Babkin[7] and by Gilman and Cowgill.[8] Ten experimental dogs were used in the course of the 11 diets studied; 3 of the animals were used on every ration studied; the tests were confirmed by further studies on from one to 5 other dogs.

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Vitamin A Deficiency in Cattle Under Natural Conditions.*

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On California ranges during the dry feed season, conditions are favorable for the development of vitamin A deficiency in livestock. Under average conditions, however, the length of the dry season coupled with the varied sources of feed containing some vitamin A is such that the reserves accumulated in the bodies of the animals from the green feed season are sufficient to carry them through the drought period. While its existence has been suspected during recent years, the past winter has been the first time the diagnosis has been definitely established. This was possible because weather conditions and management of one ranch in southern Tulare County caused its development in such a severe form that 100 animals died with many more showing symptoms in a herd of about 250 head.

The ranch comprises 3000 acres of land practically all of which is farmed to wheat and barley. The owner maintains 75 dairy cows. Calves from these cows, together with others purchased when a few days old from dairy farmers, nurse these animals. The calves are finally sold for veal.

In the spring of 1932 rains ceased early, resulting in the feed being dry and grain fields yellow by May 15. In the fall the first rains came about the middle of December and were followed by such cold weather that green feed did not become available until the middle of February, 1933.

During this unusually long dry feed period, of 9 months, part of

[7] Vineberg, A. M., and Babkin, B. P., *Am. J. Physiol.*, 1931, **97**, 69.

[8] Gilman, A., and Cowgill, G. R., *Am. J. Physiol.*, 1931, **97**, 124.

* This report is part of an investigation on the relation of nutrition to reproduction in livestock which became cooperative with the United States Bureau of Animal Industry, July 1, 1929.

the cattle grazed the unharvested grain fields through the summer. Thirty-five of the cows were left on a leased adjoining natural range until August 10th and then placed on stubble from which wheat and barley had been harvested. Early in the fall and through the winter they were fed roughage from a stack adjoining the corral. This consisted of straw mixed with wheat and barley hay showing some traces of green color. The hay came from the borders of the fields that were harvested for grain. Barley was the main concentrate fed. This was later supplemented with whole cottonseed. A group of about 50 steers purchased in October was brought in from native grass range and fed in dry lot. These steers, in addition to the straw, grain hay and barley, received 2 pounds daily of a proprietary concentrate feed containing 12% protein.

The deficiency manifestations were less marked in the adult cows than in the young stock. The general condition of the cows was poor, although 6 to 7 pounds of barley were being fed per head daily in addition to the straw and grain hay. When 2 parts of cottonseed and one part of barley were substituted for the barley alone there was evidence of improvement, but deficiency symptoms were not relieved. The most interesting symptom was night blindness, noticed in the twilight and after darkness when an electric light was turned on in the corral. If attempts were made to handle the cattle at this time they ran into each other, or objects in front of them, and became nervous and excitable. A few showed ophthalmia with ulceration of the cornea. The milk and cream from the animals entirely lacked color as did butter made from the latter.

These cows started to calve the latter part of August. The early calves were normal and although they became unthrifty, did not show definite symptoms until about 12 weeks of age. Birth of normal calves continued until late in the fall. During the months of December and January, however, when 25 to 30 cows calved, all of the calves were born weak, developed severe diarrhea and died when one to 5 days old. At this same time, calves purchased from dairymen on alfalfa ranches remained normal for 6 to 8 weeks after being brought on the ranch and nursing the same cows. This indicated the non-infectious nature of the diarrhea. One bull was kept on the ranch and although he was in poor condition during the winter, we do not have data regarding his fertility. Ability to serve cows was not completely lost. Many of the cows did not come in estrum for 5 or 6 months after calving, when green feed became available.

The feed lot steers varied in age from yearlings to 2-year-olds. The younger cattle were mostly affected. Eye lesions were the principal symptoms beginning with profuse lacrymation followed by clouding and ulceration of the cornea.

The young animals, varying in age from a few weeks to one year, showed the most marked and varied symptoms and the mortality was high. The eye lesions varied from profuse lacrymation and slight clouding of the cornea to extensive ulceration of the cornea, loss of aqueous humor, lens opacity and shrinking of the eyeball with complete and permanent blindness.

The appetites of the animals were capricious, there was intermittent diarrhea, general unthrifty appearance and pulmonary complications. With periods of inclement weather and exposure, pneumonia was the terminal condition causing death in nearly all cases.

Liver samples from 4 of the dead animals were brought to the laboratory, the liver oil extracted and tested with antimony trichloride after the method of Carr and Price[1] for the colorimetric determination of vitamin A. In all cases solutions representing as much as 10 gm. samples of liver tissue were negative. As we have demonstrated positive tests with solutions representing as little as 1 mg. of adult bovine liver tissue, we feel that the negative reaction with this large test quantity was evidence that the liver tissue in these cases contained no vitamin A.

Three animals moved to University Farm. On February 28, three animals were taken to Davis. No. 1 was a steer born on the ranch in March, 1932, and was weaned September 1. After weaning it was fed straw, grain hay, barley and salt. It first showed symptoms early in January. On February 28 it was extremely gaunt, totally blind, discharging profusely from the nostrils, quite unsteady on its legs and lacked appetite. Drenching with reconstituted dried skim milk was resorted to and in addition 30 mils of good quality cod liver oil was given daily. After 4 days the appetite began to improve, the discharge from the nostrils ceased and the muzzle became moist. It was continued on straw, barley and cottonseed meal plus the cod liver oil and made a complete recovery except for the loss of sight.

No. 2 was a steer born December 1, 1932. It came from an alfalfa ranch and grew normally during the first 6 weeks. While still nursing it developed severe diarrhea and eye lesions and showed evidence of lung involvement on January 19. On February 28, it was ex-

[1] Carr, F. H., and Price, E. A., *Biochem. J.*, 1926, **20**, 497.

tremely emaciated, the left cornea was badly ulcerated, the right cornea clouded and respiration was rapid. It was selected for pathological study without any thought of its surviving. It died on March 3, and showed extreme lung involvement which had gradually progressed over a period of 6 or 7 weeks to be the final cause of death.

No. 3 was a Holstein heifer born on the ranch November 15, 1932, and was still nursing its dam. The animal was in nearly normal condition of flesh but the right eye was badly affected with severe ulceration of the cornea. On February 28, its appetite was good and it was kept on the same diet as it had received at the ranch except that reconstituted dried skim milk was substituted for the milk of its dam. No cod liver oil was given. It gradually became worse, showing emaciation, intermittent diarrhea, irregular appetite and some evidence of lung involvement by rapid breathing under slight exertion. The regression of the animal was very gradual, considering the low vitamin A intake and its condition on arrival. It was killed March 10, in order to have fresh tissues for pathological study.

All of the animals on the ranch have recovered since the advent of green feed except for blindness in 2 cases, which will be permanent. This heavy loss could probably have been entirely obviated had the owner purchased alfalfa hay instead of the cottonseed in the fall.

The feeds on this ranch were inadequate in vitamin A, rather than completely devoid of it. The diet of the cattle was also low in calcium. The liberal feeding of grain, coupled with adequate protein when cottonseed was added, stimulated growth and milk production and is probably responsible for the severe incidence of deficiency manifestations. Under natural range conditions with deficient protein, phosphorus and low energy intake, the manifestations have been limited largely to reproductive difficulties, although the dry range forage is probably equally low in vitamin A.