Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 5, Number 1, July, 1935.

Studies in Mineral Metabolism XXXIII.

Iodine in the Nutrition of Sheep.

SECOND REPORT.

By

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Introduction.

In 1932 a two-year experiment carried out at this Institute on the effect of ·02 gm. Potassium Iodide daily per head in the ration of three groups of ewes kept on different levels of phosphorus intake was reported on. The iodide was apparently without effect on the growth, food consumption, wool growth and mortality. In regard to reproduction detrimental effects were noticed during the second lambing season, 16 months after the beginning of the investigation in the groups receiving the iodide and the inference was made that a daily dose of ·02 gm. KI had a detrimental effect in 1931. Mention was made of the possibility that a smaller dose of KI might not have produced harmful effects and that a new experiment had been started in which progressively larger doses of KI were given to different groups of ewes to investigate the matter of size of dosage and its effect. The latter experiment is reported on in this publication.

A study of the literature reveals that iodized stock licks are still widely recommended by investigators who claim to have obtained good results from Iodine feeding (Mason 1933, Weiser and Veghelyi 1932, Klein 1933, Wendt 1931, Potter *et al* 1931, Scharrer 1933, etc.), although it should also be mentioned that several research

workers have not been able to obtain beneficial effects (Crichton 1931, Malan, du Toit, and Groenewald 1932, Lines 1933, Forbes, Karns *et al* 1932, etc.). Some of these latter workers suggest that the indiscriminate use of iodine in stock licks may even affect stock detrimentally; Crichton concludes that our present state of knowledge does not warrant the general practice of feeding supplementary iodine to cows. As a careful survey of the literature strongly suggests that reports of adverse results of iodine feeding are, generally speaking, on the increase, the above conclusion of Crichton should, in the opinion of the writers, be made to apply to stock generally and even to poultry. While evidence against iodine feeding is accumulating, practical agriculturists would be wise to pause in order to consider whether the inclusion of iodine in their supplementary feeds is worth the extra cost of this product. It should however be mentioned, as was done in the first publication (Malan, du Toit, and Groenewald, 1932), that the continuous use of small quantities of iodine in stock licks or feeds has not been demonstrated conclusively to be detrimental to the health or production of stock, and that this and the hope of producing beneficial effects are probably the main causes of the continued use of iodine in stock licks and supplementary feeds.

By iodine feeding is meant the inclusion of iodine or its compounds in licks and feeds of livestock as advised by many enthusiasts without consideration of the existence of an iodine deficiency, under which conditions, as for instance in areas where endemic goitre occurs, it seems more than reasonable to expect beneficial results from the addition of iodine to the daily ration of animals. Most of the work done on this problem dealt with the effect of iodine feeding without regard to the existence of an iodine deficiency and was undertaken with the intention of finding out whether or not any extra benefit will accrue if iodine is given to stock apart from the question whether extra iodine over and above that which the constituents of the ration contain, is required. No attempt is therefore made to keep the iodine content of the ration low, which obviously might vary for different countries and may explain partly the differences in the results obtained by different workers as stated in the earlier publication (Malan *et al* 1932).

It is interesting to note that the chemical analyses of foodstuffs do not always confirm the existence of an iodine deficiency in goitrous areas (Ucko 1932, Blom 1933) and strengthens the view that endemic goitre cannot always be attributed to iodine deficiency *per se* (Ucko 1932, Olesen 1933). However, low iodine in foods is usually associated with the occurrence of goitre.

Description of Experiment.

Forty uniform two-tooth merino ewes were selected and divided into four groups. These animals were kept in a small gravelled paddock 60 ft. by 90 ft. Individual feeding pens were built in an

adjoining paddock where the animals were allowed to take their concentrates and green feed during the early afternoon and overnight. During the rest of the day they were kept in the larger paddock mentioned above. Across this paddock is a shed for shelter and a hay rack about 60 feet long, where the ewes had free access to hay regularly replenished. Drinking water was always available. The green feed and the concentrates were given in separate wooden boxes in the individual feeding pens. Food consumption was registered by weighing back at intervals the feed left over, although the ration was such that it was almost invariably completely consumed as stated later in this article. The sheep were weighed at monthly intervals, shorn four times in the course of the experiment, inspected daily, kept practically free from internal parasites throughout the course of the experiment and dipped against keds on a few occasions. The fleeces were kept for differential study, and observations on oestrum were made regularly. No attempt was made to exercise the sheep and this was considered unnecessary in view of the frequent disturbance of the sheep at weighing time, feeding, oestrus and general inspection.

