

Parasites of Cattle

- Flukes: *Fasciola hepatica* Linn.—Guam
Arthropods: *Boophilus annulatus australis* (Fuller)—Guam and Ponape
Amblyomma cyprium Neumann—Guam

Parasites of Swine

- Roundworms: *Stephanurus dentatus* Diesing—Guam and Ponape
Oesophagostomum dentatum (Rudolphi)—Guam and Ponape
Metastrongylus elongatus (Dujardin)—Guam

Parasites of Chickens

- Roundworms: *Tetrameres* sp.—Ponape
Heterakis sp.—Ponape
Tapeworms: *Amoebotaenia* sp.—Ponape
Raillietina sp.—Ponape
Arthropods: *Lipeurus caponis* (Linn.)—Ponape
Menopon gallinae (Linn.)—Ponape
Oxylipeurus angularis (Peters)—Ponape
Pterolichus obtusus Robin—Ponape and Guam
Megninia cubitalis (Megnin)—Ponape and Guam

Parasites of Dogs

- Roundworms: *Ancylostoma caninum* Ercolani—Ponape
Tapeworms: *Dipylidium* sp.—Ponape
Arthropods: *Ctenocephalides felis* (Bouché)—Ponape

Parasites of Rats

- Arthropods: (mites) *Laelaps echidnium* Berlese—Ponape

Parasites of Man

- Roundworms: *Ascaris lumbricoides* Linn.—Ponape and Truk
Strongyloides stercoralis (Bavay)—Ponape and Truk
Trichuris trichiura (Linn.)—Ponape and Truk
Wuchereria bancrofti (Cobbold)—Ponape and Truk
Hookworms (undetermined species)—Ponape and Truk
Enterobius vermicularis (Linn.)—Truk

THE RELATION OF NUTRITION TO ECTOPARASITES OF CHICKENS AND RATS. By L. KARTMAN

That nutrition of the host profoundly affects its parasites has been recognized for some time in the fields of both parasitology and economic entomology. During the past 10 years experimental work has shown that vitamin A,^{45A} thiamine,⁴⁶ and riboflavin⁴⁷ affect ectoparasite economy on the rat host. More recent work suggests that certain other factors also may be concerned. With the exception of experiments on cattle, in which it was concluded that vitamins A and D apparently have no relation to

^{45A}SEARLES, E. M., and SNYDER, F. M. A STUDY OF THE RELATION OF VITAMIN A TO LOUSE RESISTANCE IN RATS. Jour. Parasitol. 25(5):425-430. 1939.

KARTMAN, L. NEW DEVELOPMENTS IN THE STUDY OF ECTOPARASITE RESISTANCE. Jour. Econ. Ent. 36(3):372-375. 1943.

⁴⁶DE MEILLON, B., and GOLDBERG, L. DEVELOPMENT OF ORNITHODORUS MOUBATA ON NORMAL AND THIAMIN-DEFICIENT RATS. Nature 159:171. 1947.

⁴⁷GYORGY, P. PEDICULOSIS IN RATS KEPT ON A RIBOFLAVIN-DEFICIENT DIET. Soc. Expt. Biol. and Med. Proc. 38:383-385. 1938.

the economy of cattle lice, experiments involving hosts other than rats have not been conducted.⁴⁸

In 1947, experiments were undertaken to determine whether certain vitamin deficiencies have a specific effect upon the rat louse, *Polypylax spinulosa* (Burm.), and to determine whether there is a relation between malnutrition in chickens and infestation by the chicken body louse, *Eomeneantius stramineus* (Nitzsch).⁴⁹ In addition, observations were made on the effect of debeaking to determine the importance of the "grooming habit" as a delousing factor.

For the rat experiments, a strain of albino rats was obtained from the University of Hawaii Nutrition Laboratory colony and additional animals were secured from the Hawaiian Sugar Planters' Experiment Station. These were weanlings of both sexes between 26 and 28 days of age and weighing on the average about 45 grams. All rats were fed an identical basic ration free of all B-complex factors and vitamins A and D. The necessary vitamins were added to the ration in pure form and certain factors were withheld as desired. The rats were housed in groups of five per cage and received water and food *ad libitum*. Fresh water was provided each day to prevent growth of fungi or algae which might serve as a source of vitamins. When typical avitaminoses were noted, the rats were given an infestation of lice from "reservoir hosts" maintained as a source of these parasites. Control rats and those groups showing no symptoms were infested at a time generally corresponding to the onset of avitaminoses in the other test groups. The rats in all groups were maintained on the particular deficiency for a maximum period of 75 days after the initial infestation with lice except, of course, in cases where the animals died before this time.

