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PARASITOLOGY

INTRODUCTION. By J. E. Alicata

In the Territory, as in other temperate regions, parasitic diseases constitute one of the major problems in animal production. The Department of Parasitology attempts to cope with this problem, particularly as it affects cattle, poultry, and swine. With the increasing availability of reputable new drugs and insecticides in recent years, the Department has continued to give its major attention to the application of these new products to local parasite control. During the past year more attention has been given to parasites affecting poultry and most studies have been conducted cooperatively with the Departments of Poultry Husbandry and of Entomology. Of particular importance is this Station's finding that a water suspension of DDT and Lethane B–72 when used as a spray[34] is one of the most effective means of controlling ectoparasites (lice and mites) of poultry.[35] Since most of the internal parasites of poultry are directly or indirectly transmitted by arthropods breeding in poultry manure, laboratory tests have been conducted to screen out some of the older and newer insecticides to determine which ones are most effective. From these experiments have come a few promising insecticides which, however, need to be tried under field conditions to ascertain their limitations and practical methods of application.

In addition, departmental activity during the past year has included observations concerning the effectiveness of certain sulfonamides in the treatment of cecal coccidiosis of poultry, a disease of importance in Hawaii. Our observations have substantiated the reports of other investigators and lend to the belief that the finding of an effective treatment for coccidiosis constitutes one of the outstanding discoveries of economic importance to the poultry industry. Limited studies in this Station during the past year have shown that coccidiosis can be partially controlled experimentally through selective breeding. This method, although presenting many difficulties in its application, may prove to be one of the best approaches to the control of this parasite. Other brief studies of basic importance include: the relation of nutrition to ectoparasite infestation on rats and on chickens; importance of wild birds in the transmission of poultry parasites; efficacy of various concentrations of DDT-Lethane spray in poultry louse control;[36] and the economic losses of hog livers due to kidneyworm infestation in swine. Summary reports of these and other investigations of this Department appear below.

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[34]The application of DDT by the spray method for poultry ectoparasite control was first suggested in Telford, H. S. [DDT sprays.] Country Gent. 116(10):48–49. 1946.

[35]Rohm and Haas Co. (Philadelphia) in their Technical Bulletin L-1-47 independently arrived at a similar conclusion.

[36]See Entomology Department report for further discussion.

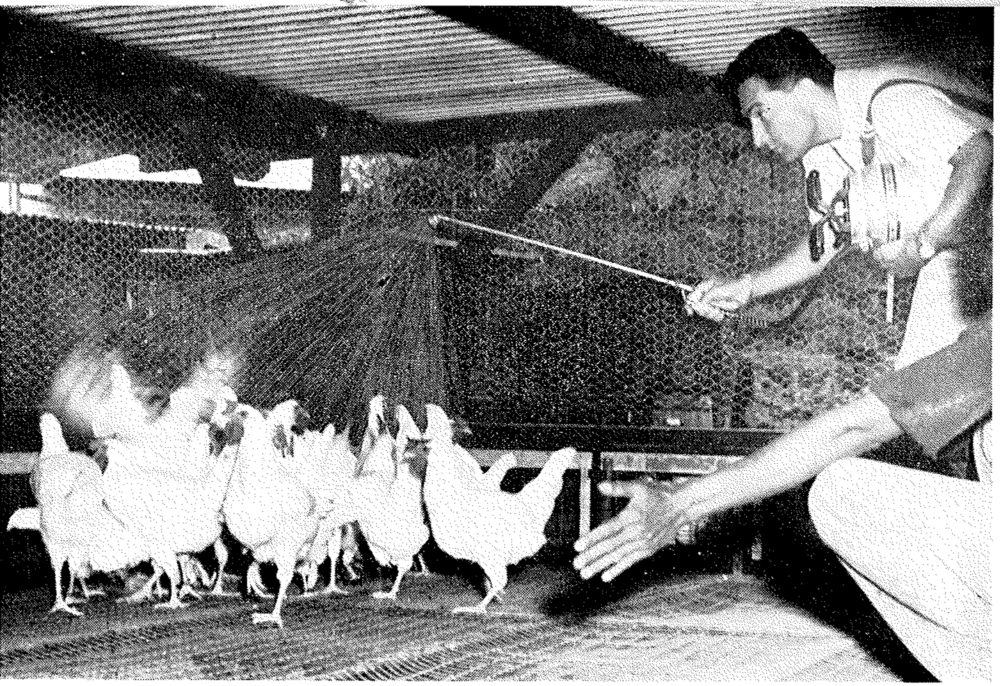

Figure 17. Controlling external parasites of chickens by spray. The new method, recently suggested on the Mainland, and the utilization of DDT-Lethane suspension, developed by this Station, form simple and effective means of controlling poultry lice and mites.

DDT-LETHANE SPRAY IN THE CONTROL OF LICE AND MITES OF CHICKENS. By J. E. ALICATA, L. KARTMAN, T. NISHIDA, and A. L. PALAFOX

In 1946, Telford[37] reported that DDT used as a spray on flocks of chickens effectively contolled louse infestation. Because few and conflicting reports were available on the effects of DDT on mites, experiments were conducted to confirm the value of DDT spray on louse control under local conditions and to determine also its effects on local poultry mites. Moreover, since Lethane dust had been found by this Station[38] to be effective in the control of lice and mites, it was decided to test the effectiveness of Lethane spray and the combination of Lethane and DDT against these pests.

