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# WORM PARASITES OF TENNESSEE CHICKENS

By

A. C. TODD



KNOXVILLE

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## F O R E W O R D

This bulletin is based on a 3-year survey of the nature and numbers of worm parasites of Tennessee chickens. Its objective is to provide a base for an understanding of the relation of worm infections to profitable poultry production.

In the course of the survey, 21 species of worms were found parasitizing chickens. Each species is shown, natural size, in the figures, and a short description of the effect of each species upon its host, so far as the effects have been elaborated, is given.

The bulletin is intended primarily for the use of county agents and teachers of vocational agriculture, but should be of practical value to poultrymen throughout the State.

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# WORM PARASITES OF TENNESSEE CHICKENS

By

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## INTRODUCTION

Chickens in Tennessee are subject to a great number of diseases, caused by a variety of disease agents. Among these agents of infection are the worm parasites (helminths). Unlike the development of virulent diseases, the onset of symptoms due to worm parasites may be very gradual. In fact, the one outstanding characteristic of worm infections is the generalness of the symptomatology. Infections with worm parasites, therefore, can exist within a farm flock without coming to the attention of the average poultryman.

By means of a survey (Todd, '46, '47), initiated in 1945 and completed in 1947, an effort has been made to establish the nature and the number of worm infections in chickens in Tennessee. In the course of the survey 1,014 chickens from all parts of the State were examined. The chickens were of all ages and breeds and appeared on the markets at poultry-dressing stations.

Of the 1,014 birds examined, 972 (95.8 percent) were parasitized by 1 or more of 21 species of worms. A total of 122,050 worms were collected, an average of 125.6 for each infected bird. The average number of species in an infected bird was 3.55. The smallest number of worms found in a chicken was 1; the largest number was 2,292, which represented only 2 species. The next largest number was 2,229, which represented 8 species. The largest number of species found in a chicken was 11, and 2 birds were found carrying this number. The first chicken's infection consisted of 7 species of roundworms and 4 of tapeworms and comprised 462 worms. The second bird, with 11 species of parasites, was infected by 4 species of roundworms and 7 of tapeworms; the total number of worms present was 51.

In the course of the survey, 3 species of worms which inhabit the intestine—*Capillaria bursata* Teixeira de Freitas and Lins de Almeida, a roundworm; *Echinoparyphium recurvatum* (Linstow, 1873), a fluke; and *Fimbricaria fasciolaris* (Pallas, 1781), a tapeworm—were found in chickens in the United States for the first time. A fourth species—*Plagiorhynchus formosus* Van Cleave, 1918, a thorny-headed roundworm—is recorded in this bulletin. This is the second record of its occurrence in chickens in the United States.

Of the 21 species of worm parasites collected, 10 are roundworms

(nematodes), 9 are tapeworms (cestodes), 1 is a thorny-headed roundworm, (acanthocephalan), and 1 is a fluke (trematode). The 21 species will be considered separately.

Complete descriptions of these species will be found in two reviews by Wehr (1943).

### NEMATODES (Roundworms)

The 10 species of nematodes collected are listed according to their incidence but not necessarily their relative importance. The largest number of nematodes found in any one chicken was 2,292, which represented 2 species—2,279 specimens of a cecalworm, *Heterakis gallinae*, and 13 specimens of another cecalworm, *Capillaria retusa*. The largest number of species of nematodes present in any one chicken was 7, and 2 chickens were found with this number. Altogether, nematodes were present in 947 (97.4 percent) of the 972 parasitized birds.

A summary of the data relating to roundworms collected during the course of the survey is given in table 1. The appearance of the 10 species, natural size, is shown in figure 1.

Table 1—Incidence of nematodes (roundworms) collected.

| Species                        | Number chickens examined | Number chickens infected | Percent incidence | Total worms collected | Average number worms present | Range of specimens present |
|--------------------------------|--------------------------|--------------------------|-------------------|-----------------------|------------------------------|----------------------------|
| <i>Heterakis gallinae</i>      | 1,014                    | 846                      | 83.4              | 64,249                | 75.9                         | 1-2,279                    |
| <i>Ascaridia galli</i>         | 1,014                    | 477                      | 47.1              | 2,950                 | 6.2                          | 1-89                       |
| <i>Capillaria retusa</i>       | 1,014                    | 389                      | 38.4              | 5,763                 | 14.8                         | 1-390                      |
| <i>Tetrameres americana</i>    | 1,014                    | 134                      | 13.2              | 1,196                 | 8.9                          | 1-137                      |
| <i>Capillaria annulata</i>     | 1,014                    | 101                      | 9.9               | 1,005                 | 9.9                          | 1-86                       |
| <i>Capillaria caudinflata</i>  | 1,014                    | 91                       | 8.9               | 930                   | 10.2                         | 1-390                      |
| <i>Capillaria bursata</i>      | 1,014                    | 26                       | 2.6               | 285                   | 10.9                         | 1-193                      |
| <i>Capillaria columbae</i>     | 1,014                    | 13                       | 1.3               | 60                    | 4.6                          | 1-15                       |
| <i>Cheilospiura hamulosa</i>   | 1,014                    | 2                        | 0.2               | 9                     | 4.5                          | 1-8                        |
| <i>Gongylonema ingluvicola</i> | 1,014                    | 1                        | 0.1               | 1                     | 1.0                          | —                          |