Feeding.

All the sheep were given the same basal ration, viz.—

225 grms. crushed yellow maize;

225 grms green feed.

Hay *ad lib.*

The maize and green feed were given daily in small separate wooden boxes in the individual feeding pens. Teff hay was given in a rack *ad lib.* and the total consumption recorded, from which it appeared that each sheep consumed on an average 2 lb. of hay daily. The KI was given in solution by adding it to the maize which, as already stated, was consumed without exception. The stock solution of KI contained 10 grms. KI per 5,000 c.c. solution and was given to the groups as follows:—

Group I—controls—received no KI solution.

Group II received 1 c.c. KI solution, i.e. ·002 gm. KI.

Group III received 10 c.c. K.I. solution, i e. ·02 gm. K.I.

Group IV received 30 c.c. KI solution, i.e. ·06 gm. KI.

The ration was adequate for growth and the sheep remained in prime condition except during lactation when insufficient protein was present and consequently a rapid drop in weight took place. This statement is confirmed by a glance at the weight curves of the sheep.

The green feed consisted of green lucerne, or green maize or barley or even silage depending on the green feed available, which was cut and then given. The green feed was not always readily

eaten but the total quantity left over a period was negligible. For instance, the maximum amount of green feed left by an animal for the whole period March, 1932, to October, 1934, was about 10 kg. out of the total of 164 kg. given and hence a complete record of the green feed left is omitted from this publication. In any case the green feed was included in the basal ration not on account of its feeding value, i.e. the nutrients it contained but to eliminate vitamin A deficiency, the effects of which might interfere with the course of the experiment or at all events can easily be made to appear in sheep and cattle kept on a dry ration for a period (du Toit *et al* 1935).

Practically all the green feed that was not eaten was left during the rainy period October, 1933, until April, 1934. The feeding boxes were not protected against rain and the green feed was invariably left untouched and was weighed back as " not eaten " after precipitation. The average quantity of green feed left per sheep per group during the experiment was as follows:—

Group I—controls: 4·5 kg.
Group II—receiving ·002 grm. KI: 4·4 kg.
Group III—receiving ·02 grm. KI: 5·6 kg.
Group IV—receiving ·06 grm. KI: 4·4 kg.

These figures may be worthy of record but the group differences are certainly insignificant.

Weighing.

The records of the monthly weights of the four groups of sheep are given in figures I, II and III. The weight curve of the control group is given in each figure for comparison.

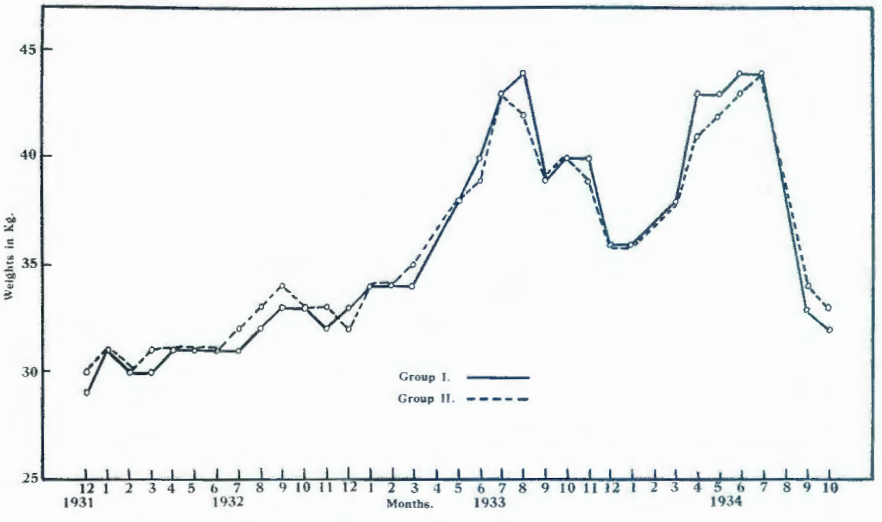

Fig. I.—Monthly Weights of Sheep.