Preliminary tests, reported in more detail elsewhere,[39] showed that DDT spray, applied at the rate of 1 pound of 50 percent wettable DDT to 5 quarts of water, gave effective control of lice and partial to complete control of mites. Sprays with Lethane B-72, applied at the rate of $\frac{2}{5}$ pound to 1 quart of water, gave complete control for mites and partial to complete control for lice. Combination of the two insecticides at the rate of 1 pound of 50-percent DDT and $\frac{3}{4}$ or $\frac{1}{2}$ pound Lethane B-72 in 6 quarts of water resulted in the complete control of both lice and mites within 1 week. The species of ectoparasites found in the chickens

[37]TELFORD, H. S., Country Gent. 1946, *op. cit.*

[38]ALICATA, J. E., HOLDAWAY, F. G., QUISENBERRY, J. H., and JENSEN, D. D. OBSERVATIONS ON THE COMPARATIVE EFFICACY OF CERTAIN OLD AND NEW INSECTICIDES IN THE CONTROL OF LICE AND MITES OF CHICKENS. Poultry Sci. 25 (4):376-380. 1946.

[39]ALICATA, J. E., KARTMAN, L., NISHIDA, T., and PALAFOX, A. L. EFFICACY OF CERTAIN SPRAYS IN THE CONTROL OF LICE AND MITES OF CHICKENS. Jour. Econ. Ent. 40(6):922-923. 1947.

were: lice—*Eomenacanthus stramineus* (Nitzsch), *Goniocotes gallinae* (De Geer), *G. gigas* Taschenberg, *Lipeurus caponis* (Linn.), *Menopon gallinae* (Linn.); mites—*Megninia cubitalis* (Megnin).

A METHOD OF COLLECTING ECTOPARASITES FROM BIRDS. By J. E. ALICATA

During the past few years a simple and practical method utilizing a modified suction apparatus has been devised by the writer for collecting mites from chickens for experimental work. This method has been used in recent years by this Station in determining the efficacy of insecticides before and after treatment.[40] It is especially valuable in collecting mites which are not readily visible. The modified apparatus consists of a glass collecting tube connected to a collecting bottle which is connected to a water filter pump (fig. 18). Nishida and Kartman (see Entomology section of this report) have used an electric suction pump instead of a water filter pump. A small amount of water is placed in the collecting bottle for trapping the ectoparasites. Continuous suction is made available by turning on the water. The tip of the collecting tube, with an opening about 2 mm. in diameter, when touched to a selected area of the body surface of the bird, sucks up any ectoparasite present. At this Station, the mites have been collected from a selected 2 square inches of the body surface area by touching the tip of the collecting tube to 50 different points within the area. After the mites are collected, the water from the bottle is poured in a Stender dish and the ectoparasites present are counted with the aid of a dissecting microscope.

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[40] ALICATA, J. E., HOLDAWAY, F. G., QUISENBERRY, J. H., and JENSEN, D. D. OBSERVATIONS ON THE EFFICACY OF CERTAIN OLD AND NEW INSECTICIDES IN THE CONTROL OF LICE AND MITES OF CHICKENS. Poultry Sci. 25(4):376–380. 1946.
ALICATA, J. E., KARTMAN, L., NISHIDA, T., PALAFOX, A. L., 1947, *op. cit.*

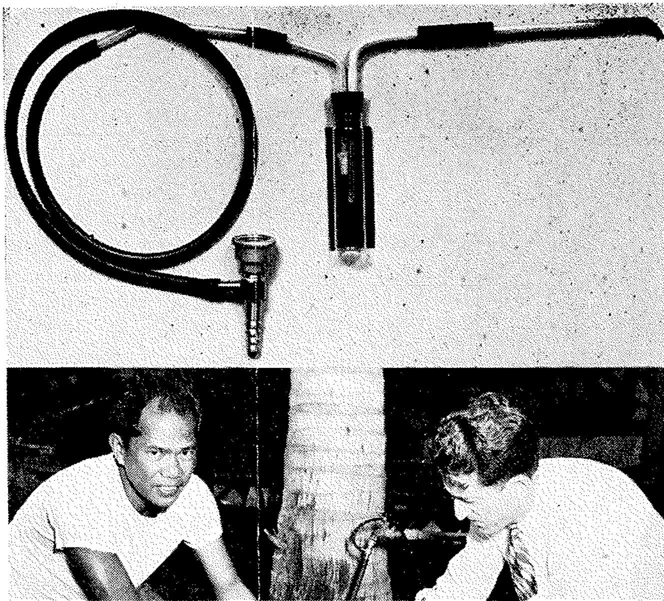

Figure 18. Top: Practical water-suction apparatus for collecting ectoparasites of birds in estimating the intensity of infestation. Bottom: The apparatus in operation.

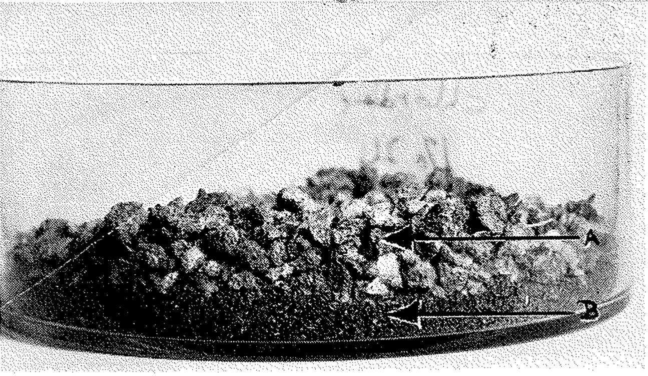

Figure 19. Type of large crystallization dish used in testing insecticides against arthropods under simulated natural conditions. Layer of dry chicken droppings (A) is always above layer of finely divided earth and feces (B), in which all stages of roaches and beetles are found.

