STUDIES ON THE BIONOMICS OF THE FOWL CESTODE *RAILLIETINA CESTICILLUS* (MOLIN)

by

ARTHUR ADAM CASE

B. S., Kansas State College
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PART I. INTERMEDIATE HOSTS OF CHICKEN TAPEWORMS FOUND IN KANSAS

INTRODUCTION

The recent findings of Ackert and Case (1938) on effects of tapeworms on chickens have re-emphasized the importance of these parasites. These authors found that cestode infections of three weeks duration affected the blood of the chickens and that infections of eight weeks duration lowered the hemoglobin and sugar content of the blood and retarded the growth of the chickens. While fowl taeniasis can be checked momentarily by administering taeniacides, no effective control of these parasites can be established without breaking the life cycle at some stage. In order to do this, knowledge must be gained of the available intermediate hosts. To determine these, life history studies of various species of fowl cestodes have been conducted recently in several laboratories; notably at the United States Zoological Division, Washington, at the Veterinary Academy, Hannover, Germany, and at the Kansas State College of Agriculture and Applied Science, Manhattan.

Whereas, a decade ago, garden slugs, earthworms, and flies were thought to be the principal intermediate hosts of chicken tapeworms, the recent findings have shown that ground beetles (Carabidae) are doubtless the principal means of transmitting the more common chicken tapeworms. It was to make known more generally the newer knowledge of intermediate hosts of fowl tapeworms found in Kansas that this study was undertaken.

NORTH AMERICAN CHICKEN TAPEWORMS

Of ten species of tapeworms found in the United States (Cram,1928), the following six species have been reported from Kansas:

Raillietina cesticillus (Molin, 1858)
Choanotaenia infundibulum (Bloch, 1779)
Raillietina tetragona (Molin, 1858)
Hymenolepis carioca (Magalhaes, 1898)
Raillietina echinobothrida (Megnin, 1880)
Amoebotaenia sphenoides (Railliet, 1892)

The other four species reported from this country are: *Davainea proglottina* (Davaine), *Diorchis americana* Ransom, *Hymenolepis cantaniana* (Pol.), and *Metroliasthes lucida* (Ransom).

Kansas Fowl Cestodes and Their Intermediate Hosts

Raillietina cesticillus. The fowl cestode that probably is of the most common occurrence in Kansas is the rather large species, Raillietina cesticillus whose habitat is the duodenum. Perry (1934) reported it from 62 percent of the chickens he examined. However, Adams and Geiser (1933) found it in only 12 percent of the chickens they examined in Texas. Although houseflies can probably act as intermediate hosts (Ackert, 1918; Reid and Ackert, 1937) the most important intermediate hosts are various species of beetles (Coleoptera), especially the family Carabidae (ground beetles). Besides several genera of the families Scarabaeidae, Tenebrionidae, and Ostomidae, there are eight genera and 25 species of Carabidae which may serve quite readily as intermediate hosts. The beetles most frequently found at Manhattan (Riley County, Kansas) are of these species. In half an hour in midsummer (July) it has been possible to collect 175 Carabidae on the campus of Kansas State College. The most numerous of these Carabidae are species of the genera Amara and Cratacanthus. After a morning rain, beetles of these genera may be seen by the hundreds. Species of Cratacanthus and Amara have been found to be the best intermediate hosts for the cestode R. cesticillus as determined by experimentation. The ease with which mature cysticercoids can be developed in beetles has led to the use of R. cesticillus for experimental studies of Ackert and Case, mentioned above, of Ackert and Reid (1937) who demonstrated an age resistance of older chickens to the growth of these cestodes, and of Harwood and Luttermoser (1938) who found that infections of this cestode retarded the growth of chickens.

