The Use of Vitamin A Supplements for Sheep

By B. L. CAMPBELL*

THE sheep population of Australia now exceeds 130 million, spread over the greater part of the Commonwealth and grazing under a wide variety of climatic and nutritional conditions. In some areas, sheep may have to exist for long periods on dry native pastures or be fed supplementary rations, both of which can be low in carotene, the precursor of Vitamin A. In these circumstances, it is possible that the body reserves of vitamin A may become so depleted as to limit production.

Underwood and Conochie (1941), working with wethers and non-breeding ewes in two districts typical of a large portion of the agricultural areas of Western Australia, have shown that a marked seasonal change occurs in the vitamin A reserves in the liver of sheep grazing under the conditions normally experienced in these districts. After five to six months' grazing on the dry mature pasture species and cereal stubbles, considerable depletion occurred before the advent of green feed in the autumn. Underwood and Conochie (1943) further showed that the carotene content of all the annual pasture species fell from very high values throughout their growing period to very low values as the plants matured and dried off in early summer. Legumes,. when completely matured, were just as low in carotene content as the annuals., The dominance of climatic factors and stage of growth over species differences, was also shown. Continuing these studies, Underwood and Curnow (1944a), and Underwood, Colman, and Curnow (1948) investigated the carotene content of grains and fodders commonly used in supplementary feeding. They estimated that wheat, oats, barley or poor quality wheaten or oaten hay would not supply the minimum requirements of carotene for growth or for the prevention of night blindness, an early clinical symptom of vitamin A deficiency, and would be very inadequate for breeding stock even if fed to the limit of appetite.

Peirce (1945) found that young weaners and ewes kept in pens on a diet deficient in carotene, but adequate in other respects, showed rapid depletion of liver reserves and became night-blind after five months. Growth was normal for approximately one year, after which animals developed muscular incoordination, anorexia, and suffered loss of weight.

Peirce (1946), working in two low rainfall areas of South Australia with three-year-old ewes and wethers, found that in the autumn, between consecutive summer and winter grazing periods, all of the sheep examined had adequate reserves of vitamin A in the liver.

All animals are born with very low vitamin A reserves. The new-born lamb depends on the colostrum and milk from its dam for its supplies of vitamin A until pasture intake is sufficient to supply all requirements.

Peirce (1947) found a high concentration of vitamin A in the colostrum, of the ewe. The amount fell rapidly during the first week, but was still a rich source of vitamin A for the suckling lamb. Underwood and Curnow (1944b) found optimal values in the colostrum of Border Leicester x Merino and Merino ewes which had been grazing young green pastures for two months prior to lambing. The following summer was exceptionally long and dry, with ewes grazing carotene deficient pasture throughout pregnancy and for about two months previously. At the next lambing the vitamin A content of colostrum from the same ewes, while variable, had only about 20-30 per cent. of the values obtained in the previous summer. Milk from the Merino ewes nine days after parturition contained only a trace of vitamin A.

The effect of vitamin A deficiency on the reproductive capacity of various" animals is well known. For example, Gunn, Sanders, and Granger (1942) observed that seminal degeneration occurred in rams within three months when fed on diets deficient in carotene. Six to eight weeks elapsed after adequate

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amounts of carotene or vitamin A were given before semen quality returned to normal. This work was continued by Sapsford (1951), who related seasonal changes in spermatogenesis in rams to their plane of nutrition and to their vitamin A status.

Plasma vitamin A levels fell more rapidly in the rams on a higher plane of nutrition than in those on a lower plane. Morphological abnormality of spermatozoa, attributed to vitamin A deficiency, appeared at an earlier date in the high-plane group except when rams with presumably low stores of vitamin A in the liver were fed on the deficient diets.

The Commonwealth Scientific and Industrial Research Organization and the New South Wales Department of Agriculture have carried out co-operative experiments designed to obtain further information on the vitamin A requirements of sheep and the conditions under which vitamin A deficiency may occur. Production and drought maintenance rations have been used with different types of sheep and the comparative performance of weaners given vitamin A in various media studied. The results of these experiments are discussed in this paper.

I. THE EFFECT OF VITAMIN A SUPPLEMENTATION ON THE PERFORMANCE OF DIFFERENT TYPES OF SHEEP.

(a) Breeding Ewes.