HETERAKIS GALLINAE (Gmelin, 1790), in point of incidence and numbers, was the most successful helminth collected, being found in the ceca of 83.4 percent of all chickens examined. A total of 64,249 specimens were collected, an average of 75.9 worms in each infected bird. The smallest number found in one chicken was 1; the largest number was 2,279.

A total of 17,496 adults were separated by sex; 9,734 were found to be females and 8,122 males, a ratio of approximately 9 females to 8 males.

In the past, infections with *H. gallinae* have been dismissed lightly on the assumption that the worm has only a low-grade pathogenicity, effecting only slight injury to the cecal mucosa. In fact, more attention has been given to possible transmission of the blackhead organism from chickens to turkeys



Fig. 1—The ten species of roundworm parasites, natural size, found in Tennessee chickens.

Reading clockwise, beginning at the 1 o'clock position, the species are : *Capillaria annulata*, *Gongylonema ingluvicola*, *Tetrameres americana*, *Cheilosporua hamulosa*, *Ascaridia galli*, *Capillaria caudinflata*, *Capillaria columbae*, *Capillaria bursata*, *Capillaria retusa*, *Heterakis gallinae*.

through the egg of the worm. It now appears that injury to the cecal mucosa at the time of first penetration of the host tissue by larvae of *H. gallinae*—2448 hours after infection (Roberts, 1937)—may have greater importance than has been attached to it. The effect of *H. gallinae* infection upon the critical period of weight-gain in broilers constitutes a serious problem.

*ASCARIDIA GALLI* (Schrank, 1788) was found in the intestine of 477 (47.1 percent) of the chickens examined. A total of 2,950 specimens were collected, an average of 6.2 worms in an infected bird; the range of numbers present was 1 to 89.

The first 961 specimens of *A. galli* collected were separated by sex; 488

were adult females, 67 larval females, 354 adult males, and 52 larval males.

Infections with *A. galli* have shown that this worm can be seriously pathogenic. That it is in a position of great economic importance is shown by its incidence in 47.1 percent of Tennessee chickens examined. The onset of symptoms first appears at about 10 days after infection, when the larval worms commence their invasion of the intestinal mucosa and submucosa. Slight hemorrhage, more pronounced enteritis, and the development of anemia result in the production of unthrifty, emaciated, and generally weak chickens, whose market value is lessened.

Although young birds are more seriously affected than adults, the survey showed that broilers, at market time, will have had fewer opportunities to pick up an infection; *A. galli* will have produced its greatest effect upon hens coming to market.

*CAPILLARIA RETUSA* (Railliet, 1893) was found in the ceca of 389 (38.4 percent) of the chickens examined. This species was first recorded in the United States by Morehouse (1939), who reported it from an Ohio chicken. Subsequently he recorded this species in 2 chickens from Iowa and 1 from Alabama. That it is of common occurrence and wide distribution in Tennessee is shown by its incidence in the survey.

The effect of *C. retusa* upon its host has not been studied; the life cycle is not known. The worms were found as often in the distal portions of the ceca as in the neck region. It appeared, however, that they were more often embedded in the mucosa of the neck region and tended to be free in the lumen of the distal portion. No specimens of *C. retusa* were collected from chickens less than 20 weeks of age, and the older chickens which were infected, in the majority of cases, gave evidence of having had access to fresh green feed.

When the first 1,095 specimens collected were separated by sex, it was found that 496 were females and 599 males, a larger proportion of males than females.

*TETRAMERES AMERICANA* Cram, 1927, was found in the proventriculus of 134 (13.2 percent) of the birds examined. A total of 1,196 specimens were collected, almost all of them females; the average number of specimens present was 8.9 and the range of numbers present was 1 to 137.