Intermediate Hosts of R. cesticillus. COLEOPTERA: Family Cantharidae: Podabrus modestus Say; Family Carabidae: Amara sp., Amara basillaris (Say), Amara fallax Lec., Amara (Curtonotus) laticollis Lec., Amara (Celia) musculа Say, Amara (Percosia) obesa Say, Anaferonia (Pterostichus) sp., Anaferonia constricta Say, Anaferonia near substriata (Lec.), Anisotarsus sp, Anisotarsus agilis (Dej.), Anisotarsus subvirens Csy., Chalenius tomentosus Say, Cratacanthus dubius Beauv., Harpalus sp., Harpalus faunus Say, Harpalus herbivagus Say, Harpalus pennsylvanicus DeGeer, Pterostichus (Poecilus) chalcites Say, Pterostichus near constricta, Pterostichus (Abacidus) permundus Say, Pterostichus near permundus, Pterostichus (Eumolops) torvus Lec., Selenophorus (pedicularius DeG.), Triplectrus rusticus Say, (Jones, 1929).

Family Ostomidae: Tenebroides mauritanicus (L.) (Case and Ackert, 1938); Family Scarabaeidae: Choeridium histeroides (Web.), Aphodius granarius (L.); Family Tenebrionidae: Tenebrio sp., Tribolium confusum Duval., Tribolium sp.

Hymenolepis carioca. Second in the list of tapeworms from Kansas chickens appears to be Hymenolepis carioca, a delicate, thread-like cestode which may be present in large numbers (500 or more) in a single bird, according to Ferry (1934). Twiehaus (unpublished) likewise found large infections of this cestode in ailing chickens in Kansas that were sent to the Kansas State College Poultry Diseases laboratory in April, 1939. Adams and Geiser (1933) found this species to be the most abundant in Texas (37 percent). As to transmission, Cram and Jones (1929) found that various species of Coleoptera may act as intermediate hosts of H. carioca. Subsequent studies by Jones indicated that the beetles that could transmit these tapeworms belong to the Scarabaeidae and possibly to the Carabidae.

Intermediate Hosts of H. carioca. COLEOPTERA: Family Carabidae: Anisotarsus agilis (Dej.); Family Scarabaeidae: Aphodius granarius (L.), Choeridium histeroides (Web.); Family Histeridae: Carcinops quatuor-decimstriata Steph.

Raillietina tetragona. The third ranking tapeworm in prevalence in the vicinity of Manhattan appears to be Raillietina tetragona. It was third (38 percent) in Ferry's studies in eastern Kansas and second in Texas (Adams and Geiser). This large tapeworm attaches itself to the lower portion of the small intestine and may produce nodules of the intestine which closely resemble lesions of tuberculosis. Horsfall (1938) reported that the common pavement ants Tetramorium caespitum (L.) and Pheidole vinelandica Forel. could serve as intermediate hosts of R. tetragona. Repeated attempts to infect various species of beetles with feedings of gravid R. tetragona proglottids have been unsuccessful, so it is probable that beetles are not natural intermediate hosts of this tapeworm. Studies upon ants as means of transmitting chicken tapeworms from one host to another are in progress at the Kansas Agricultural Experiment Station.

Intermediate Hosts of R. tetragona. HYMENOPTERA: Family Formicidae: Tetramorium caespitum (L.) and Pheidole vinelandica Forel (Jones and Horsfall, 1934).

Choanotaenia infundibulum. A fowl cestode that is of very common occurrence if the vicinity of Manhattan, Kansas, is Choanotaenia infundibulum. Both Ferry (1934) and Adams and Geiser (1933), however, found this species to be the least abundant of the tapeworms they studied. Its habitat is the duodenum.

As to intermediate hosts, Guberlet (1916) found that houseflies (Musca domestica L.) are a means of transmitting Choanotaenia infundibulum from one chicken to another. Cram (1928), Cram and Jones (1929) and Wetzel (1936) obtained evidence that pointed to beetles as being important intermediate hosts of this tapeworm. Horsfall and Jones (1937) added six species of beetles and two grasshoppers as new intermediate hosts of _C. infundibulum_. The writer has found recently that three additional species of beetles may serve as intermediate hosts of this tapeworm. They are: _Amara fallax_ Lec., _Anaferonia constricta_ Say, and _Tenebroides mauritanicus_ (L.).