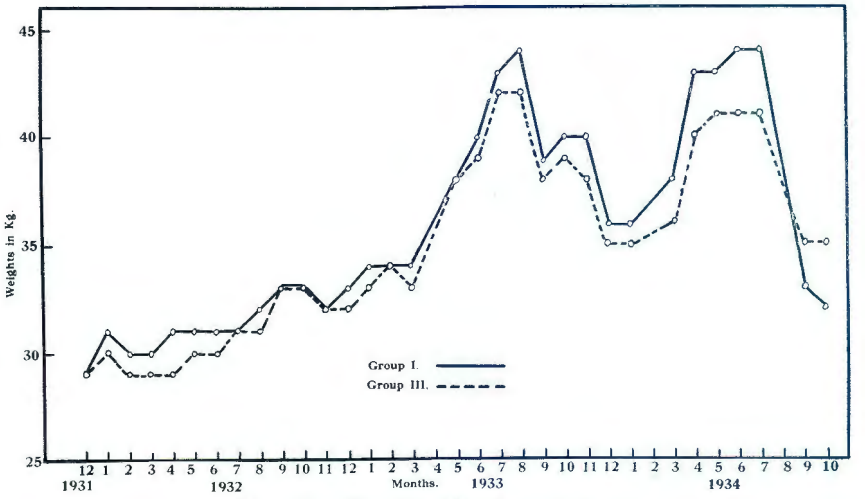

Fig. II.—Monthly Weights of Sheep.

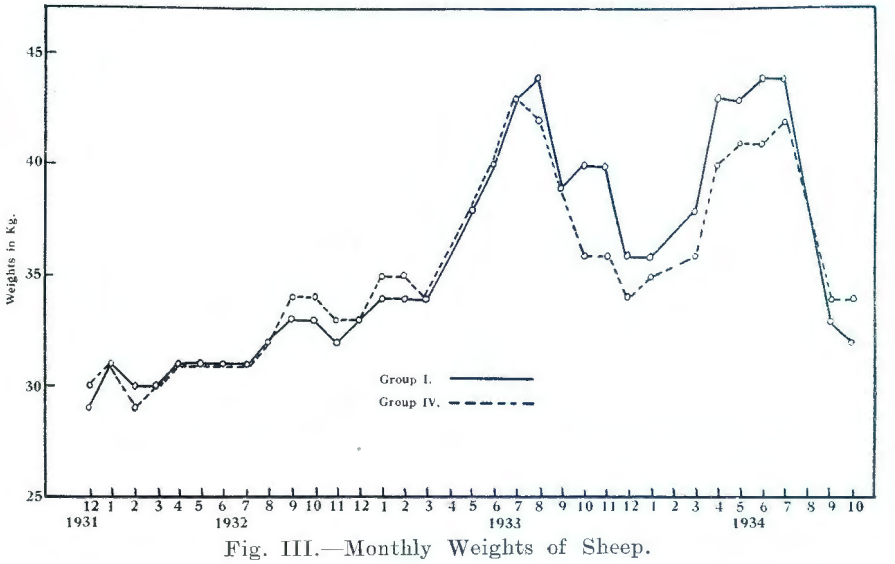

Fig. III.—Monthly Weights of Sheep.

The animals were weighed in the morning after they had been kept away from water and hay for about 15 hours and this method was found to be very satisfactory for recording correct weights when weighing only once per month.

A glance at figures I, II and III reveals the fact that significant differences in the weight curves of the sheep are absent. Apparently therefore different quantities of KI were without effect on the weight increase of the sheep. The remarkably sudden drops in weight from August, 1933, and again from July, 1934, were due to lambing and subsequent lactation which will be dealt with more fully under reproduction. During these periods the decreases in weight were apparently not affected by the KI present.

Wool Produced.

A record of the wool produced in 1931, 1932 and 1934 respectively, each calculated on the basis of 365 days' growth, which can be done, as the annual growth of wool, according to Bosman (1935), takes place proportionately throughout the year, provided the conditions of feeding are not changed, is given in the table below:—

TABLE I.