CONTROL OF ARTHROPOD CARRIERS OF POULTRY PARASITES. By L. KARTMAN, Y. TANADA, F. G. HOLDAWAY, and J. E. ALICATA

In the Hawaiian Islands, poultry are raised largely off the ground in houses with wire floors, and the droppings from the birds accumulate under the houses. These droppings are generally infested with large numbers of arthropods, many of which are known to serve as mechanical or biological carriers of poultry endoparasites such as coccidia, roundworms, and tapeworms. As far as is known, only a few preliminary experiments have been conducted on the control of arthropods infesting poultry manure.[41]

This project has been carried out cooperatively by the Parasitology and Entomology departments since 1947. The work to date has been confined to laboratory screening of various insecticides preliminary to testing the more promising materials under field conditions.

The first few tests included several forms: a roach, *Pycnoscelus surinamensis*; an earwig, *Euborellia annulipes*; a beetle, *Alphitobius* sp.; and a sowbug, *Porcellio laevis*. Later tests were confined to the burrowing roach and the beetle.

Laboratory experiments were limited to direct contact tests in which the arthropod walked over a glass surface previously treated with dusts and suspensions; and tests under simulated natural conditions in which the arthropod was allowed an orientation period in a "familiar environment" prior to insecticidal application (fig. 19). In both cases, observations were made at 24- and 48-hour intervals relative to mortality and moribundity. Moribund individuals were allowed at least 24 hours for recovery in order to eliminate possible errors in estimating percentage control as percent mortality plus percent moribundity. Control tests were run in all experiments and replications and duplications made whenever possible.

Table 47 summarizes only the most typical data for all the materials tested. Data for the lowest concentration of the insecticide tested, except for sabadilla and sodium fluoride, are shown in the table. Where the material was received as a special formulation from the manufacturer, this could obviously not be accomplished.

[41]ALICATA, J. E. CONTROL OF THE COCKROACH (PYCNOSCELUS SURINAMENSIS), THE CARRIER OF EYEWORMS OF POULTRY. Hawaii Agr. Expt. Sta. Rpt. 1937–38, pp. 95–96. 1938.

——THE LIFE HISTORY OF THE GIZZARD WORM (CHEILOSPIRURA HAMULOSA) AND ITS MODE OF TRANSMISSION TO CHICKENS, WITH SPECIAL REFERENCE TO HAWAIIAN CONDITIONS. Livro Jubilar do Prof. Lauro Travassos, Rio de Janeiro, Brazil 11–20, 1938

——THE VALUE OF CRUDE NAPHTHALENE IN CONTROLLING THE BEETLE ALPHITOBIUS DIAPERINUS. Hawaii Agr. Expt. Sta. Rpt. 1943–44, pp. 106-107. 1945.

TANADA, Y., HOLDAWAY, F. G., and QUISENBERRY, J. H. CONTROL OF FLIES IN POULTRY DROPPINGS. Hawaii Agr. Expt. Sta. Rpt. 1944–46, pp. 71–74. 1947.

Table 47. Laboratory results on the relative toxicity of various materials against arthropods inhabiting poultry manure.