Further evidence that houseflies may serve as intermediate hosts of _C. infundibulum_ was presented by Wetzel (1936) who reported that only 20 percent of the houseflies in his experiments developed cysticercoids and that the number of cysticercoids was small. Reid and Ackert (1937) found a natural infection of 91 cysticercoids in a housefly at Manhattan, Kansas. Even if only 20 percent of the houseflies developed cysticercoids, the quantities of flies around poultry yards at certain times of the year could easily supply the cysticercoids necessary to produce the heavy tapeworm infections (75 percent) in the naturally infected chickens in an experiment by Reid and Ackert (1937) at Manhattan, Kansas.

Intermediate Hosts of _C. infundibulum_. COLEOPTERA: Family Carabidae: _Amara fallax_ Lec., _Anaferonia constricta_ Say, _Cratacanthus dubius_ Beauv., _Stenocellus debilipes_ (Say), _Stenolophus conjunctis_ (Say); Family Ostomidae:

Tenebroides mauritanicus (L.); Family Scarabaeidae: Aphodius granarius (L.), Aphodius sp., Geotrupes sylvaticus Panz.; Family Staphylinidae: Apocellus sphaericollis (Say); Family Tenebrionidae: Alphitophagus bifasciatus (Say).

DIPTERA: Family Muscidae: Musca domestica (L.).

ORTHOPTERA: Family Locustidae (Acrididae): Dicromorpha viridis (Scudder); Melanoplus femur-rubrum (DeGeer).

Raillietina echinobothrida. Among the less abundant tapeworms in Kansas is the largest species Raillietina echinobothrida. This worm resembles R. Tetragona closely and is distinguished from it with difficulty. R. echinobothrida also attaches itself in the posterior part of the small intestine, and has about the same effects upon the host as R. tetragona. Ferry (1934) found this cestode in 4 percent of the chickens examined in Douglas County, Kansas, and Adams and Geiser found it in 12 percent of the fowls examined in Texas. According to Horsfall (1938), the common pavement ant, Tetramorium caespitum may serve as an intermediate host of R. echinobothrida. An interesting observation was made by Horsfall (1938) who stated, "The first clue to the intermediate hosts of R. echinobothrida and R. tetragona was discovered while the writer had under observation in the experimental yard several fecal samples containing R. echinobothrida proglottids. An ant carried one of these segments from the feces to an entrance to a nest and disappeared with it. Ants were then examined from this yard and all were found to be negative until August 16, 1935, at which time 3 T. caespitum were dissected and found to contain 4 cysticercoids the scoleces of which resembled those of R. echinobothrida." Larvae of R. echinobothrida in the naturally infected ant Tetramorium semilaeve from Marseilles, France, were reported by Joyeux and Baer (1937).

Intermediate Hosts of R. echinobothrida. HYMENOPTERA: Family Formicidae: Tetramorium caespitum (L.) T. semilaeve, and Pheidole vinelandica Forel.

Amoebotaenia sphenoides. A tapeworm present in 4 percent of the chickens examined by Ferry (1934) was the small wedge-shaped Amoebotaenia sphenoides. This cestode, which apparently is of rare occurrence in the United States was reported from 8 percent of the chickens examined by Adams and Geiser (1933) in Dallas County, Texas. The intermediate hosts are annelids, according to Mönnig (1927) who, in 14 days, grew the cysticercoids in earthworms Ocnerodrilus (Ilyogenia) africanus Beddard . Four weeks were required for the cysticercoids to develop into adult tapeworms in chickens. Grassi and Rovelli (1889) and

Meggit (1916) undoubtly secured cysticercoids of this tapeworm by feeding the oncospheres to earthworms (*Allolobophora foetida* Eis.)