It was observed that rats deficient in vitamin A, thiamine, riboflavin, and pantothenic acid maintained a mild pediculosis after infestation or until death. In no case did the number of parasites equal or exceed the original number placed on the host. In rats deficient in riboflavin the pediculosis was maintained for about 26 days after which the lice completely disappeared with the onset of alopecia on all these animals. These data confirm former observations on vitamin A and riboflavin, cited above, but do not appear to agree fully with the work on thiamine which was done with ectoparasites other than lice. In addition, the role of pantothenic acid in rat pediculosis⁵⁰ is given further support as is the observation that pediculosis is absent in riboflavin-deficient rats suffering with alopecia.⁵¹

The present data also suggest that rats fed diets deficient in pyridoxine, folic acid, and choline, respectively, were able to rid themselves completely of the initial infestation and a later reinfestation of lice. Control rats fed a complete ration also remained completely free of lice.

Table 52 summarizes data for tests involving thiamine, riboflavin, and pantothenic acid deficiencies in relation to rat pediculosis. This experi-

Table 51. Relation of various avitaminoses to rat pediculosis.

Rats fed ration lacking:	Number of rats	Sex	Average body weight (grams)			Number of lice with which infested at:		Pediculosis at termination of experiment or death of rats	Remarks
			Initial	Peak	At depletion	Depletion	12 to 27 days after depletion		
Vitamin A.....	5	3 ♂ 2 ♀	45.2	81.6	68.4	50	50	Pediculosis present	One rat died prior to reinfestation
Thiamine (B ₁).....	5	3 ♂ 2 ♀	53.6	98.0	71.8	50	50	Pediculosis present	Four rats died prior to reinfestation
Riboflavin (B ₂).....	5	3 ♂ 2 ♀	45.8	114.4	78.8	50	25	Pediculosis present	Mild pediculosis until 26 days after first infestation when all rats developed severe alopecia
Pyridoxin (B ₆).....	5	2 ♂ 3 ♀	46.2	146.8	106.6	50	25	Pediculosis absent	
Pantothenic acid...	5	3 ♂ 2 ♀	34.4	98.2	58.6	50	25	Pediculosis present	Two rats died prior to initial infestation
Folic acid.....	5	4 ♂ 1 ♀	36.0	205.6	....	50	25	Pediculosis absent	No avitaminosis noted
Choline.....	5	3 ♂ 2 ♀	45.8	178.8	....	50	25	Pediculosis absent	Extreme variation in symptoms among these animals
Control (no deficiency).....	5	3 ♂ 2 ♀	53.0	233.6	....	50	25	Pediculosis absent	Infested at time other groups showed avitaminoses

Table 52. Relation of certain B-complex factors to rat pediculosis.

Rats fed ration lacking:	Number of rats	Sex	Average body weight (grams)			Number of lice with which infested at:		Pediculosis at termination of experiment or death of rats	Remarks
			Initial	Peak	At depletion	Depletion	31 days after depletion		
Thiamine (B ₁).....	4	4 ♂	46.0	78.5	67.0	50	50	Pediculosis present	Therapeutic feeding of B ₁ reduced the lice from + to 0 within 30 days
Riboflavin (B ₂).....	10	4 ♂ 6 ♀	57.8	98.5	94.4	50	....	Pediculosis present	
Pantothenic acid...	10	3 ♂ 7 ♀	57.8	114.9	72.0	50	....	Pediculosis present	Two rats died prior to infestation with lice
Control (no deficiency).....	10	2 ♂ 8 ♀	55.8	187.9	....	50	....	Pediculosis absent	All these rats lost their lice 15 days after infestation

⁴⁸MATTHEWS, J. G. N. Y. (Cornell) Agr. Expt. Sta. Bul. 832. 1946.

⁴⁹BARGER, E. H., and CARD, L. E. DISEASES AND PARASITES OF POULTRY. War Dept. Ed. Manual—EM 879, pp. 1-399. 1943.

⁵⁰GYORGY, P., and ECKARDT, R. E. FURTHER INVESTIGATIONS ON VITAMIN B₆ AND RELATED FACTORS OF THE VITAMIN B₂ COMPLEX IN RATS. Biochem. Jour. 34:1143-1154. 1940.