The above records appear to be the first to indicate wide distribution of *T. americana* within a state.

This worm (fig. 1) is notable because it is of a species which exhibits sexual dimorphism. The male ranges up to 5.5 mm. in length and has been found only on the muscosal surface of the proventriculus. The female becomes globular in shape after it migrates deep in the glands of the proventriculus and can be observed from the outer surface of the organ, where it appears as a dark object somewhat more than 1/16 inch in diameter. Upon

removal from the proventriculus the female is bright red in color, presumably because of ingested blood.

The pathology of *T. americana* has not been studied in detail.

*CAPILLARIA ANNULATA* (Molin, 1858), Cram, 1926, is one of the 2 species of helminths found in the crop of Tennessee chickens; it was present in 101 (9.9 percent) of the birds examined. A total of 1,005 specimens were collected, and the average number of specimens present was 9.9. The range of specimens present was 1 to 86. When the first 224 specimens collected were separated by sex it was found that 167 were females and 57 were males.

This worm (fig. 1) is the largest of the 5 species of capillarids found parasitizing Tennessee chickens, females ranging up to 94 mm. in length, males up to 37 mm.

The end result of infection with *C. annulata* is the destruction of large portions of the inner lining of the crop. The activities of the worms as they migrate beneath the mucosa cause a thickening of the mucosa, and an affected area may slough off. In only 1 of the 101 infected birds was there found the extensive destruction and formation of a fibrinous pseudomembrane described by Hung (1926) in the turkey.

The presence of *C. annulata* in the crop is easily determined by examination of the inner surface of the organ, particularly when the surface is stretched tight.

*CAPILLARIA CAUDINFLATA* (Molin, 1858), a species from the intestine, was found in 91 (8.9 percent) of the birds examined. A total of 930 specimens were collected. The average number of specimens present in an infected bird was 10.2, and the range was 1 to 390.

When the first 167 specimens collected were separated by sex it was found that 143 were females and 24 males.

*CAPILLARIA BURSATA* Teixeira de Freitas and Lins de Almeida, 1934, the second species of capillarid occurring in the intestine, was found in 26 (2.6 percent) of the birds examined. A total of 285 specimens were collected, and the average number of worms present in an infected bird was 10.9; the range of numbers present was 1 to 193.

*CAPILLARIA COLUMBAE* (Rudolphi, 1819), the third species of intestinal capillarid, was present in 13 (1.3 percent) of the birds examined. A total of 60 specimens were collected, and the average number of worms present was 4.6; the range of worms present was 1-15.

The pathological effect of only 1 species of intestinal capillarid — *C. columbae*—has been studied in detail. The life cycle of *C. bursata* is not known. The life cycle of *C. columbae* is direct, and the life cycle of *C. caudinflata* requires species of earthworms as the intermediate host.

*C. columbae* has been reported to be a seriously pathogenic form, and

it seems very reasonable that such will be true of the other 2 species of intestinal capillarids when they are assayed.

*CHEILOSPIURA HAMULOSA* (Diesing, 1851) was found in the gizzard of only 2 of the 1,014 chickens examined.

Evidence obtained by examination of one flock in Knox County indicates that when conditions in the poultry yard are favorable for survival of the intermediate host (species of grasshoppers and crickets in particular) the worm can be a serious problem. None of the other 20 species of worms recorded from chickens in Tennessee produced such severe and widespread lesions in the organ infected.

*GONGYLONEMA INGLUVICOLA* (Ransom, 1904) was found in the crop of only one chicken examined. A single female specimen was collected.

### CESTODES (Tapeworms)

Wehr (1943) listed 9 species of tapeworms that have been recorded from chickens in the United States. All of these species were found in the course of the survey in Tennessee, although one species, *Metroliasthes lucida* Ransom, 1900, was not found in chickens, but only in turkeys. A tenth species, *Fimbriaria fasciolaris* (Pallas, 1781), not previously reported in the United States, was recorded once in the survey from a chicken in Davidson County.

The largest number of tapeworms found in any one chicken was 1,894, which represented 4 species, and included 1,707 specimens of *Hymenolepis carioca*, 130 *Raillietina cesticillus*, 5 *R. echinobothrida*, and 52 *R. tetragona*. The same chicken was infected by 78 roundworms of 3 species. The largest number of species of tapeworms found in any one chicken was 7 (10 specimens of *Amoebotaenia sphenoides*, 1 *Choanotaenia infundibulum*, 2 *Davainea proglottina*, 4 *H. carioca*, and 1 specimen each of *R. cesticillus*, *R. echinobothrida*, and *R. tetragona*). Only one chicken was infected by as many as 7 species. Altogether, cestodes were present in 708 (72.8 percent) of the 972 parasitized birds.