Intermediate Hosts of *A. sphenoides*. OLIGOCHAETA: Family Lumbricidae: *Allolobophora foetida* (Eisen), and *Ocnerodrilus* (*Ilyogenia*) *africanus* Beddard.

Davainea proglottina (not reported from Kansas). A small tapeworm (four to nine segments) that is found in many countries, but has not been reported from Kansas is *Davainea proglottina*. Because of its minute size it may have been overlooked. Various writers have described it and Levine (1938) has studied phases of its biology. Wetzel (1936) reported that the most important intermediate host of *D. proglottina* in Germany is the garden slug *Agriolimax agrestis*. Mönnig (1938) lists as intermediate hosts of *D. proglottina* the slugs: *Limax cinerus*, *Arion* sp., *Cepoa* sp., and the snail *Physa heterostropha* (Say). Of these genera, *Agriolimax* and *Physa* are found in Kansas; so that it is possible that *D. proglottina* for which these gastropods may serve as intermediate hosts, is also present in Kansas, especially in the eastern part of the state where the rainfall is heavier.

Intermediate Hosts of *D. proglottina*. PULMONATA: Family Arionidae: *Arion* sp.; Family Limacidae: *Agriolimax* sp., Copoa sp., Limax cinerus; Family Physidae: Physa heterostropha (Say).

SUMMARY OF PART I

1. Of ten species of fowl tapeworms reported from the United States, the following six species have been found in chickens in Kansas: Raillietina cesticillus (Molin, 1858), Choanotaenia infundibulum (Bloch, 1779), Raillietina tetragona (Molin, 1858), Hymenolepis carioca (Magalhaes, 1898), Raillietina echinobothrida (Megnin, 1880), and Amoebotaenia sphenoides (Railliet, 1892).

2. The three following species of beetles are here reported for the first time as intermediate hosts of the chicken cestode Choanotaenia infundibulum: Amara fallax Lec., Anaferonia constricta Say, and Tenebroides mauritanicus (L.).

3. The known species of intermediate hosts of the tapeworms found in Kansas chickens consists of beetles, flies, ants, slugs, snails, and earthworms. They are given according to order, family, and genus for the respective tapeworms.

4. Most numerous of these intermediate hosts are ground beetles (Carabidae) of which eight genera and 25 species have been identified as intermediate hosts of chicken cestodes.

Altogether, 19 genera and 29 species of beetles may act as intermediate hosts for one or more of the important chicken tapeworms found in Kansas.

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PART II. EFFECTS OF THE FOWL TAPEWORM RAILLIETINA CESTICILLUS (MOLIN) UPON GROWING CHICKENS

INTRODUCTION

Experimental evidence of effects of tapeworms upon their hosts is almost lacking. This doubtless has been due largely to inability to secure at one time large numbers of infective tapeworm larvae and their definitive hosts. Circumstantial evidence has pointed to certain effects of cestodes upon man, but such effects have been attributed to worry from the knowledge of having a tapeworm rather than to the tapeworm itself. While some knowledge of the subject can be gained by comparing the symptoms of an infected animal with its behavior after anthelmintic treatment, more reliable evidence would be obtainable from numbers of animals of approximately the same age and inheritance, one half of which were parasitized and the other half used as controls.

The literature pertinent to the intermediate hosts of fowl tapeworms found in Kansas, which has been reviewed in Part I of this study, showed that of various invertebrates (ants, flies, beetles, slugs, and snails) ground beetles (Carabidae) are the most important intermediate hosts of the fowl tapeworm <u>Raillietina cesticillus</u> (Molin). From the work of Cram (1928), Cram and Jones (1929), Wetzel (1936), and Reid, Ackert and Case (1938) upon beetles as intermediate hosts and the ease with which they may be infected, experiments were begun to study the effects of the fowl cestode R. cesticillus on growing chickens.