Groups of full-mouthed ewes were completely hand fed from November, 1948, a production ration of wheaten chaff 45, oats 25, bran 25, and linseed meal 5 parts by weight with or without a ground limestone supplement, and were mated to lamb in July-August, 1949, and again in August, 1950. At the first lambing 79.1 per cent. of the lambs survived, compared with only 7.7 per cent. at the second lambing, when plasma vitamin A levels of the ewes had fallen to 10 μg. per 100 ml. plasma or less. Two doses each of 150,000 I.U. of vitamin A given to the ewes failed to prevent the loss of lambs during the succeeding four weeks.

The ewes were then mated a third time and a portion of them drenched at twelve successive fortnightly intervals with a vitamin A concentrate equivalent to 150,000 I.U. of vitamin A per head per fortnight. Thus each treated ewe was given a total of 1,800,000 I.U. of vitamin A. At the third lambing all lambs from the treated ewes survived, whereas only 8.5 per cent. survived from those untreated.

These results support observations made by other workers. Peirce (1954) has observed that the vitamin A reserves of mature sheep decline slowly. In one experiment the concentration of vitamin A in the blood of the animals did not fall below 15 μg. per 100 ml. plasma until they had been receiving for 16 months a ration supplying 10 μg. or less of carotene per kg. bodyweight per day. In another experiment the rate of depletion was even slower. On approximately the same low intake of carotene the concentration had only fallen to 21 μg. vitamin A per 100 ml. plasma after 19 months.

(b) Lambs.

Data collected in our experiments and also under field conditions have indicated that losses of lambs born during a drought may be due to vitamin A deficiency. Low plasma vitamin A levels have been obtained in unweaned lambs.

Experiments have been carried out to study the effect of dosing lambs with vitamin A supplements and the results of this work are reviewed briefly.

Treatment of ewes and their lambs with massive doses of vitamin A has been as follows:

Group I Both dams and lambs treated.
Group II Dams treated, lambs not treated.
Group III Dams not treated, lambs treated.
Group IV Neither dams nor lambs treated.

Treated ewes were given one million international units of vitamin A approximately 120 days before lambing. Treatment of lambs is indicated in Figure I, in which changes in plasma vitamin A levels are recorded. It is evident from these data that mean plasma vitamin A values for lambs in Groups II and IV had fallen to very low levels approximately 120 days after birth, whereas those of Groups I and III were still relatively high. Thereafter losses were heavy in the two untreated groups of lambs and totalled 11 (48 per cent.) compared with only two deaths (8 per cent.) in the two treated groups.

EFFECT OF VITAMIN A SUPPLEMENTATION ON PERFORMANCE OF LAMBS FROM TREATED AND UNTREATED EWES

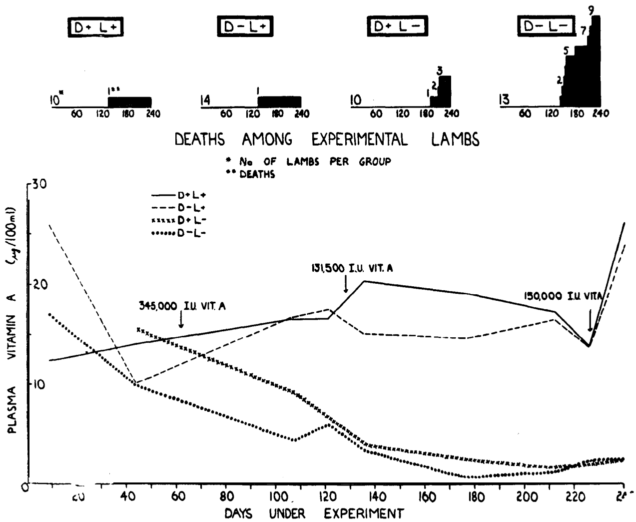

FIGURE 1: Effect of Vitamin A supplementation on performance of ewes and lambs.

It is obvious from these data that pre-natal supplementation of the ewe with vitamin A is not a satisfactory method of preventing vitamin A deficiency in the offspring. Treatment of the lamb is the most effective method under conditions where deficiency symptoms and losses would otherwise occur.

(c) Weaners.