Wool Production (grams) per 365 days.

(Clean weights expressed on dry basis and grease weights on airdry basis.)

Group I.

Experiment No.	Grease weight, 1931. Pre-experimental period.	Clean dry weight.	Grease weight, 1932. Experimental period 1st year.	Clean dry weight.	Grease weight, 1934. Experimental period 3rd year.
32882	3,878	1,556	3,474	1,347	ewe died
32889	4,119	1,692	3,713	1,538	3,438
32897	4,045	1,703	3,688	1,574	3,287
32898	3,612	1,608	3,550	1,547	3,080
32905	4,526	1,833	4,002	1,602	3,515
32886	3,617	1,499	3,435	1,365	3,421
32913	3,878	1,517	3,807	1,467	ewe died
32914	3,491	1,760	3,295	1,544	3,105
32921	3,954	1,784	3,081	1,441	ewe died
32890	4,097	1,858	ewe died	—	—
TOTAL.....	39,218	16,810	32,045	13,425	19,846
AVERAGE....	3,922	1,681	3,561	1,492	3,308

Group II.

Experiment No.	Grease weight, 1931. Pre-experimental period.	Clean dry weight.	Grease weight, 1932. Experimental period 1st year.	Clean dry weight.	Grease weight, 1934. Experimental period 3rd year.
32883	3,370	1,402	3,476	1,435	3,239
32888	4,242	1,822	3,702	1,500	3,459
32891	4,331	1,868	3,844	1,676	3,049
32896	3,587	1,560	3,239	1,443	2,877
32899	4,281	1,832	3,917	1,763	ewe died
32904	3,950	1,839	3,459	1,388	3,328
32907	3,342	1,420	3,467	1,514	3,207
32912	3,833	1,526	3,508	1,386	ewe died
32915	3,588	1,619	3,250	1,417	2,376
32920	3,503	1,431	3,313	1,316	ewe died
TOTAL.....	38,027	16,319	35,175	14,838	21,535
AVERAGE....	3,803	1,632	3,518	1,484	3,076

Group III.

Experiment No.	Grease weight, 1931. Pre-experimental period.	Clean dry weight.	Grease weight, 1932. Experimental period 1st year.	Clean dry weight.	Grease weight, 1934. Experimental period 3rd year.
32884	3,875	1,824	3,126	1,374	3,489
32887	3,778	1,909	3,052	1,532	2,998
32892	4,428	1,889	3,936	1,565	ewe died
32895	3,454	1,632	2,747	1,333	2,658
32900	3,583	1,503	3,417	1,476	3,475
32903	4,675	1,722	4,596	1,761	3,384
32908	3,400	1,465	3,358	1,187	3,381
32911	3,642	1,667	3,175	1,290	2,809
32916	4,035	1,708	3,444	1,428	2,851
32919	4,121	1,672	3,202	1,329	3,450
TOTAL.....	38,991	16,991	34,063	14,275	28,495
AVERAGE....	3,899	1,699	3,406	1,428	3,166

Group IV.

Experiment No.	Grease weight, 1931. Pre-experimental period.	Clean dry weight.	Grease weight, 1932. Experimental period 1st year.	Clean dry weight.	Grease weight, 1934. Experimental period 3rd year.
32885	4,409	1,893	3,886	1,700	3,839
32906	3,466	1,496	3,254	1,274	2,871
32893	4,104	1,691	3,539	1,535	3,347
32894	4,049	1,674	3,479	1,399	3,208
32901	4,398	1,794	3,618	1,356	3,798
32902	3,330	1,482	3,133	1,214	2,041
32909	3,745	1,674	3,196	1,325	3,081
32910	3,808	1,572	3,063	1,158	3,173
32917	3,501	1,472	2,711	1,140	2,514
32918	4,201	1,915	3,714	1,680	4,094
TOTAL.....	39,011	16,663	33,593	13,781	31,966
AVERAGE....	3,901	1,666	3,359	1,378	3,197

The 1931 and 1932 fleeces were scoured to obtain the weights of clean wool but as these results are entirely insignificant when the wool production of the different groups is compared for these two seasons, i.e. when no iodine was given (1931) and when iodine was given (1932) scouring the wool was discontinued and only the grease weights for 1934 are given. The amount of wool produced in 1933 was unfortunately not registered. A statistical analysis of the weights of wool produced revealed no significant difference. As a matter of fact the weights are remarkably constant. In the entire absence of significant differences in the weights of wool produced by the groups receiving KI when compared with the control group and with the wool weights prior to KI feeding it may reasonably be concluded that the quality of the wool was not affected by the feeding of KI to the sheep (Bosman 1935).