The 9 species of tapeworms recorded in the survey are listed and considered according to their incidence, but not necessarily their relative importance. A summary of the data relating to tapeworms collected is given in table 2. The worms are shown, natural size, in figure 2.

Table 2—Incidence of cestodes (tapeworms) collected.

| Species                           | Number chickens examined | Number chickens infected | Percent incidence | Total worms collected | Average number worms present | Range of specimens present |
|-----------------------------------|--------------------------|--------------------------|-------------------|-----------------------|------------------------------|----------------------------|
| <i>Hymenolepis carioca</i>        | 1,014                    | 415                      | 40.9              | 26,424                | 63.7                         | 1-1,707                    |
| <i>Raillietina tetragona</i>      | 1,014                    | 283                      | 27.0              | 4,409                 | 15.6                         | 1-405                      |
| <i>Raillietina cesticillus</i>    | 1,014                    | 246                      | 24.3              | 4,265                 | 17.3                         | 1-258                      |
| <i>Raillietina echinobothrida</i> | 1,014                    | 140                      | 13.8              | 732                   | 5.3                          | 1-38                       |
| <i>Davainea proglottina</i>       | 1,014                    | 100                      | 9.8               | 5,088                 | 50.9                         | 1-530                      |
| <i>Amoebotaenia sphenoides</i>    | 1,014                    | 67                       | 6.6               | 946                   | 14.1                         | 1-164                      |
| <i>Hymenolepis cantianiana</i>    | 1,014                    | 60                       | 5.9               | 3,442                 | 57.4                         | 1-840                      |
| <i>Choanotaenia infundibulum</i>  | 1,014                    | 51                       | 5.0               | 284                   | 5.6                          | 1-37                       |
| <i>Fimbriaria fasciolaris</i>     | 1,014                    | 1                        | 0.1               | 8                     | 8.0                          | —                          |



Fig. 2—The ten species of tapeworm parasites, natural size, found in Tennessee chickens.

Reading clockwise, beginning at the 12 o'clock position, the species are: *Hymenolepis carioca*, *Hymenolepis cantaniana*, *Davainea proglottina*, *Raillietina cesticillus*, *Amoebotaenia sphenoides*, *Choanotaenia infundibulum*, *Fimbriaria fasciolaris*, *Raillietina tetragona*, *Raillietina echinobothrida*, *Metroliasthes lucida*.

*HYMENOLEPIS CARIOCA* (Magalhaes, 1898) was the most successful tapeworm in Tennessee chickens, from the standpoint of incidence and numbers. This tapeworm was found in 415 (40.9 percent) of the birds examined. A total of 26,424 specimens were collected, an average of 63.7 in an infected bird. The range of specimens present was 1 to 1,707.

The pathology of *H. carioca* has not been studied extensively. Luttermoser (1940) reported that infections with *H. carioca* had slight effect on the growth rate of the host.

*RAILLIETINA TETRAGONA* (Molin, 1858) is the largest tapeworm found

in Tennessee chickens. It occurred in 283 (27.0 percent) of the birds examined. The mature specimens generally were found in the posterior region of the small intestine. A total of 4,409 specimens were collected, an average of 15.6 worms in an infected bird. The range of specimens was 1 to 405.

*R. tetragona* is one of 3 species of *Raillietina* occurring in Tennessee chickens. Each of them must be regarded as a serious problem because of the destruction to host tissue caused by the spines of the suckers and rostellum. No studies of the effect on growth rate of chickens by *R. tetragona* have been made.

*RAILLIETINA CESTICILLUS* (Molin, 1858) was found in 246 (24.3 percent) of the chickens examined. A total of 4,265 specimens were collected, an average of 17.3 worms in an infected bird. The range of specimens present was 1 to 258.

The cumulative effect of *R. cesticillus* upon its host is expressed by retardation of growth, according to Harwood and Luttermoser (1938).

*RAILLIETINA ECHINOBOTHRIDA* (Megnin, 1881) is the second tapeworm of large size occurring in Tennessee chickens. This species can attain as great a length as *R. tetragona* and is heavier-bodied. Mature specimens were found in the posterior portion of the small intestine, not infrequently with their scolices attached to the lining of the ceca, the strobilae extending anteriorly into the small intestine.

*R. echinobothrida* was found in 140 (13.8 percent) of the birds examined. A total of 732 specimens were collected, an average of 5.3 worms in an infected bird. The range of specimens present was 1 to 38.