MATERIALS AND METHODS

The experiments were conducted in the animal house, a tightly screened, frame structure with concrete floors. To this house the fowls were brought as day-old chicks from a commercial hatchery, and given an adequate diet. The ground beetles (Carabidae) were collected at some distance from any poultry yard to avoid previous infection with tapeworm eggs. As the beetles were known to be cannabalistic, each was placed in a separate container. After a few hours, the beetles readily take the proglottids.

In the experiments, each beetle was fed a motile gravid proglottid of the tapeworm R. cesticillus collected from the feces of infected chickens. After returning the beetle to the jar about three inches of moist earth was added, the lid placed on loosely, and the jar set in a dark place.

The beetles were then fed on various animal tissues, such as meat scrap and live beetles. The most satisfactory method was to place in the jar at weekly intervals, a half dozen experimentally reared meal beetles (<u>Tenebrio</u> sp.) Water was supplied daily and the jars checked for dead beetles, food, and moisture content. Under such conditions the beetles lived 20 to 60 days.

In the bodies of the beetles the tapeworm eggs developed into cysticercoids in from 15 to 20 days. Their removal presented problems: (1) the taxonomic structures of the beetles had to be left intact, and (2) the cysticercoids had to be removed alive and infective. Gassing the beetles also killed the cysticercoids. Continued immersion in tap water caused evagination of the cysticercoids which rendered them non-infective.

One of the best methods of removing the cysticercoids was to anesthetise the beetle with ether, pin it dorso-ventrally in a blackened dissecting dish, and float the cysticercoids from the body cavity of the beetle through an opening in the dorsum. To prevent evagination of the cysticercoids, a 0.1 per cent NaCl solution was used. Measurements of three cystercoids selected at random from each beetle were quickly made as an identification check.

The cysticercoids to be fed to the chickens were transferred from the salt solution to filter paper or were given by means of a small pipette to whose bulb was attached a Hoffman screw compressor. With a slight turn of the screw, the cysticercoids were drawn into the pipette and held there until fed.

As to methods of blood examination, the hemoglobin tests were made with the New Dare hemoglobinometer. The blood sugar tests were made according to the method of Folin and Wu.

EXPERIMENTAL DATA

In the first experiment, 21 chickens three weeks old were divided into two groups of 17 and four birds, respectively. Each of the 17 chicks was given 10 cysticercoids of R. cesticillus per week for three weeks. The other four chickens which received no cysticercoids were kept as controls. Weights of all birds were taken each week during the period the cystercoids were administered. After the last feeding of cystercoids, the chickens were kept under observation for six weeks. During the seventh, eighth, and ninth weeks following the final feeding of cysticercoids hemoglobin and blood sugar tests were made (Table 1). From the time the chicks were first parasitized until the blood sugar determinations were made the controls and the parasitized birds were kept in the same pens and had the same food.

At the beginning of the experiment, the parasitized and control chickens were matched as nearly as possible. For example, parasitized chicken A 690 may be compared with control chicken A 706. Both weighed 116 gm. at the start of the experiment. In the blood tests, the former had a homoglobin percentage of 52 as compared with 62 for the control. The blood of the parasitized bird contained 168.8 mg. of sugar per 100 cc. of blood as compared with 181.6 mg. for the control chicken. As to growth, the parasitized chicken gained 156 gm. while the control added 284 gm. Chilling was observed in the parasitized chicken but not in the control (Table 1).

The heaviest control chicken (A 667) weighing 132 gm. as compared with the parasitized bird (A 659) which weighed 125 gm. showed less marked differences. There was scarcely any difference in the hemoglobin percentage of the blood. The parasitized chicken (A 659) had 186.8 mg. of sugar as compared with 212 mg. in the control (A 667). In weight the parasitized bird gained 139 gm. and the control 154 gm. Again the parasitized bird manifested chilling while the control failed to do so. As a group, the parasitized chickens averaged 118.5 gm. while the controls averaged 120.5 gm. at the beginning of the experiment. The hemoglobin percentage on the average was practically the same for both groups. That there was a difference in the sugar volume is indicated by an average of 172.7 mg. as compared with an average of 186.7 mg. for the control group. In weights also there was a marked difference.