It has been mentioned previously, Underwood and Conochie (1943), that some fodders frequently fed during droughts in Australia cannot supply the minimum requirements of vitamin A. This has been confirmed by Franklm et al. (1955). Uniform groups of Merino weaners were fed mixtures of 50:50, 10:90 or 0:100 parts by weight of wheaten chaff and wheat for 240 days. Some of these groups were fed at drought maintenance levels and others ad lib. One half of the weaners in each group received 500,000 I.U. of vitamin A after 21 days and 132 days later one half of the survivors of these treated the second dose did not significantly affect the performance of the weaners. sub-groups received a second dose of 345,000 I.U. of vitamin A. However,

TABLE 1: Summary of Losses in Groups Treated and Untreated with a Vitamin A Supplement.

	No Vitamin A		Plus Vitamin A	
Ration	Total	Died	Total	Died
50-50 wheaten chaff-wheat, daily and weekly	39	21	41	9*
10:90 wheaten chaff-wheat, daily and weekly	21	8	21	2†
0:100 wheaten chaff-wheat, daily and weekly	33	27	32	4‡
10:90 wheaten chaff-wheat, **ad lib.**	11	7	12	1*
50:50 wheaten chaff-wheat, **ad lb.**	11	1	11	0ns
Total — all rations	115	64	117	17‡

†Significantly different from the control groups at 5.0 per cent. level.
*Significantly different from the control groups at 1.0 per cent. level.
‡Significantly different from the control groups at 0.1 per cent. level.
ns.—Non-significant.

In general, deaths among the weaners did not occur until the blood plasma vitamin A had fallen to very low levels. Body weight was maintained fairly constant until some time before death when there was a rapid decline in body weight due to anorexia from vitamin A deficiency.

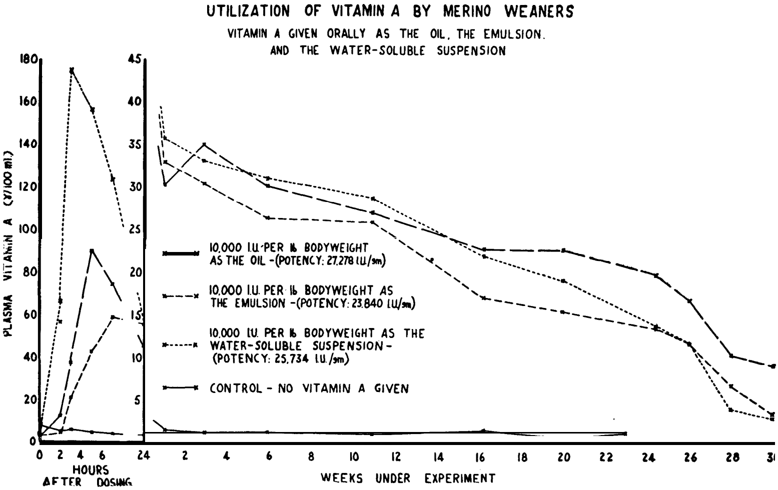

Figure 2: Effect of administration of Vitamin A in different media on performance of weaners.

II. ADMINISTRATION OF VITAMIN A IN DIFFERENT MEDIA

A number of vitamin A concentrates are available, including fish oils, emulsions and water-miscible products. Various claims, based mainly on work carried out with animals other than sheep, have been made concerning the relative value for sheep of these three classes of vitamin A supplement.

One of the few experiments dealing with the comparative efficiencies of absorption and utilization of these vitamin A preparations by ruminants was carried out by Bolin, Eveleth and Bolin (1950). However, their experiments were of short duration and mainly served to emphasize the need for a more detailed long-term study of this problem with ruminants. This has been included in our investigations. One experiment has been completed and a second one is still in progress, so that a summary only of the main points are included here.

In the first experiment, 27 seven-month-old Merino weaners were given a carotene deficient ration of oat grain only, plus 1.5 per cent. finely-ground limestone and 0.5 per cent. salt (NaC1), for 90 days prior to randomization into four uniform groups on the basis of body weight and plasma vitamin A levels. All animals were penned singly and continued to receive the same carotene-deficient ration. Weaners in three of these groups were treated by drenching with a single massive supplement of 10,000 I.U. of vitamin A per pound body weight, given either as the oil, the emulsion, or the water-miscible form.

Blood samples were collected before treatment, at 2, 3, 5, 7, and 24 hours' after treatment and thereafter at regular intervals until the vitamin A reserves were again depleted. Finally, survivors were slaughtered 36 weeks after drenching with vitamin A concentrates, and livers assayed for residual vitamin A. The data in figure 2 illustrate the comparative changes in mean plasma vitamin A concentrations of the untreated and three treated groups.