This worm has been found to cause the formation of tubercles on the wall of the posterior part of the intestine, and mortalities following heavy infections have been reported. In Tennessee chickens no nodules were found that were evident through the outside covering of the intestine. In 2 chickens, however, young specimens of *R. echinobothrida* were found with their scolices attached in the mucosa and submucosa so firmly that they were surrounded by growths of the host tissue.

*DAVAINEA PROGLOTTINA* (Davaine, 1860) is a tapeworm whose presence in chickens seems to have been frequently overlooked because of its small size. It has been most often reported from the east and west coasts, according to Wehr (1943). In Tennessee this worm was found in 100 (9.8 percent) of the birds examined. A total of 5,988 specimens were collected, an average of 50.9 in an infected bird. The range of specimens present was 1 to 530.

*D. proglottina* is considered to be one of the seriously pathogenic tapeworms in poultry.

*AMOEBOTAENIA SPHENOIDES* (Railliet, 1892) has been reported in chickens in Texas and Kansas. In Tennessee the worm was found in 67 (6.6 percent) of the chickens examined. A total of 946 specimens were collected, an average of 14.1 in an infected bird. The range of specimens present was 1 to 164.

The effect of this worm on the host has not been studied exhaustively. It appears that *A. sphenoides* is often overlooked in the examination of chickens because of its small size and fragile construction.

*HYMENOLEPIS CANTANIANA* (Polonio, 1860) is the third small species of tapeworm found in Tennessee chickens. It occurred in 60 (5.9 percent) of the chickens examined. A total of 3,442 specimens were collected, an average of 57.4 in an infected bird. The range of specimens present was 1 to 840.

Because of its small size and its resemblance to immature specimens of *H. carioca*, this species also appears to have been often overlooked. It is generally considered to be of little or no economic importance.

*CHOANOTAENIA INFUNDIBULUM* (Bloch 1779) was found in the intestine of 51 (5.0 percent) of the chickens surveyed. A total of 284 worms were collected and an average of 5.6 per bird constituted the infection. The range of worms present was 1 to 37.

*FIMBRIARIA FASCIOLARIS* (Pallas, 1781) was first found to occur in the United States (Todd, 1947) during the course of the survey of helminths in Tennessee chickens. Eight specimens were recovered from a chicken in Davidson County.

### **TREMATODES** (Flukes)

*ECHINOPARYPHIUM RECURVATUM* (Linstow, 1873) is the only species of trematode found in chickens during the survey; 2 specimens were found in a chicken examined in Washington County.

*E. recurvatum* had been reported by Anneraux (1940) as occurring in turkeys in California.

### **ACANTHOCEPHALA** (Thorny-headed Roundworms)

*PLAGIORHYNCHUS FORMOSUS* Van Cleave, 1918, was described originally from a flicker (*Colaptes auratus*) by Van Cleave (1918). It appears that the worm was first reported from chickens in the United States by Jones (1928).

*P. formosus* was found in a single chicken during the course of the survey, and 2 specimens were collected. This appears to be the second report of its occurrence in chickens in the United States.

### **GENERAL CONSIDERATIONS**

The 1,014 chickens examined during the two and one-half years of the survey represent a very small sample of the total population of chickens in the State. An effort was made to give the sample more significance by examining chickens from all sections of the State, and by sampling in each section once during each season of the year.

It seems evident from the survey that not all of the worm parasites occurring in chickens in Tennessee, and in the country as a whole, are known. The worms identified in the survey are not new discoveries, as can be seen from the dates of their original descriptions. The new fact which has emerged from this survey is the magnitude of the problem; that is, the incidence of parasitic worms in 95.8 percent of the chickens examined. The fact that 95.8 percent of the birds examined were infected, however, is not a true expression of the economic importance of these parasites.

In order to estimate any connection between incidence of worm parasites and profitable poultry production it is necessary to analyze methods of poultry production now employed.

In brief, poultrymen are concerned with the production of chickens for meat and for eggs. Meat chickens may be divided into two age groups: (1) fryers, broilers and roasters, which appear on markets when 10 to 20 weeks of age; and (2) mature chickens, such as hens and cocks which are over one year old.

It should be re-emphasized that unprofitable chickens should be culled, so that feed, labor, and space may be saved, diseases and parasites controlled, and profitable poultry be kept.

The survey data relating to the parasite problems of the two age groups of meat chickens is contained, in part, in table 3.