A summary of the wool production data appears in Table 2, which represents the wool production of the different groups during each of the four years that the sheep were under observation. This table gives the results of wool production at a glance.

TABLE II.

Average Wool Production of Groups (grams).

	Supplements.	1931 clip.	1932 clip.	1934 clip.
Group 1.....	No iodide	3,922	3,561	3,308
Group 2.....	·002 gm. KI.	3,803	3,518	3,076
Group 3.....	·02 gm. KI.	3,899	3,406	3,166
Group 4.....	·06 gm. KI.	3,901	3,359	3,197

Reproduction.

In the last publication (Malan *et al* 1932) it was concluded that ·02 grm. KI had detrimental effects on reproduction and it was furthermore suggested that limiting factors such as phosphorus deficiency might intensify the effects of iodine feeding. In that experiment it appeared that the sheep on the lowest phosphrous intake and given KI aborted sooner and produced less live lambs than those on a higher P intake during the second lambing season. Even in the KI group receiving adequate phosphorus abortions occurred and lambing was a failure.

In considering the available data and the ill effects of KI the authors state the following: " Whether the detrimental effect was entirely due to the iodine administered is difficult to state positively, but that the iodide seemed to aggravate the state of affairs is almost a certainty, and apparently much more so in the group receiving a minimum of phosphorus in its ration." Subsequent work has revealed that vitamin A deficiency was an additional limiting factor and that, just as P deficiency appeared to exaggerate the effects of iodine feeding so vitamin A deficiency most probably acted similarly. The work on vitamin A deficiency which is in the course of being published reveals an interesting fact, viz. that in the experimental feeding of cattle and sheep, especially in experiments on mineral metabolism where purified foods are often given, provision has to be made for the adequate supply of vitamin A. If this is not done complications in reproduction may be anticipated.

On looking at the lambing charts of the present experiment in the light of the earlier work (1932) it must be remembered therefore that the results in the earlier work were complicated by a vitamin A deficiency which was eliminated from the latter work and which most probably intensified the results obtained in the earlier experiment.

With regard to the observations on oestrum, fuller details of which will be published at a later date, it should be mentioned that the iodine supplements were found to have no significant influence on the occurrence, periodicity or the duration of oestrum.

The lambing charts for 1933 and 1934 are given in tables III and IV below.

TABLE III.

Lambing Chart, 1933.