Table 1. Showing comparative results of blood tests and gains in weight of parasitized chickens with those of unparasitized fowls. All chickens were 14 weeks of age. The parasitized ones became infected. Period of parasitism 11 weeks.

Chick	Weight at beginning (gm.)	Weight at end (gm.)	Gain (gm.)	Hemo-globin (%)	Blood sugar (mg.)	Chilling
			Parasitized			
A 654	123	226	103	67	149.0	Yes
A 659	125	264	139	64	186.8	Yes
A 655	125	264	139	66	150.4	Yes
A 663	121	312	191	58	220.0	Yes
A 677	120	320	200	50	181.0	Yes
A 683	120	286	166	70	199.0	Yes
A 692	120	304	184	64	174.6	Yes
A 699	120	256	136	80	145.0	Yes
A 700	125	280	155	69	198,0	Yes
A 661	117	268	151	68	102.0	Yes
A 662	114	260	146	66	178.6	Yes
A 665	112	288	116	60	207.2	Yes
A 666	115	284	169	53	186.8	Yes
A 668	114	284	170	52	175.4	Yes
A 673	114	241	127	66	158.3	Yes
A 686	115	246	131	55	155.8	Yes
A 690	116	272	156	52	168.8	Yes
Average	118.5	275.8	151.7	62.3	172.7	Yes
			Controls			
A 688	118	296	178	64	222.0	No
A 667	132	286	154	53	212.0	No
A 691	116	268	152	63	131.6	No
A 706	116	300	284	62	181.6	No
Average	120.5	287.5	192	63	186.7	No

The parasitized birds made an average gain of 151.7 gm. as compared with a 192 gm. average for the control group. All of the parasitized chickens manifested chilling on cool or rainy days, whereas no such behavior was observed in the controls which usually remained at the feed hoppers. From these results, it appears that infections with the tapeworm R. cesticillus cause reduction in the blood sugar and in the growth of chickens and interfere with normal behavior of the fowls (Table 1).

In the second experiment, 13 chicks 9 days old were divided into groups of 10 and three, respectively. Each of the 10 chicks was given 10 cysticercoids of R. cesticillus per week for eight weeks. The other three chickens which were kept as controls received no cysticercoids. Weights of all birds were taken each week during the period the cysticercoids were administered. After the last feeding the chickens were kept under observation for six weeks. During the seventh and eighth weeks following the final feeding of cysticercoids the hemoglobin and blood sugar tests were made as in Experiment I. From the time the chicks were first parasitized until the blood sugar determinations were made the controls and the parasitized birds were kept in the same pens and had the same feed.

At the beginning of experiment II, the young chickens were matched as nearly as possible according to weight. Comparing individuals of the two groups, it may be seen that the parasitized chick (A 590) which at the beginning of the experiment weighed 51 gm. and its control (A 606), 53 gm. differ but little in the hemoglobin percentage: 57 for the parasitized chick and 58 percent for the control. A marked difference occurred in the sugar; parasitized chicken (A 590) had 138.8 mg. as compared with 165.2 mg. of sugar for the control. In growth, there was also a difference. The parasitized bird gained 999 gm. as compared with 1197 for the control. The chilling noted in Experiment I recurred also in Experiment II in the parasitized group, whereas no such behavior occurred among the controls.

A parasitized chick (A 604) and a control chick (A 585) which weighed the same amount at the beginning of the experiment showed some variation. The hemoglobin percentage remained somewhat higher in the parasitized bird (67 per cent) than in the control (60 per cent), but the blood sugar in the parasitized bird which had five large cestodes was only 144.4 mg. of sugar per 100 cc. of blood as compared with 172 mg. in the control. In growth, there was also a marked difference. The parasitized bird gained 946 gm. to 1321 gm. by the control.

