5 | 22·0 | 22·5 | 27·5 | — |
| 32898. | 153 | Ram | 6·5 | 15·5 | 17·5 | 19·5 | — |
| 32883. | — | — | — | — | — | — | Ewe died at beginning of experiment. |
| 42020. | 151 | Twin Rams | 5·0 | — | — | — | Died one day after birth. |
| | | | 5·5 | 10·5 | 13·5 | 16·0 | |
| 32901. | 128 | Ewe | 6·5 | 13·0 | 15·0 | 21·0 | — |
| 41798. | — | — | — | — | — | — | Not pregnant. |
| 32910. | 152 | Ewe | 7·0 | 15·0 | 16·5 | 23·0 | — |
| 32914. | 150 | Ewe | 7·5 | 10·0 | 13·0 | 21·0 | — |
| 41754. | — | — | — | 17·0 | 20·0 | 28·0 | — |
| 32897. | 155 | Ram | 8·5 | 10·0 | 13·0 | 21·0 | — |
| | TOTAL..... | | 54·0 | 113·0 | 131·0 | 177·0 | |
| | AVERAGE..... | | 6·7 | 14·1 | 16·4 | 22·1 | |

The number of lambs reared in this experiment is too small to justify conclusions being drawn; in group 1 for instance only two lambs remained alive. One point is remarkable, however, viz. that in group 4, where 8 lambs were reared, all were strong and showed an increase which is perhaps just suggestive of better feeding conditions in this group than in group 2, for instance, where at least two lambs were below normal weight seven weeks after birth. Although milk production is admittedly important the available information, due mainly to the comparatively large number of lambs that did not survive the lactation period, is insufficient to justify definite conclusions in regard to the milk yield of the ewes as judged by the weight increase of the lambs.

### *Food Consumption.*

The food consumption of the individual animals was recorded by weighing back all the feed left over in the feeding boxes at weekly intervals. From the following figures which represent the percentages of food eaten per group for the full period it is obvious that no significant difference exists between the groups.

| *Groups.* | *Maize Eaten.* | *Green Feed Eaten.* |
|---|---|---|
| 1..... | 86 per cent..... | No green feed given. |
| 2..... | 86 per cent..... | 98·3 per cent. |
| 3..... | 90 per cent..... | 99 per cent. |
| 4..... | 92 per cent..... | 98 per cent. |

The absence of significant differences in the quantities of maize and green feed consumed by the respective groups indicates that groups 3 and 4 were daily consuming the additional protein contained in the 50 grm. of blood meal given, over and above that contained in the rest of the ration. Although this additional protein effected a more rapid increase in weight during pregnancy it was apparently without effect on the weight during lactation, during the first month of which all the groups showed remarkable decreases in weight. Hay was consumed at the rate of approximately 1·5 lb. per head per day.

### *Wool Production.*

The weights of wool produced are given in Table 2.

A glance at Table 2 reveals that groups 3 and 4 receiving the extra protein in their ration produced significantly more wool per head than groups 1 or 2 on maize and hay. This result confirms the observation made in regard to body weight that half a pound of maize, and hay of the quality usually available in this country, even if given ad lib, do not supply sufficient protein for wool production and reproduction.

TABLE 2.

*Weights of Wool in Kgs.*

| Group 1. | | Group 2. | | Group 3. | | Group 4. | |
|---|---|---|---|---|---|---|---|
| Nos. | Wt. of Wool. | Nos. | Wt. of Wool. | Nos. | Wt. of Wool. | Nos. | Wt. of Wool. |
| 32900.... | 3·6 | 32887... | 3·8 | 32904... | 4·1 | 32886... | 4·3 |
| 41795.... | 2·9 | 32902... | 2·7 | 32895... | 3·6 | 32898... | 5·0 |
| 32917.... | ♎ | 41693... | 3·2 | 32·07... | 3·8 | 32883... | ♎ |
| 32916.... | 3·4 | 41868... | 3·6 | 41698... | 4·3 | 42020... | 3·6 |
| 41825.... | 3·2 | 32911... | 4·3 | 41789... | 3·6 | 32901... | 4·6 |
| 32888.... | 4·1 | 32896... | 4·1 | 41881... | 5·5 | 41798... | 5·0 |
| 41787.... | 3·2 | 41817... | 3·4 | 32903... | 5·0 | 32910... | 4·3 |
| 32885.... | 4·3 | 32893... | 4·1 | 32894... | 4·5 | 32914... | 5·0 |
| 32905.... | ♎ | 32891... | 3·6 | 32908... | 4·3 | 41754... | 3·4 |
| 32889.... | ♎ | 32906... | — | — | — | 32897... | 4·8 |
| TOTALS..... | 24·7 | | 36·4 | | 34·6 | | 40·0 |
| AVERAGES..... | 3·5 | | 3·6 | | 4·3 | | 4·4 |