One consideration should be set forth before table 3 is examined: The survey data reveal the fact that a given farm flock tends to have a characteristic parasite fauna. For example, *Capillaria retusa* was present in 78 of 125 chickens (62.4 percent) examined from about 10 flocks in Knox County in 1945, but was not present in any of the 148 chickens examined from the University farms; and 25 of the 148 University chickens (17.0 percent) carried *Choanotaenia infundibulum*, but only 2 of the same 125 chickens (1.3 percent) from Knox County were infected.

To a great extent the amount of the infection is governed by the age of the chickens when released from the brooder and the time and opportunity for infection.

The practice of rearing young birds in quarters and on ranges separate from older birds has long been recommended. That procedure receives strong support by a comparison (table 3) of the parasites found in immature and adult birds. The immature birds discussed here were mainly 8-12 weeks of age; some were as old as 26 weeks; but none were producing eggs.

Of 124 immature birds examined, 113 (91.1 percent) were parasitized by 1 or more of 7 species of helminths. Of 890 adult birds examined, 859 (96.5 percent) were parasitized by 1 or more of 21 species of helminths. The average number of species found in immature birds was 1.9, and the range of species present in a single infected bird was 1 to 6; only 1 bird had as many as 6 species. The average number of species found in adult birds was 3.7,

Table 3—Comparison of infections of immature and adult birds.

| Species                                 | Number birds examined |       | Number birds infected |       | Percent birds infected |       | Range of worms present |         | Average infection |       |
|-----------------------------------------|-----------------------|-------|-----------------------|-------|------------------------|-------|------------------------|---------|-------------------|-------|
|                                         | Immature              | Adult | Immature              | Adult | Immature               | Adult | Immature               | Adult   | Immature          | Adult |
| <b>NEMATODES (Roundworms)</b>           |                       |       |                       |       |                        |       |                        |         |                   |       |
| <i>Ascaridia galli</i> .....            | 124                   | 890   | 43                    | 434   | 38.0                   | 48.7  | 1-29                   | 1-89    | 3.2               | 6.5   |
| <i>Capillaria annulata</i> .....        | 124                   | 890   | 1                     | 100   | 0.8                    | 11.2  | ----                   | 1-86    | 1.0               | 10.4  |
| <i>Capillaria bursata</i> .....         | 124                   | 890   | 0                     | 26    | 0.0                    | 2.9   | ----                   | 1-193   | ----              | 10.9  |
| <i>Capillaria caudinflata</i> .....     | 124                   | 890   | 1                     | 90    | 0.8                    | 10.1  | ----                   | 1-390   | 1.0               | 10.3  |
| <i>Capillaria columbae</i> .....        | 124                   | 890   | 0                     | 13    | 0.0                    | 1.5   | ----                   | 1-15    | ----              | 4.6   |
| <i>Capillaria retusa</i> .....          | 124                   | 890   | 0                     | 389   | 0.0                    | 43.7  | ----                   | 1-390   | ----              | 14.8  |
| <i>Cheilospiura hamulosa</i> .....      | 124                   | 890   | 0                     | 2     | 0.0                    | 0.2   | ----                   | 1-8     | ----              | 4.5   |
| <i>Gongylonema ingluvicola</i> .....    | 124                   | 890   | 0                     | 1     | 0.0                    | 0.1   | ----                   | ----    | ----              | 1.0   |
| <i>Heterakis gallinae</i> .....         | 124                   | 890   | 110                   | 736   | 97.3                   | 82.7  | 1-326                  | 1-2,279 | 30.9              | 82.7  |
| <i>Tetrameres americana</i> .....       | 124                   | 890   | 0                     | 134   | 0.0                    | 15.1  | ----                   | 1-137   | ----              | 8.9   |
| <b>CESTODES (Tapeworms)</b>             |                       |       |                       |       |                        |       |                        |         |                   |       |
| <i>Amoebotaenia sphenoides</i> .....    | 124                   | 890   | 0                     | 67    | 0.0                    | 7.5   | ----                   | 1-164   | ----              | 14.1  |
| <i>Choanotaenia infundibulum</i> .....  | 124                   | 890   | 23                    | 28    | 20.3                   | 3.1   | 1-37                   | 1-21    | 7.2               | 4.2   |
| <i>Davainea proglottina</i> .....       | 124                   | 890   | 0                     | 100   | 0.0                    | 11.2  | ----                   | 1-530   | ----              | 50.9  |
| <i>Fimbriaria fasciolaris</i> .....     | 124                   | 890   | 0                     | 1     | 0.0                    | 0.1   | ----                   | ----    | ----              | 8.0   |
| <i>Hymenolepis cantaniana</i> .....     | 124                   | 890   | 0                     | 60    | 0.0                    | 6.7   | ----                   | 1-840   | ----              | 57.4  |
| <i>Hymenolepis carioca</i> .....        | 124                   | 890   | 39                    | 376   | 34.5                   | 42.2  | 1-284                  | 1-1,707 | 42.3              | 65.9  |
| <i>Raillietina cesticillus</i> .....    | 124                   | 890   | 0                     | 246   | 0.0                    | 27.6  | ----                   | 1-258   | ----              | 17.4  |
| <i>Raillietina echinobothrida</i> ..... | 124                   | 890   | 0                     | 140   | 0.0                    | 15.7  | ----                   | 1-38    | ----              | 5.2   |
| <i>Raillietina tetragona</i> .....      | 124                   | 890   | 1                     | 282   | 0.8                    | 31.7  | ----                   | 11-405  | 1.0               | 15.6  |