As groups, the parasitized birds averaged 53.8 gm. at the beginning of the experiment while the controls averaged 54 gm. The hemoglobin percentage averaged only slightly less in the parasitized group (55.1 per cent as compared with 56.3 per cent in the controls). However, in blood sugar, the parasitized birds averaged 135.8 as compared with 167.06 mg. The average gains in weight likewise showed a marked difference. The parasitized birds gained an average of 971.4 gm. while the controls gained an average of 1217.7 gm. The chilling which was characteristic of the parasitized chickens in the first experiment occurred also in the second group of parasitized chickens. It was entirely absent from the control group.

The results of Experiment II as shown in Table 2 indicate that an infection of fowl tapeworms over a 15 week period failed to produce much effect upon the hemoglobin percentage but reduced markedly the amount of sugar in the blood and the rate of growth of the chickens. That the parasites were the cause of these differences was indicated in part by the chilling of the chickens that were infected.

DISCUSSION

Up to the present, the results indicate that growing chickens that have received 30 or more cysticercoids when infected for two to three months show reduced amount of

Table 2. Showing comparative results of blood tests and gains in weight of parasitized chickens with those of unparasitized fowls. All chickens were 16 weeks of age. The parasitized ones became infected. The period of parasitism was 15 weeks.

Chick	Weight at beginning (gm.)	Weight at end (gm.)	Gain in weight (gm.)	Hemo-globin (%)	Blood sugar (mg.)	Tape-worms	Chilling
			Parasitized				
A 590	51	1050	999	57	138.8	4 large	Yes
A 592	49	950	901	55	216.0	0	No
A 586	61	1175	1114	45	177.4	3	Yes
A 604	54	1000	946	67	144.4	5 large	Yes
A 598	54	1200	1146	65	148.0	0	Yes
A 580	61	925	864	45	160.0	25 large	Yes
A 588	62	950	888	47	149.2	6 large	Yes
A 607*	49	747	698	55	-----	12 large	Yes
A 584	47	1355	1308	58	133.2	27 large	Yes
A 594	50	900	850	57	85.0	22 large	Yes
Average	53.8	1025.2	971.4	55.1	135.8	10.4	Yes
			Controls				
A 606	53	1250	1197	58	165.2	0	No
A 585	54	1375	1321	60	172.0	0	No
A 595	55	1190	1135	51	185.0	0	No
Average	54	1271.66	1217.07	56.3	167.06	0	No

* The blood of this bird would not give a reading on either blood sample.

blood sugar and decreased gains in weight (Ackert and Case, 1938). Harwood and Luttermoser (1938) also found that chickens infected with the tapeworm R. cesticillus showed reduced rates of growth. In the present experiments little difference occurred between the hemoglobin percentages of the parasitized group and the controls.

Concerning sugar, Table 2 shows that one parasitized bird failed to give a blood sugar test which would indicate a very low sugar content of this bird's blood. This chicken, A 607, had 12 very large tapeworms, gained much less weight than the average of the parasitized group, and had a hemoglobin percentage of 55, slightly less than the group average. The parasitized chicken in Experiment II, A 592, had no tapeworms at postmortem and this may explain the high blood sugar test for this bird (Table 2). The data revealed that in both experiments, the parasitized birds gained less than the controls, and their blood sugar percentage was much lower, both, as individuals, and as groups. A very noticeable difference between the parasitized and control chickens was evident on cool mornings and on cool days following rains when the parasitized birds would ruffle their feathers, chill, and seek the warmth of the brooder heat unit while the controls in the same pen were apparently normal and remained at the feed hoppers, and never went near the heat units.

SUMMARY OF PART II

1. Methods of culturing bettles for the purpose of obtaining cysticercoids of R. cesticillus are described. Pint Mason fruit jars containing a few inches of soil served as culture receptacles.

2. A successful technique for obtaining cysticercoids from beetles (Carabidae) and for parasitizing chickens with them was developed.

3. Data from two experiments indicated that chickens parasitized during a period of 11 to 15 weeks showed lowered blood sugar and reduced gains in weight.

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