

THE VITAMIN REQUIREMENT OF VARIOUS SPECIES OF ANIMALS

III. THE PRODUCTION AND CURE OF XEROPHTHALMIA IN THE SUCKLING

VICTOR E. NELSON, ALVIN R. LAMB

AND

V. G. HELLER

AMES, IOWA

It is a well known fact that vitamin A is necessary in the diet if normal growth and reproduction shall take place. In the absence of this particular dietary factor a condition known as xerophthalmia or keratomalacia results. It is equally well known that the higher animals cannot synthesize this vitamin and that they must depend, therefore, on green plant tissue as the ultimate source of the vitamin. During the past year some work has been done demonstrating that the quantity of this vitamin in milk will vary with the quantity of vitamin A in the diet.¹ This is to be expected since the animal cannot synthesize this unknown substance, and consequently if the vitamin is not present in the diet the mother cannot secrete it into the milk.

Andrews² showed that the milk of a mother whose children had died from beriberi, and whose diet was, therefore, presumably deficient in vitamin B, produced polyneuritis in suckling pups. It must be remembered, however, in this connection that the pups were fed a milk which was not normal for the species, and it may well be that the requirement of pups for vitamin B is different than that of man. We have some data on this point which will form a separate paper of this series.

McCollum³ has shown that mother rats which were kept on a satisfactory diet until the birth of the young and then were at once restricted to diets lacking vitamin A did not rear the young. He believed it probable that this milk was deficient in quality rather than quantity. He also reported the occurrence of sore eyes in young rats on diets deficient in vitamin A. These sore eyes, however, often occurred after the suckling period, when the young were consuming some of the mother's diet. He also noticed sore eyes on a ration

* Received for publication, Feb. 24, 1922.

* From the Department of Chemistry and the Agricultural Experiment Station, Iowa State College.

1. Drummond, Coward and Watson: *Biochem. J.* **15**:540, 1921.

2. Andrews: *Philippine J. Sc., Ser. B* **7**:67, 1912.

3. McCollum and Simmonds: *Am. J. Physiol.* **46**:275, 1918; McCollum, Simmonds and Pitz: *J. Biol. Chem.* **27**:33, 1916.

which contained 5 per cent. butter fat, but was deficient in other respects. We have noticed similar symptoms in both rats and rabbits on defective diets, which symptoms could not be relieved by the administration of butterfat. In a few cases the animals became totally blind. McCollum did not attempt to cure this condition by feeding vitamin A to the mother. In his experiments the mother rats no doubt had, at the beginning of the suckling period, considerable reserve of vitamin A in their tissues since they had been upon an adequate diet up until the young were born.

In a previous article we ⁴ have demonstrated that the rabbit requires more vitamin A than the rat for normal growth and reproduction. The rabbit consistently develops xerophthalmia on diets deficient in vitamin A.⁵ This symptom, however, is not to be confused with the occasional occurrence of sore eyes under other unfavorable conditions of environment and diet even though vitamin A is present in the diet. This latter type of sore eyes is probably due to direct infection.

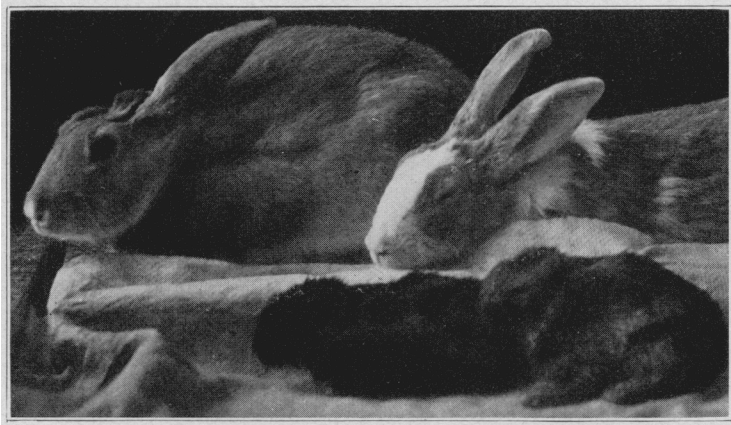
It is possible to feed a rabbit a diet which is below the optimum in its vitamin A content which will produce slow growth with no apparent symptom of dietary deficiency. This kind of diet was fed to six rabbits, five males and one female. The diet had the following composition:

White corn.....	55
Linseed oil meal.....	22
Oats	15
Meat meal tankage.....	5
Supplementary salt mixture.....	3
	100

This diet has been reported ³ as deficient in vitamin A and capable of producing xerophthalmia in young growing rabbits. The animals mentioned were started on this diet, however, at a weight of 2,000 gm. and were three-fourths grown. After a period of three months they reached an average weight of 2,400 gm. and appeared to be in excellent condition. They were healthy, fat, clear of eye and possessed sleek, fine coats. At this time the female gave birth to five young which she suckled and cared for in a normal manner. Soon after the birth of the young the mother began to lose in weight and developed symptoms of xerophthalmia. Two of the young died before their eyes were opened. The rabbit normally opens its eyes at the age of 10 days. About one week later a third young rabbit died with typical symptoms of xerophthalmia. The two remaining young, which were more vigorous, remained alive with distinct evidence of xerophthalmia. At this point the mother was given in addition to her ration from 1 to 2 gm. butter fat per day. The xerophthalmia in the mother

4. Nelson, Lamb and Heller: *Am. J. Physiol.* **59**:335, 1922.
 5. Nelson and Lamb: *Am. J. Physiol.* **51**:530, 1920.

cleared up slowly. One of the young (the black shown in the photograph with eyes swollen shut) had become very weak, and died three days later, although the eyes were considerably improved. The other young (grey shown in picture with its eyes almost swollen shut) showed marked improvement in the eye condition and began to grow very rapidly, doubling its weight in thirteen days thereafter. The two young were in very poor condition, had ceased growing entirely, and if butter fat had not been fed to the mother we believe they would certainly have died within twenty-four hours. It seems quite evident that the mother immediately transferred the vitamin A in the butter fat to her own milk and thereby relieved the offspring. During all this time the young were suckling the mother and eating no other food.



The effect of the strain of reproduction on the development of xerophthalmia. The grown rabbit on the left is normal. The doe on the right, on the same ration, developed xerophthalmia in both herself and young, which was cured in both by the administration of butter fat to the doe.

The mature rabbit on the left in the accompanying figure is a representative animal from the group on the above ration. This animal is much more vigorous than the one on the right and the difference in vigor is much greater than is apparent in the picture, which was taken at the time the butter fat feeding was begun. Up until the birth of the young, the two grown rabbits were equally vigorous. The mother rabbit on the right shows xerophthalmia which is indicated by the fact that the eyelids are swollen nearly shut. A typical film had developed on this eye at the time this photograph was taken. It is evident that the strain of reproduction and lactation brought about this symptom of the deficient diet which would otherwise not have become apparent. We are now studying the effect of breeding on the production of symptoms of dietary deficiency using the males of this group of animals on their present diet.