and the range of species was 1 to 11. Moreover, the average infected immature bird carried 47.4 worms, and the average infected adult bird carried 135.8 worms, nearly 3 times as many.

A further comparison can be made of immature and adult birds with respect to the 7 species of worms found in both groups. It can be noted (table 3) that adult birds had the higher percentages of infection with 5 species; they had a higher average number of worms of 6 species; and the range of specimens present was wider in adult birds in the case of 6 species.

The fact that only 7 species of worms were found in the 113 parasitized immature birds is not interpreted to mean that the younger birds were not susceptible to infection by the other 14 species, but rather that they were not subject to conditions in which they might have picked up the infection.

These data make it clear that young birds should be kept separate from older birds.

It appears from another study (Todd and McSpadden, 1947) that chickens released from brooders at 8 to 10 weeks will have low worm burdens. This suggests that birds released from brooders with few or no worms and finished for market as fryers and broilers in a 2-week period, might, during those 2 weeks, escape the lowered rates of weight gain which result from worm infections, provided they were given reasonably clean quarters separate from older birds and from areas to which older birds have been allowed access or where droppings from other chickens have been thrown. That not all fryers and broilers produced in Tennessee escape heavy worm infections is glaringly evident in such birds received by the Agricultural Experiment Station for diagnosis of infections.

The survey indicates that worm infections in Tennessee chickens are apt to constitute problems concerning older birds. The poultryman is interested in the relationship of worm infection to egg production and to the weight and condition of the hen when she is removed from a flock and sent to market. The survey is based on birds which appeared on markets and furnishes no data on the egg production of these birds before they came to market.

One purpose in conducting the survey was to arrive at some indication of the total effects of these infections upon their hosts. There is little information upon the subject in the literature relating to helminths in chickens. No work, for example, has been done with simultaneous infection by 2 or more species of worms — and the average infection found in Tennessee chickens is 3.55 species.

The average farm flock in Tennessee has a unique parasite fauna. The average infected mature bird carried 135.8 worms of 3.7 species. The range of number of species present in any one chicken was 1 to 11. In table 4, data are summarized which relate to the number of species present, the average number of worms constituting the infections, and the smallest and the largest number of worms comprising the infections in mature chickens. There

Table 4—Range of worms present in 859 infected adult chickens and average infection per bird.

| Number species present | Number birds in each group | Range of worms present | Average infection per bird |
|------------------------|----------------------------|------------------------|----------------------------|
| 1                      | 88                         | 1-294                  | 24.9                       |
| 2                      | 165                        | 2-2,292                | 65.3                       |
| 3                      | 167                        | 3-1,468                | 96.2                       |
| 4                      | 170                        | 6-1,768                | 184.8                      |
| 5                      | 94                         | 15-749                 | 148.9                      |
| 6                      | 81                         | 11-687                 | 169.2                      |
| 7                      | 51                         | 27-1,972               | 286.9                      |
| 8                      | 29                         | 38-2,229               | 364.9                      |
| 9                      | 7                          | 98-441                 | 206.4                      |
| 10                     | 5                          | 148-1,033              | 376.8                      |
| 11                     | 2                          | 51-462                 | 256.5                      |

is an apparent progression in number of worms constituting an infection as the number of species present in an infected bird increases. Although these figures do not distinguish individual species, it seems possible that progressively greater effects of parasitism also are indicated in table 4. That the number of worms of an individual species present in chickens will increase when the number of other species present have increased, is indicated in table 5, which relates to the 3 most prevalent worms in Tennessee chickens, namely, *Heterakis gallinae* from the ceca, and *Ascaridia galli* and *Hymenolepis carioca* from the intestine.