Insecticide and toxicant content	Type of mixture and conditions of test**	Rate of application	Number of tests	Number of arthropods per test per species††	Average percentage control‡‡ at: 24 hours				48 hours			
					Roach	Earwig	Sowbug	Beetle	Roach	Earwig	Sowbug	Beetle
Lethane B-71, 10% +DDD, 4% +Sulfur, 30%*	dust - DC	0.03 gm. per sq. in.	3	10	63.3	26.6	26.6	0.0	80.0	36.6	30.0	0.0
Lethane B-71, 10% +DDD, 4% +Sulfur, 30%*	dust - SNC	0.03 gm. per sq. in.	2	10	20.0	20.0	35.0	15.0	45.0	40.0	55.0	25.0
Lethane B-71, 10% +DDT, 4%+Sulfur, 30%*	dust - DC	0.03 gm. per sq. in.	3	10	43.3	80.0	86.6	90.0	50.0	83.3	96.6	96.6
Lethane B-71, 10% +DDT, 4%+Sulfur, 30%*	dust - SNC	0.03 gm. per sq. in.	2	10	25.0	95.0	70.0	85.0	40.0	100.0	100.0	100.0
Lethane A-70, 7½% +DDD, 5%*	dust - DC	0.03 gm. per sq. in.	3	10	50.0	73.3	86.6	0.0	63.3	83.3	90.0	0.3
Lethane A-70, 7½% +DDT, 5%*	dust - SNC	0.03 gm. per sq. in.	2	10	25.0	45.0	60.0	30.0	75.0	65.0	90.0	55.0
Lethane A-70, 7½% +DDT, 5%*	dust - DC	0.03 gm. per sq. in.	3	10	33.3	56.6	83.3	23.3	40.0	96.6	100.0	63.3
Lethane A-70, 7½% +DDT, 5%*	dust - SNC	0.03 gm. per sq. in.	2	10	60.0	65.0	65.0	100.0	55.0	95.0	100.0	100.0
Sabadilla with lime, 50%†	dust - SNC	0.03 gm. per sq. in.	2	10	20.0	0.0	75.0	5.0	15.0	5.0	100.0	15.0
Sodium fluoride, 100%	dust - DC	0.03 gm. per sq. in.	3	10	30.0	86.6	96.6	0.0	73.3	93.3	100.0	0.0
Sodium fluoride, 100%	dust - SNC	0.03 gm. per sq. in.	2	10	15.0	25.0	85.0	0.0	30.0	65.0	100.0	15.0
Lethane B-72, 5%*	aqueous susp. - SNC	26 cc. per sq. ft.	2	10	10.0	5.0	30.0	0.0	40.0	0.0	50.0	10.0
Lethane B-72, 5% +DDT, 5%*	aqueous susp. - SNC	26 cc. per sq. ft.	2	10	35.0	85.0	95.0	75.0	70.0	80.0	100.0	100.0
Lethane B-72, 5% +DDD, 5%*	aqueous susp. - SNC	26 cc. per sq. ft.	2	10	30.0	25.0	70.0	10.0	70.0	60.0	100.0	30.0
DDT, 1%	dust - SNC	0.03 gm. per sq. in.	2	10-20-50	44.5	10.0	30.0	93.9	60.0	35.0	45.0	97.9
DDT, ½%*	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	23.7	....	....	50.9	28.1	....	....	70.0
DDT (Tech.), 1%	sol. (kerosene) - SNC	26 cc. per sq. ft.	2	10	75.0	100.0	100.0	95.0	70.0	100.0	100.0	100.0
DDD, 1%*	dust - SNC	0.03 gm. per sq. in.	2	10-20-50	30.0	....	....	26.7	30.0	....	....	31.6
DDD, ½%*	aqueous susp. - SNC	26 cc. per sq. ft.	2	20	5.2	....	....	12.0	33.2	....	....	38.0
Chlordan, 1%‡	dust - SNC	0.03 gm. per sq. in.	2	20-50	65.0	....	....	90.0	60.0	....	....	93.0
Chlordan, ½%‡	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	35.0	....	....	64.0	42.8	....	....	72.0
Chlordan (Tech.), 1%‡	sol. (kerosene) - SNC	26 cc. per sq. ft.	2	10	70.0	100.0	85.0	100.0	75.0	100.0	100.0	100.0
Toxaphene, 1%§	dust - SNC	0.03 gm. per sq. in.	2	20-50	18.2	....	....	68.0	55.0	....	....	91.9
Toxaphene, ½%§	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	5.5	....	....	20.0	28.5	....	....	46.0
Methoxychlor, 1%‖	dust - SNC	0.03 gm. per sq. in.	2	20-50	30.0	....	....	48.0	47.4	....	....	71.4
Methoxychlor, ½%‖	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	25.0	....	....	10.0	25.0	....	....	36.0
Gamma Benzene Hexachloride, 1%‖	dust - SNC	0.03 gm. per sq. in.	2	20-50	65.0	....	....	66.6	73.7	....	....	95.9
Gamma Benzene Hexachlor., ½%‖	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	60.0	....	....	37.1	100.0	....	....	88.0
Parathion, 1%¶	dust - SNC	0.03 gm. per sq. in.	2	20-50	95.0	....	....	98.0	95.0	....	....	98.0
Parathion, ½%¶	aqueous susp. - SNC	26 cc. per sq. ft.	2	20-50	81.7	....	....	94.0	95.0	....	....	100.0
Control (untreated)	SNC		2	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control (kerosene)	SNC	26 cc. per sq. ft.	2	10	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0
Control (water)	SNC	26 cc. per sq. ft.	2	20-50	10.0	....	....	4.0	16.0	....	....	22.0
Control (pyrax)	SNC	0.03 gm. per sq. in.	2	20-50	0.0	....	....	18.0	0.0	....	....	10.0

* Supplied by Rohm and Haas Co., Philadelphia, Pa.
† Supplied by John Powell Export Corp., New York, N. Y.
‡ Supplied by Velsicol Corp., Chicago, Ill.
§ Supplied by Hercules Powder Co., Wilmington, Del.
‖ Supplied by E. I. du Pont de Nemours and Co. Inc., Wilmington, Del.
¶ Supplied by American Cyanamid Co., New York, N. Y.
** DC =direct contact test and SNC =test under simulated natural conditions.
†† 20-50 refers solely to numbers of roaches and beetles respectively.
‡‡ Control =mortality plus moribundity.

The data indicate that Parathion, gamma benzene hexachloride, DDT, and Chlordan are the most effective insecticides tested under these conditions. The combination of either Lethane B–71 or A–70 with DDT and sulfur also shows promise. DDT and Chlordan in kerosene solutions are better than as dusts or suspensions. Unfortunately, solutions of the other materials could not be tested because they were not available to the writers.

Although the laboratory experiments are far from conclusive, the data suggest that some of the insecticides show properties which warrant trials under field conditions.

BREEDING CHICKENS FOR RESISTANCE TO CECAL COCCIDIOSIS.

Coccidiosis is one of the most important parasitic diseases of poultry. Joint experiments conducted by the Departments of Parasitology and of Poultry Husbandry have resulted in segregating through selective breeding two lines of birds, one relatively resistant to and the other relatively susceptible to coccidiosis. Each bird was infected with approximately 120,000 coccidial oocysts. Results of studies conducted this year show that the offspring of each of these two lines possess survival rates comparable to those of their parents. The average survival rate of offspring (F_1 generation) of the resistant line was 40.2 percent. The survival rate of the susceptible line was 15.9 percent, or 24.3 percent less than that of the resistant line. More detailed information appears in the report of the Department of Poultry Husbandry.