⁵¹GYORGY, P. Personal communication to the author. 1948.

ment further confirms the positive effect on rat pediculosis of deficiencies of these factors in the diet. It is interesting to note that the rats on a thiamine-deficient ration were able to rid themselves of their lice within about 30 days with the therapeutic feeding of thiamine.

For the chicken experiments, White Leghorn chickens 8 weeks of age were divided into two groups on the basis of body weight. The heavier group was fed a normal diet while the lighter birds were maintained on a ration containing suboptimal amounts of animal protein and required vitamins. The preliminary experiment was based on the production of mild malnutrition in the birds, while the second test was based on severe malnutrition. Half the birds in each group were debeaked and regular observations on weight, state of health, and pediculosis were made. Periodic observations on the degree of pediculosis were based on aspirator samples of body lice obtained by means of a suction apparatus and standardized procedure in securing the sample (see fig. 18). All birds were infested with approximately equal numbers of body lice when body weight differences in the two groups appeared to be of significance as an index of relative state of health.

Tables 53 and 54 summarize data on the relation of mild and severe malnutrition in chickens to degree of infestation by the body louse. These data also point out the effect of debeaking on pediculosis. Birds showing a mild order of malnutrition exhibited no apparent difference in the degree of pediculosis as compared with birds in robust health. On the other hand, birds showing a severe malnutrition exhibited a significantly lower degree of pediculosis than birds in good condition. This trend apparently obtained from about 1 month after the initial infestation until the termination of observations 38 days later.

Observations on debeaking suggest that debeaked birds on a normal ration have a significantly higher degree of body louse infestation than their non-debeaked coop-mates feeding on the same ration. This correlation does not appear to be significant for birds suffering from either mild or severe malnutrition. It is interesting to note that the degree of pediculosis on normal birds with normal beaks is about the same as that for birds suffering from severe malnutrition. This might indicate that the lice were reduced mechanically in the first case and by a lack of essential nutritive factors in the second case. When the diets were reversed, as between the two groups of birds, a tendency for decreased pediculosis on the normal birds and increased pediculosis on the deficient birds became obvious within 34 days. The normal birds apparently began to lose their lice more rapidly than lice on the deficient birds increased (see table 55). It should also be noted that the relation of debeaking of the normal birds to degree of pediculosis was still in evidence after 34 days on the deficient diet. Non-debeaked birds harbored an average of 8.5 lice each and debeaked birds had an average of 18.0 lice each.

Acknowledgment is made to Merck and Company, Inc., New Jersey, which supplied the following vitamins: biotin, pantothenic acid, choline, niacin, riboflavin, thiamine, and pyridoxine; and to Lederle Laboratories Division, American Cyanamid Company, New York, which supplied the folic acid used in the diets.

Table 53. Relation of mild malnutrition in chickens to pediculosis, and effect of debeaking.

Type of diet	Number of birds	Sex	Age at start	Average body weight (grams)		Infested 11-20-47. Average number of lice per bird	Final louse count 3-8-48. Average per bird	Average number of lice on birds		Remarks
				Initial	Final			Not debeaked	Debeaked	
Normal . . .	10	10 ♂	8 weeks	451.5	1,619.7	150	37.7	27.5	41.8	Three birds died prior to initial count and are not included in data
Deficient . .	10	10 ♂	8 weeks	351.1	1,375.8	150	32.6	31.4	33.8	

Table 54. Relation of severe malnutrition in chickens to pediculosis, and effect of debeaking.

Type of diet	Number of birds	Sex	Age at start	Average body weight (grams)		Infested 4-13-48. Average number of lice per bird	Final louse count 6-17-48. Average per bird	Average number of lice on birds		Remarks
				Initial	Final			Not debeaked	Debeaked	
Normal . . .	14	8 ♂ 6 ♀	8 weeks	512.1	1,642.9	100	20.2	6.9	33.6	Seven birds died prior to initial count and are not included in data
Deficient . .	14	6 ♂ 8 ♀	8 weeks	412.7	732.4	100	6.9	4.8	12.0	

Table 55. Effect of reversal diet on chicken pediculosis.

Type of diet		Number of birds	Sex	Average body weight (grams)		Average number of lice per bird		Remarks
Original	Final			When diets reversed	Final	When diets reversed	Final	
Normal . . .	Deficient	8	4 ♂ 4 ♀	1,626.0	1,594.0	22.9	11.3	On deficient diet for 34 days
Deficient . .	Normal	4	4 ♀	798.8	1,086.8	4.8	6.5	On normal diet for 34 days