It must be pointed out, however, that the weights of the grease wool are given in Table 2 and that the increased wool production in groups 3 and 4 must be regarded as tentative until further studies on the fleeces have been completed.

The KI supplement given to all the groups except 4 was clearly without effect on the weights of the wool produced.

*Reproduction.*

Details in regard to reproduction are given in Table 1.

Table 1 reveals several interesting points: With the exception of group 4 where no KI was given reproduction was very unsatisfactory. In group I where greenfeed was omitted and vitamin A deficient only 2 lambs of the nine born survived. In groups 2 and 3 receiving greenfeed and greenfeed plus bloodmeal respectively reproduction was not normal. In group 4 where 8 ewes lambed, 9 lambs were born, while one of the twin lambs died 3 days after birth. It is remarkable that reproduction was poor only in the three groups

receiving supplements of KI irrespective of other factors such as for instance absence of greenfeed in group 1, or supplementary protein feeding in group 3. The results have been summarized as follows:—

| Groups. | Remarks on Treatment. | Remarks on Production. |
|---|---|---|
| 1..... | Hay, maize and KI given. Vitamin A very low; protein poor in quality | All the ewes lambed; 7 lambs died within 3 days and 2 lambs reached the age of 7 weeks when they were discharged. |
| 2..... | Hay, maize, greenfeed and KI. Vitamin A adequate but protein still poor in quality | All the ewes lambed; 3 lambs died within 3 days and 7 reached age of 7 weeks (discharged). |
| 3..... | Hay, maize, greenfeed, bloodmeal and KI; quantity and quality of protein improved | All the ewes lambed; 4 lambs died within 3 days and 5 were discharged at 7 weeks. |
| 4..... | Hay, maize, greenfeed and bloodmeal. The ration is the same as that of Group 3, except that KI was omitted | One ewe not pregnant and one died in the course of the experiment. All the other ewes lambed. Of the 9 lambs born (1 pair of twins), 1 of the twins died, 3 days after birth. All the other were discharged when 7 weeks old. |

*Discussion.*

The bodyweights and data on food consumption can justifiably be dismissed without further discussion as the difference in bodyweights between groups 3 and 4 on the one hand and 1 and 2 on the other was not associated with the KI supplements, as already stated.

In regard to reproduction, however, the best group, as judged by the number of lambs reared was the one which did not receive KI in its ration. In the poorest group, viz. group 1, the vitamin A intake was too low for normal reproduction (Malan et al 1932) and it would again appear as in the earlier work just quoted that the vitamin A deficiency intensified the deleterious effect on reproduction of the KI in the ration. It is clear, however, from the results obtained in group 2, as was also concluded from the 1935 experiment, that the supply of 200 grm. greenfeed per animal per day, which provided adequate vitamin A, as reference to the vitamin A content of the liver will verify, improved but did not remove the cause of poor reproduction. The addition of bloodmeal to the ration, as was done in group 3, brought about no further improvement until the KI was omitted from the ration (group 4), when reproduction was significantly benefitted. Although the ration of group 4 contained bloodmeal it could probably easily be improved upon both in quality and palatability. Still, reproduction in this group was very satisfactory in spite of the one lamb of twins dying a few days after birth. On the addition of KI to this ration, however (group 3), reproduction was decidedly abnormal with 4 lambs living less than 3 days. As a matter of fact the effect of the bloodmel supplement seems to have been entirely masked by the deleterious effects of the KI supplement in group 3.