No. of ewe and group.	Gestation period, days.	Details about lamb at birth.	Weight Kg.	Weight of lamb after 1 month.
Group I.				
32882	149	Normal lamb.....	2·7	Died of hunger 7 days after birth.
32889	148	,, ,, ...	3·9	7·2 Kg.
32897	147	,, ,, ...	4·4	9·4 ,,
32898	151	,, ,, ...	4·2	7·9 ,,
32905	151	,, ,, ...	3·4	Lamb died 3 days old. Ewe no milk.
32886	154	,, ,, ...	3·6	10·2 Kg.
32913	147	,, ,, ...	2·7	6·3 ,,
32914	151	,, ,, ...	3·2	8·4 ,,
32921	158	Dead lamb partly decomposed		Lamb dead.
AVERAGES..	149·8	Average weight..	3·5	Average weight 8·2 Kg.
Group II.				
32883	155	Lamb born dead...	4·6	Lamb dead.
32888	152	,, ,, ...	4·0	,, ,,
32891	150	Normal lamb.....	4·0	6·5 Kg.
32896	152	,, ,, ...	4·7	9·3 ,,
32899	—	Ewe died—pregnant	—	Ewe dead.
32904	147	Normal lamb.....	3·4	Died of hunger. Ewe not enough milk.
32907	150	,, ,, ...	4·2	Died of Hunger. Ewe no milk.
32912	152	,, ,, ...	3·4	5 Kg.
32915	150	,, ,, ...	2·7	6·1 Kg.
32920	154	,, ,, ...	3·7	Lamd died of hunger.
AVERAGES..	151·3	Average weight..	3·9	Average weight 6·7 Kg.
Group III.				
32884	153	Normal lamb.....	3·6	8·2 Kg.
32887	149	,, ,, ...	3·7	6·7 ,,
32892	152	,, ,, ...	4·6	10 ,,
32895	152	,, ,, ...	3·8	Lamb died 3 days old, Ewe no milk.
32900	150	,, ,, ...	3·7	Lamb died shortly after birth.
32903	152	,, ,, ...	3·8	Lamb died ,, ,, ,,
32908	153	Born dead.....	4·9	,, dead.
32911	149	Dystokia.....	4·8	Lamb dead, wrong preseravtion.
32916	151	Normal lamb.....	3·2	10 Kg.
32919	152	,, ,, ...	3·5	5·9 ,,
AVERAGES..	151·3	Average weight..	4·1	Average weight 8·2 Kg.
Group IV.				
32885	150	Normal lamb.....	3·7	9·3 Kg.
32906	151	,, ,, ...	3·8	6·2 ,,
32893	149	,, ,, ...	4·0	9·1 ,,
32894	149	,, ,, ...	4·5	8·8 ,,
32901	149	,, ,, ...	3·0	7·9 ,,
32902	149	,, ,, ...	4·7	10·2 ,,
32909	153	,, ,, ...	4·7	8·4 ,,
32910	153	,, ,, ...	4·6	8·6 ,,
32917	151	,, ,, ...	3·5	8·1 ,,
32918	147	,, ,, ...	4·1	7·9 ,,
AVERAGES..	150·1	Average weight..	4·1	Average weight 8·2 Kg.

TABLE IV.

Lambing Chart, 1934.

No. of ewe and group.	Gestation period days.	Details about lamb at birth.	Weight, Kg.	Weight of lamb after 2 months.
Group I.				
32882	150	Dead lamb.....	3·0	Dead.
32889	153	Healthy lamb.....	2·9	6·8 Kg.
32897	154	,, ,, ...	3·4	Died, age 3 days. Ewe no milk.
32898	145	,, ,, ...	3·5	7·7 Kg.
32905	149	,, ,, ...	2·3	10·4 ,,
32886	150	,, ,, ...	2·7	Died, 3 days old. Ewe no milk.
32913	149	,, ,, ...	3·0	Died, 2 days old. Ewe no milk.
32914	156	,, ,, ...	3·4	10·4 Kg.
32921	ewe died	—	—	—
AVERAGES..	150·8	Average weight..	3·2	Average weight 8·8 Kg.
Group II.				
32883	159	Dystokia.....	3·4	Died shortly after birth.
32888	152	Healthy.....	3·1	9·1 Kg.
32891	149	,, ...	3·5	5·5 ,,
32896	160	,, ...	3·3	Died, 21 days old. Ewe not enough milk.
32899	ewe died	—	—	—
32904	150	Healthy.....	3·3	10·4 Kg.
32907	149	,, ...	3·5	Died, 12 days old. Dipping accident.
32912	148	,, ...	3·6	Died of hunger, Ewe no milk.
32915	151	,, ...	3·3	Died of hunger. Ewe not enough milk.
32920	148	Dystokia.....	3·9	Dead shortly after birth.
AVERAGES..	151·8	Average weight..	3·4	Average weight 8·3 Kg.
Group III.				
32884	No lamb	No lamb.....	—	No lamb.
32887	150	Healthy lamb.....	3·0	Died 2 days old. Ewe no milk.
32892	149	,, ,, ...	4·1	Died. Ewe no milk.
32895	148	,, ,, ...	4·0	10·9 Kg.
32900	150	,, ,, ...	3·3	Died 24 days old. Ewe not enough milk.
32903	148	Dystokia.....	4·3	Died shortly after birth.
32908	148	Healthy lamb.....	3·9	6·8 Kg.
32911	147	Dead lamb.....	3·1	Dead.
32916	149	Healthy lamb.....	3·2	6·8 Kg.
32919	No lamb	No lamb.....	—	No lamb.
AVERAGES..	148·6	Average weight..	3·6	Average weight 8·2 Kg.
Group IV.				
32885	144	Healthy.....	3·7	Died 2 days old. Ewe no milk.
32906	150	,, ...	3·6	7·7 Kg.
32893	150	,, ...	3·8	6·4 ,,
32894	148	,, ...	3·6	7·7 ,,
32901	135	,, ...	2·9	10·4
32902	150	,, ...	3·4	Died 19 days old. Ewe not enough milk.
32909	148	,, ...	3·5	10·4 Kg.
32910	149	,, ...	3·6	Died 1 day old. Ewe no milk.
32917	150	,, ...	3·3	7·3 Kg.
32918	145	,, ...	3·4	Died 2 days old. Ewe no milk.
AVERAGES..	146·9	Average weight..	3·5	Average weight 8·3 Kg.