SULFONAMIDES IN THE TREATMENT OF CECAL COCCIDIOSIS IN CHICKENS. By J. E. Alicata, J. Y. C. Yuen, and A. L. Palafox

Sulfonamides are the only drugs known to have definite value in the treatment of cecal coccidiosis in chickens. In recent years, several of these drugs, especially sulfadiazine, sulfaguanidine, sulfamerazine, sulfamethazine, and sulfaquinoxaline, have been shown by various investigators to reduce the mortality of chickens even when administered in the later stages of the infection.[42] The experiments summarized below were undertaken to secure further data on the efficacy of sulfamethazine since it is considered one of the best treatments for cecal coccidiosis. This drug was also compared with sulfaguanidine, which is considerably less expensive. Dusting sulfur, which is very inexpensive and known to have prophylactic value in coccidiosis, was also used to determine whether it had any possible curative value when used in moderately high concentrations. In each of these experiments the drug was thoroughly mixed with mash and administered to the birds for four consecutive days beginning either on the fourth or on the second day following experimental coccidial infection.

The results of these experiments are summarized in table 48. Experiments I to III show that when sulfaguanidine was administered at a 1-percent level on the fourth day of infection the average mortality in

[42]Thorp, W. T. S., Gordeuk, S., Glantz, P. L., and Learned, M. THE CHEMOTHERAPY OF CECAL COCCIDIOSIS. Am. Jour. Vet. Res. 3(27):196–203. 1947.

Delaplane, J. F., Batchelder, R. M., and Higgins, T. C. SULFAQUINOXALINE IN THE PREVENTION OF EIMERIA TENELLA INFECTIONS IN CHICKENS. North Amer. Vet. 28:19–24. 1947.

three experiments was 36.9 percent lower than that of the control. In similar experiments with sulfamethazine the mortality was reduced by 74.6 percent. The administration of sulfur yielded no beneficial effects. In experiments IV and V either sulfaguanidine or sulfamethazine was administered on the second day of infection, and mortality was completely checked. These observations support the reports of other investigators of the curative value of sulfaguanidine and sulfamethazine. According to the present results sulfamethazine was found to be about twice as effective in reducing mortality as sulfaguanidine when administered in the later stage of the infection.

Table 48. Mortality of 4-week-old chicks following the administration of sulfonamides or sulfur in mash 4 and 2 days after experimental infection with about 80,000 sporulated oocysts of *Eimeria tenella.*

Drug and percentage used in mash	Experiment number					Total percentage average for Experiments I, II, and III
	I*	II*	III*	IV†	V†	
Control (no treatment)						
Number of birds used	30	30	21	24	24	
Percent mortality	50.0	70.0	47.6	70.8	58.3	55.8
Sulfaguanidine, 1 percent						
Number of birds used	30	29	21	26	......	
Percent mortality	33.3	48.6	23.8	0.0	......	35.2
Percent reduction in mortality in comparison with control	33.3	30.6	50.0	100.0	......	36.9
Sulfaguanidine, 0.5 percent						
Number of birds used	......	......	......	......	23	
Percent mortality	......	......	......	......	0.0	......
Percent reduction in mortality in comparison with control	......	......	......	......	100.0	......
Sulfamethazine, 1 percent						
Number of birds used	30	30	21	26	......	
Percent mortality	16.6	16.6	9.5	0.0	......	14.2
Percent reduction in mortality in comparison with control	66.8	76.3	80.1	100.0	......	74.6
Sulfamethazine, 0.5 percent						
Number of birds used	......	......	......	25	......	
Percent mortality	......	......	......	0.0	......	......
Percent reduction in mortality in comparison with control	......	......	......	100.0	......	......
Sulfur, 5 percent						
Number of birds used	30	30	......	26	24	
Percent mortality	63.0	66.6	......	50.0	83.0	64.8
Percent reduction or increase (+) in mortality in comparison with control	+10.7	4.9	......	4.9	+29.8	+5.8

*Medicated feed administered beginning with the fourth (96 hrs.) day of infection.
†Medicated feed administered beginning with the second (48 hrs.) day of infection.

The writers are indebted to Lederle Laboratories Division, Pearl River, N. Y., for supplying the sulfonamides used in these experiments.

WILD BIRDS AS POSSIBLE CARRIERS OF POULTRY PARASITES. By J. E. ALICATA, L. KARTMAN, and H. I. FISHER

Wild birds, particularly sparrows, mynahs, and doves, are frequently seen on poultry farms and often eat from the feeding troughs of chickens. These observations led to a brief study to determine to what extent these birds served as reservoir hosts of poultry parasites in this locality. During the first quarter of 1947 several wild birds were obtained from two poultry farms near Honolulu and were examined for parasites. Those which were recovered are listed below.