In the absence of an ideal ration it is impossible to state from a consideration of the available data that ·05 grm. KI administered daily to sheep will produce deleterious effects on reproduction under all conditions, but there can be no doubt that the only common factor in all three groups, showing unsatisfactory reproduction was the KI supplement, which on being omitted improved reproduction very considerably and significantly. The number of animals in the different groups is small for an experiment of this nature where many incidental factors might influence the rearing of lambs, especially when deleterious factors have been introduced. No final conclusion can be drawn in regard to the effect of KI on milk production.

### *Vitamin A Content of Livers.*

The vitamin A content of the livers of some of the lambs that died, was determined according to the method of Rosenthal & Erdelyi (1934) with remarkable results. The livers of four lambs in group 1 showed no vitamin A or only slight traces.

$\frac{N}{100}$ $KMnO_4$ solution was used as the standard colour against which the colour due to the presence of vitamin A was read in a 50 mm. Leitz colorimeter, the standard being placed at 10 on the millimeter scale. Readings to about 40 on the mm. scale could easily be taken and a trace is intended to mean a slight coloration but too ill-defined to be compared with the $KMnO_4$ solution.

It should be remembered that the quantity of vitamin A present is inversely proportional to the colorimetric reading; a trace indicates a reading greater than 40 against the Standard at 10 while stronger solutions can be expressed in terms of their colorimetric readings. 75 grm. of liver were used for each determination and the comparative quantities of vitamin A were then calculated for the total weight of liver as follows:—

$$\frac{(\text{reading of standard}}{(\text{reading of unknown}} \times \frac{\text{total weight of liver})}{75\quad)}$$

The values so obtained are obviously now directly proportional to the vitamin A content of the liver.

In groups 3 and 4 where greenfeed was given to the ewes the average values of the livers of the animals killed was approximately 250 while the comparative value of those killed in group 1 was not more than 10, suggesting that the vitamin A of the livers of the sheep in the latter group was only about a twenty-fifth of that of the two former groups. The livers of the lambs of the ewes in the groups mentioned show similar differences, as would be anticipated from the fact that the intake of one group was practically devoid of carotene while the other groups received daily approximately 20 mgm. carotene per head in the greenfeed, as determined by chemical analysis. Vitamin A is apparently supplied by the mother to foetus as was also observed and verified in the case of rats by Dann (1934). The livers of the lambs in group 1 contained little or no vitamin A and the livers of the mothers were practically devoid of it.

## Summary and Conclusions.

When the daily ration of Merino ewes contained ·05 gm. KI for a period of about twelve months no effects were observed in body-weight and food consumption. Reproduction was, however, abnormal in all the groups receiving the KI supplement, the effects of which were more pronouncedly deleterious in sheep on a carotene low diet than when 200 grm. greenfeed were supplied daily. The response to increased protein feeding in the form of bloodmeal was marked by the detrimental effect of KI on reproduction. As all the rations can easily be improved both in quality and palatability it cannot be inferred that the quantity of KI given will affect reproduction in sheep adversely under ideal feeding conditions. The conclusion is justified, however, that when greenfeed is absent or inadequate as frequently happens in practice good quality protein is not available and the incorporation of KI in sheep licks is distinctly dangerous and may even cause losses due to abnormal reproduction.

## REFERENCES.

MALAN, A. I.; DU TOIT, P. J.; AND GROENEWALD, J. W. (1930). Studies in Mineral Metabolism XXXIII: Iodine in the Nutrition of Sheep. 18*th Report of the Director of Veterinary Services and Animal Industry*, pp. 651-676 (1935). *Onderstepoort Journal*, Vol. 5, No. 1, pp. 189-200.

DANN, W. J. (1934). *Biochem. Jnl.*, 28, pp. 2141-2146.

ROSENTHAL, E., AND ERDELYI, J. (1934). The New Colour Test for Vitamin A. *Biochem. Jnl.*, 28, p. 41-

ROSENTHAL, E., AND ERDELYI, J. (1934). The New Colour Test for Vitamin A. *Biochem. Zft.*, 271, p. 414.