Several interesting points are brought out in the lambing charts. In contrast to the lambing results reported in the earlier work where a vitamin A deficiency was present, no abortions took place.

It is noteworthy that Bekker (1931) also reported abortions subsequent to feeding KI to sheep. The dose (·076 gm.) given was slightly larger than that of Group IV (·06 gm. KI) and what appears to be more important, pregnancy and lambing occurred during a period of drought when the vitamin A content of the pasture was at its lowest. The probability of abortions after KI feeding during droughts has an important practical aspect and seems to justify further investigation.

Four full-time and overtime foetusses were born dead in July, 1933 and two in 1934 out of a total of 38 and 36 pregnant ewes respectively. The gestation periods during both seasons were apparently unaffected by the KI supplement. Neither the birth weights of the lambs nor their weights at the time of their discharge from the experiments showed any significant group differences. The number of lambs that died of hunger during both seasons on account of lack of milk is remarkable. This number appears to be significantly less in Group IV in July, 1933, but not so in July, 1934, and there is not enough evidence that any one group did better than the other in this respect. It was noticeable indeed that the ewes, while being in excellent condition at lambing lost weight very rapidly during lactation and that in a remarkable number of cases they had no milk or not enough to keep the lambs alive. A protein deficiency was suspected during this period and the matter is being further investigated. The number of deaths of lambs in the separate groups is, however, not significantly different and it can only be concluded that the KI supplement here too was without effect. Apparently therefore no visibly detrimental effects of iodine feeding was experienced in regard to reproduction, nor can it be said that the iodine acted beneficially.

After the removal of the lambs at the age of three months the ewes dried off and directly began gaining in weight without change of diet.

Summary and Conclusions.

1. Data are presented on the effect of KI in the feed of 40 merino ewes for a period of 30 months.

2. The quantities of KI given per sheep daily were ·002 grm., ·02 grm., ·06 grm. in three groups respectively, while one group received no KI and acted as controls.

3. Observations were made on the food consumption, weight increase, wool production, reproduction and health of the animals for the full period of the experiment. Further, observations were made on the oestrus cycle of the ewes and no significant group differences were observed.

4. The animals were fed in individual feeding boxes except the hay, which was given *ad lib.*

5. It is concluded that neither the small dose nor the bigger quantities of KI fed had any visible effect on the weights, wool production and reproduction of the animals.

6. It is also pointed out that the ill effects ascribed to iodide feeding in the earlier work were apparently aggravated by another deficiency, the possibility of the existence of which was not considered in the earlier work, viz. vitamin A.

7. It is concluded that the addition of KI to sheep licks is unwarranted, may even produce visably detrimental effects under conditions of drought, when a vitamin A shortage may exist, and is to be discouraged in practical farming unless there is reason for believing that an iodine deficiency exists.

8. Further work on the effects of iodine feeding under practical conditions, as for instance during severe droughts when apparently detrimental effects may be experienced, is being undertaken.

The writers wish to acknowledge gratefully the assistance of Mr. A. P. Malan, Statistican, in dealing with the results given in the lambing charts.

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