HOST	NUMBER EXAMINED	PARASITES RECOVERED
English sparrow (*Passer domesticus*)	20	Lice: *Myrsidea* sp. Mites: *Atricholaelaps megaventralis* Strandtmann; *Neonyssus* sp.; *Proctophyllodes truncatus* Robin; *Syringophilus columbae* Hirst. Hippoboscids: *Ornithoica vicina* (Walker). Roundworms: *Tetrameres* sp. Tapeworms: undetermined species.
Mynah (*Acridotheres tristis*)	5	Lice: *Menacanthus spinosus* (Piaget); *Myrsidea invadens* (K. & Ch.). Mites: *Montesauria* sp.; *Pteronyssus* sp. (close to *P. truncatus* Trouessart); *Trouessartia* sp. (close to *T. trouessarti* Oudms.). Roundworms: *Cheilospirura* sp.; *Microtetrameres* sp.; *Oxyspirura mansoni* (Cobbold). Tapeworms: undetermined species. Flukes: undetermined species.
Barred dove (*Geopelia striata striata*)	5	Lice: *Columbicola* sp.; *Goniodes* sp. Mites: *Liponyssus bursa* (Berlese).
Chinese dove (*Streptopelia chinensis*)	1	Mites: *Pterolichus* sp.
Brazilian cardinal (*Paroaria cucullata*)	2	Lice: *Myrsidea incerta* (Kellogg). Roundworms: *Tetrameres* sp.
Japanese white-eye (*Zosterops palpebrosus japonicus*)	2	Mites: *Dermoglyphus elongatus* (Megnin); *Megninia* sp. (close to *M. gallinulae* (Buch.); *Pteronyssus* sp.?; *Trouessartia* sp. (close to *T. trouessarti* Oudms.).

In addition to the above findings, blood smears taken from seven sparrows, two Japanese white-eyes, and three mynahs all proved to be negative for protozoan parasites.

Of the parasites listed above, the mite *Liponyssus bursa* and the eyeworm *Oxyspirura mansoni* also parasitize chickens. Wild birds, therefore, may serve as reservoir hosts for those parasites. The gizzard worm, *Cheilospirura* sp., reported from a mynah above, was a single immature specimen and not easily identified as to species. Further studies are desirable to find out if *Cheilospirura hamulosa*, a gizzard-worm parasite of chickens, can be transmitted by mynahs.

Figure 20. Liver of swine, showing lesions and discolorations resulting from migration of immature kidney-worms, *Stephanurus dentatus*. Such livers are condemned at slaughter, resulting in loss to raiser and consumer.

The ectoparasites listed above were identified by the following workers: lice, by E. W. Stafford; mites, by E. W. Baker and H. H. J. Nesbitt; hippoboscids, by J. C. Bequaert. Their assistance is gratefully acknowledged.

ECONOMIC LOSSES OF HOG LIVERS DUE TO KIDNEY-WORM INFESTATION. By L. KARTMAN and J. E. ALICATA

Previous reports made by the Parasitology Department[43] state that of 25,234 hogs slaughtered in Honolulu during 1945 and 1946, 2.8 percent showed adult kidney worms in the kidney fat. This figure represented only a partial incidence of infection since no record was available on the young migrating worms which before reaching the kidneys migrate to various parts of the body and particularly the liver where they produce many lesions resulting in grayish-white scars, abscesses, and discolorations and giving the liver a mottled appearance (fig. 20). In this condition the liver is condemned under meat-inspection regulations and results in a loss of an item of marketable value.

A recent survey at the Honolulu Pork Center indicated that the majority of hog livers discarded by the inspectors showed lesions caused mainly by kidney worms and to a much lesser extent by the migrating larvae of the intestinal roundworm, *Ascaris lumbricoides*.

Factual confirmation on liver losses due to parasitic infection was obtained by personal conversations with inspectors of the Territorial Board of Health, Food and Drug Division. In addition, an analysis was made of the monthly reports of the Division of Pure Food and Drugs, kindly supplied by Mr. George Akau, Food Commissioner and Analyst. These reports indicated that parasitic lesions and abscesses are the chief cause for discarding hog livers and it seemed important that the available figures be analyzed in terms of economic value to the merchants and people of Honolulu.

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[43]ALICATA, J. E. PARASITES AND PARASITIC DISEASES OF DOMESTIC ANIMALS IN THE HAWAIIAN ISLANDS. Pacific Sci. 1(2):69–84. 1947.

Table 49. Economic losses of hog livers mainly due to kidney-worm infestation.

Month	Number of livers examined		Number of livers discarded		Number of livers discarded due to parasite lesions		Percentage of livers discarded due to parasite lesions		Approximate weight of parasitized livers (pounds)*		Approximate cost of parasitized livers†			
											Wholesale		Retail	
	1946	1947	1946	1947	1946	1947	1946	1947	1946	1947	1946	1947	1946	1947
January	5,264	3,229	264	316	264	316	5.0	9.4	924	1,106	$304.92	$575.12	$415.80	$884.80
February	4,919	3,404	297	335	297	335	6.0	9.8	1,029	1,173	339.57	609.96	463.05	938.40
March	5,046	3,739	349	436	349	436	6.7	11.6	1,221	1,526	402.93	793.52	549.45	1,220.80
April	4,460	3,579	244	263	244	178	5.2	4.9	854	623	281.82	323.96	384.30	498.40
May	4,236	3,660	590	526	469	480	11.0	1.3	1,641	1,680	541.53	873.60	738.45	1,344.00
June	4,394	3,340	381	295	206	295	4.6	8.8	721	1,033	237.93	537.16	324.45	826.40
July	4,488	3,448	706	459	706	459	15.7	13.3	2,471	1,607	815.43	835.64	1,111.95	1,285.60
August	4,708	3,480	294	130	292	130	6.2	3.7	1,032	455	340.56	236.60	464.40	364.00
September	3,876	3,033	400	383	377	383	9.7	12.5	1,309	1,341	431.97	697.32	589.05	1,072.80
October	3,108	3,239	358	339	347	339	8.4	10.4	1,214	1,187	400.62	617.24	546.30	949.60
November	3,473	3,135	357	291	357	291	10.2	9.2	1,249	1,019	412.17	529.88	562.05	815.20
December	4,531	4,050	201	915	201	915	4.6	22.5	703	3,203	231.99	1,665.56	316.35	2,562.40
Total	53,503	41,336	4,441	4,688	4,109	4,557	7.6 (average)	11.0 (average)	14,368	15,953	$4,741.44	$8,295.56	$6,465.60	$12,762.40

* Based on average weight of hog livers as reported by local markets.