In a second experiment, 95 two-tooth Merino ewes were given the same ration as in the previous experiments, and after depletion of vitamin A reserves, were divided into four groups, three of which were treated similarly to those in the first experiment. Again plasma samples were collected immediately before and after vitamin A administration and at intervals over the succeeding 22 weeks. Groups of ewes, allotted at random prior to treatment with vitamin A, have been slaughtered at intervals in order to obtain comparative data on vitamin A storage in the liver.

Food consumption, the onset of night blindness, and other relevant data have also been collected in both experiments.

Daily feed intakes, body weight changes and plasma vitamin A levels have not been significantly different when the vitamin A supplement has been administered either as oil, emulsion, or in the water-miscible form. Liveweight increase, food consumption, and wool production have been significantly less in the untreated control animals.

The surviving sheep in the untreated control group, in the first experiment, were dosed with vitamin A in oil at the rate of 10,000 I.U. per pound bodyweight, eighteen weeks after the other three groups had been treated. The long period on the vitamin A deficient ration, associated with very low plasma vitamin A levels, did not apparently impair the efficiency of absorption of the above dose in so far as this could be determined from restored night vision and subsequent plasma vitamin A levels, bodyweight changes and food consumption data after treatment.

The night blindness test has proved a relatively effective means of diagnosing vitamin A deficiency. There has been a satisfactory correlation between night-blindness symptoms and plasma vitamin A levels. Animals which were night blind did not have plasma vitamin A levels greater than 14 μg. per 100 ml. Sheep which were night blind and had extremely low plasma levels of vitamin A had recovered full night vision when re-tested three days after treatment with 10,000 I.U. vitamin A per lb. bodyweight, and remained normal for at least 16 weeks thereafter.

III. PRACTICAL CONSIDERATIONS.

Under the simulated drought conditions of our experiments, it has been established that-

(a) Lambs and weaners are most likely to show clinical symptoms of vitamin A deficiency, whereas adult dry sheep can withstand long periods on carotene deficient rations.

(b) Administration of vitamin A to pregnant or lactating ewes is not nearly so effective in preventing avitaminosis A in lambs as is treatment of the lambs themselves.

(c) The occurrence of night-blindness was found to be correlated with plasma vitamin A levels and appears to offer a sound practical method for identifying vitamin A deficiency where laboratory facilities are not available.

(d) Sheep may have very low plasma vitamin A levels for some months without showing any clinical symptoms of vitamin A deficiency other than that of night blindness.

(e) The administration of vitamin A in oil, as an emulsion, or in the water-miscible form, is equally effective for sheep when administered as one massive dose.

(f) A dose of approximately 500,000 I.U. of vitamin A cured night blindness and restored plasma vitamin A levels to normal in deficient sheep. Night blindness symptoms began to re-appear approximately four months later, but satisfactory food consumption and growth were maintained for at least a further two months. Treatment at more frequent intervals than six months does not appear to be necessary.

(g) Finally, it should be stressed that an uncomplicated vitamin A deficiency is an infrequent occurrence.

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DISCUSSION OF PAPERS BY PROF. G. L. McCLYMONT AND MR. B. L. CAMPBELL.

Mr. P. R. KNIGHT: Is there any effective parenteral injection whereby lambs could be given a vitamin A supplement in lieu of oral administration?

Prof. McCLYMONT: From our own work with ewes and from published overseas results, injected vitamin A appears to be utilized less efficiently than that given by oral administration.

Mr. WILKIE: Were vitamin A levels determined on the milk from ewes discussed in Prof. McClymont's paper? There is evidence that the placenta acts as a barrier to vitamin A transfer in cattle and that bovine milk levels of vitamin A will be low when the vitamin A content of the feed is low, even though the dam may not be suffering from avitaminosis A.

Prof. McCLYMONT: In the early experiments milk vitamin A levels were low. All animals are born with low vitamin A reserves.

Mr. CAMPBELL: Ewes dosed regularly with vitamin A supplements produced colostrum which was rich in vitamin A, Milk from ewes given only two doses of vitamin A prior to birth of lambs was very low in vitamin A content. Similarly ewes receiving no vitamin A supplements at any stage had very low milk vitamin A levels.