† Calculated on basis of market price current during the year.

Table 50. Percentage (average of two trials) of snails surviving following various exposures to water containing ground samples of various parts of the desert date, *Balanites aegyptiaca*.

Dilution of sample in water	Period of exposure (hours)	Control		Sample 1*		Sample 2†		Sample 3‡		Sample 4§		Sample 5‖	
		Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
1:1,000	1	100.0	0.0	0.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
	2	100.0	0.0	.....	.....	100.0	0.0	100.0	0.0	20.0	80.0	90.0	10.0
	5	100.0	0.0	.....	.....	87.5	12.5	97.5	2.5	12.5	87.5	90.0	10.0
	24	100.0	0.0	.....	.....	32.5	67.5	40.0	60.0	0.0	100.0	15.0	85.0
	48	100.0	0.0	.....	.....	0.0	100.0	0.0	100.0	.....	.....	12.5	87.5
1:2,000	1	100.0	0.0	12.5	87.5	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
	2	100.0	0.0	0.0	100.0	100.0	0.0	100.0	0.0	82.5	17.5	97.5	2.5
	5	100.0	0.0	.....	.....	90.0	10.0	100.0	0.0	57.5	42.5	95.0	5.0
	24	100.0	0.0	.....	.....	35.0	65.0	32.5	67.5	0.0	100.0	45.0	55.0
	48	100.0	0.0	.....	.....	25.0	75.0	30.0	70.0	.....	.....	45.0	55.0

* Pulp and shell of green-ripe fruits.
† Seeds of immature and ripening fruits.
‡ Leaves.
§ Bark of large limbs and trunk.
‖ Small branches and twig with adhering bark.

Table 49 indicates the pertinent data concerning availability of hog livers during 1946 and 1947 and losses of livers during the same periods. It should be noted that the percentage of total hog livers discarded during 1946 was 7.6 due to parasitism, while that from all causes was 8.3. Even more striking, in 1947, 11.0 percent of all livers were discarded because of parasitism, whereas 11.3 percent was the total of all livers discarded during that period. This substantiates the contention that parasitism accounts for the bulk of hog liver losses.

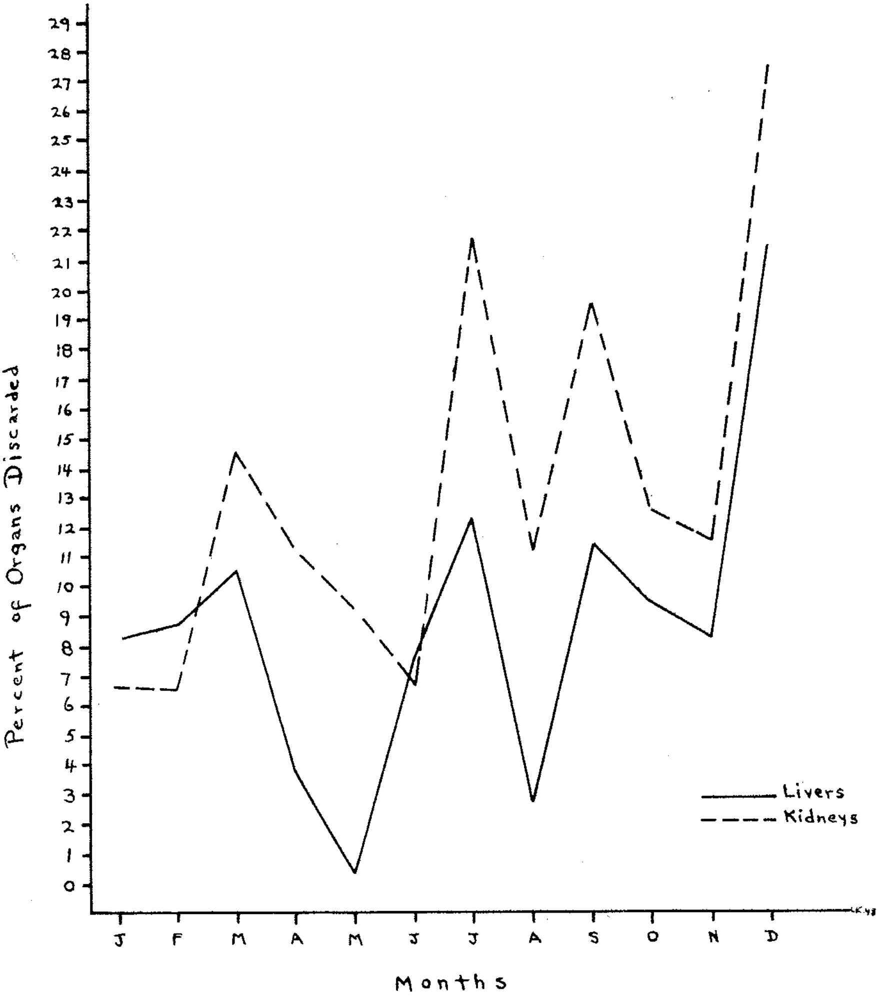

Figure 21. Economic losses in hogs due to kidney-worm infestation, showing parasitized livers discarded as related to parasitized kidneys discarded from hogs slaughtered at Honolulu Pork Center during 1947. (Based on figures from Division of Pure Food and Drugs, Territorial Board of Health.)

During the survey at the Pork Center, it was also noted that the discarding of kidneys was for the most part due to the presence of the kidney worms. These observations were confirmed by an analysis of the monthly inspection data already mentioned. A significant correlation was noted between the numbers of parasitized kidneys discarded and parasitized livers condemned (fig. 21). These data further emphasize the importance of the kidney worm as a chief cause of liver damage and subsequent economic waste.

These findings emphasize the need for more stringent sanitary measures in hog raising as a prophylaxis in the control of kidney worms.

TOXICITY OF THE DESERT DATE TO FRESH-WATER SNAILS. By J. E. ALICATA

According to studies conducted by H. K. Plank,[44] various parts of the desert date (*Balanites aegyptiaca*) are toxic to snails, *Australorbis glaboratus* (Say), which serve as intermediate host for certain blood flukes found in man. This report led to Station observations to determine possible similar effects of this tree on the local fresh-water snails which serve as intermediate host for the liver fluke, *Fasciola gigantica* Cobbold, of cattle.

The samples of various parts of *Balanites* used in making the observations were secured through the kindness of Dr. H. K. Plank from plants grown in Puerto Rico. Each sample was finely ground and added to 1.5 liters of tap water in large glass moisture dishes at the rate of 1 part to 1,000 or 2,000 parts of water. About 1 hour after the above preparations were made, 20 live snails were added to each dish. The results of these tests which are summarized in table 50 show that the samples from various parts of the plant demonstrated different degrees of toxicity. The sample containing ground pulp and shell of green-ripe fruits proved to be most toxic, killing 100 percent of the snails within 1 hour in a dilution of 1:1,000 and in 2 hours in a dilution of 1:2,000.

The above observations indicate that *Balanites* is toxic to fresh-water snails of the genus *Fossaria* and may be found useful in effecting some control of these snails; however, the practical application of this finding under field conditions remains to be determined.

PARASITOLOGICAL OBSERVATIONS IN MICRONESIA. By. J. E. ALICATA

As a part of the Micronesian expedition of the University of Hawaii in the summer of 1946, observations were made by the writer on parasitic diseases of man and economically important animals on the islands of Ponape, Guam, and Truk. More detailed reports of these findings have already been published elsewhere.[45] The following list summarizes the parasites noted in various localities.

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[44] PLANK, H. K. ALL PARTS OF THE DESERT DATE TOXIC TO SNAILS. Puerto Rico Agr. Expt. Sta. Rpt. 1945, p. 24. 1946.

[45] ALICATA, J. E. HELMINTHIC INFECTIONS AMONG NATIVES ON THE ISLANDS OF PONAPE AND TRUK, EASTERN CAROLINES. Jour. Parasitol. 32 (Sect. 2):12–13. 1946.

——LEPTOSPIRAL INFECTION AMONG RODENTS IN MICRONESIA. Science 105 (2722): 236. 1947.

——OBSERVATIONS ON PARASITES OF DOMESTIC ANIMALS IN MICRONESIA. Pacific Sci. 2 (1):65–66. 1948.

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 riboflavin[47] 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.
[46]De Meillon, B., and Goldberg, L. Development of Ornithodorus moubata on normal and thiamin-deficient rats. Nature 159:171. 1947.
[47]Gyorgy, 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, *Polyplax spinulosa* (Burm.), and to determine whether there is a relation between malnutrition in chickens and infestation by the chicken body louse, *Eomenacanthus 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 pediculosis[50] 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-

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

[49]Barger, E. H., and Card, L. E. Diseases and parasites of poultry. War Dept. Ed. Manual—EM 879, pp. 1–399. 1943.

[50]Gyorgy, P., and Eckardt, R. E. Further investigations on vitamin B_6 and related factors of the vitamin B_2 complex in rats. Biochem. Jour. 34:1143–1154. 1940.

[51]Gyorgy, P. Personal communication to the author. 1948.

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	Two rats died prior to infestation with lice
Pantothenic acid...	10	3♂ 7♀	57.8	114.9	72.0	50	....	Pediculosis present	
Control (no deficiency).....	10	2♂ 8♀	55.8	187.9	....	50	....	Pediculosis absent	All these rats lost their lice 15 days after infestation

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 idex 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	
Deficient..	14	6 ♂ 8 ♀	8 weeks	412.7	732.4	100	6.9	4.8	12.0	Seven birds died prior to initial count and are not included in data

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

CONTROL OF LICE AND MITES OF POULTRY.

Experimental work in cooperation with the Entomology Department has shown that 10 pounds of a 50-percent wettable DDT powder per 100 gallons of water plus 1 or 2 pounds of Lethane B–72 per 100 gallons of water gave 100-percent control of chicken lice for about 1 month and 88-percent control for about 2 months. Benzine hexachloride at from 12 to 14 pounds of "Lexone 50" (6-percent gamma isomer) per 100 gallons of water gave 95-percent control of chicken lice for 15 days and 78-percent control for about 2 months. Treated birds were given maximum opportunity to regain their infestation. For details, see the Entomology Department report bearing the above title.