The data in tables 3, 4, and 5 define the worm parasite problem relating to chickens in Tennessee which are 6 months or more of age. From the poultryman's standpoint, the effects of worm parasites upon these chickens are as follows: (1) the more pathogenic species may cause the death of infected birds; (2) worm burdens can decrease, or delay, or interrupt egg production; (3) worm infection may result in lighter birds at marketing, because of weight losses; (4) there is lower general resistance to other diseases.

The tables previously referred to indicate that principles established in the field of pure parasitology need interpretation in an applied field. For example, the principle that an animal becomes more resistant to infection as it grows older seems to have been received too readily by poultrymen, at least when worm parasites constitute the infection. It is evident, in table 3, that mature chickens carry a greater number and variety of worm parasites than immature birds. This is true because the older birds have had more time and opportunity to become infected, not because younger birds are less susceptible. It is evident that while age resistance is a well-known fact in regard to worm parasites of chickens (Herrick, 1926), it does not confer immunity from infection at any age.

The laboratory can demonstrate that if a bird is once infected with a single helminth, it will allow less of the same species to develop a second infection — that it will have acquired immunity. Under conditions, however, where the infection is composed of more than one

Table 5—Number of specimens per infected bird of the three most prevalent worm parasites in Tennessee, arranged according to the number of other species present.

| Number<br>other<br>species<br>present | <i>Ascaridia galli</i>                 |                                   |                      | <i>Heterakis gallinae</i>              |                                   |                      | <i>Hymenolepis carioca</i>             |                                   |                      |
|---------------------------------------|----------------------------------------|-----------------------------------|----------------------|----------------------------------------|-----------------------------------|----------------------|----------------------------------------|-----------------------------------|----------------------|
|                                       | Number<br>birds<br>in<br>each<br>group | Range<br>of<br>numbers<br>present | Average<br>infection | Number<br>birds<br>in<br>each<br>group | Range<br>of<br>numbers<br>present | Average<br>infection | Number<br>birds<br>in<br>each<br>group | Range<br>of<br>numbers<br>present | Average<br>infection |
| 0                                     | 8                                      | 1-12                              | 4.6                  | 87                                     | 1-245                             | 25.3                 | 6                                      | 1294                              | 56.7                 |
| 1                                     | 80                                     | 1-31                              | 4.4                  | 169                                    | 1-2,279                           | 54.2                 | 48                                     | 1-229                             | 26.3                 |
| 2                                     | 101                                    | 1-44                              | 4.9                  | 169                                    | 1-628                             | 52.4                 | 88                                     | 1-1,385                           | 59.7                 |
| 3                                     | 104                                    | 1-53                              | 6.9                  | 163                                    | 1-615                             | 95.0                 | 99                                     | 1-1,291                           | 110.8                |
| 4                                     | 57                                     | 1-89                              | 8.4                  | 93                                     | 1-714                             | 98.5                 | 52                                     | 1-419                             | 28.3                 |
| 5                                     | 48                                     | 1-65                              | 8.5                  | 78                                     | 1-632                             | 90.8                 | 41                                     | 1-267                             | 29.4                 |
| 6                                     | 34                                     | 1-35                              | 5.1                  | 47                                     | 1-1,305                           | 120.9                | 39                                     | 1-1,707                           | 101.8                |
| 7                                     | 23                                     | 1-44                              | 8.7                  | 27                                     | 1-1,981                           | 173.5                | 21                                     | 1-81                              | 15.5                 |
| 8                                     | 7                                      | 1-17                              | 4.7                  | 7                                      | 16-132                            | 54.6                 | 7                                      | 4-194                             | 55.6                 |
| 9                                     | 6                                      | 1-33                              | 9.7                  | 5                                      | 4-537                             | 153.2                | 5                                      | 1-194                             | 19.2                 |
| 10                                    | —                                      | —                                 | —                    | 2                                      | 21-68                             | 44.5                 | 2                                      | 4-223                             | 113.5                |

the situation is different. From table 4, which shows progressive increase of total numbers of worms present as the number of species increases, and in table 5, in which a progression of numbers of a single species in a given chicken is shown with the addition of other species, it appears that an acquired immunity from one worm parasite will be lessened when the host's resistance is lowered by further infection. The average number of species present in infected chickens in Tennessee was 3.55. Effects of parasites upon their hosts therefore must be calculated on an aggregate of species present.

If losses in productiveness due to worm parasite infections cannot be avoided by allowing the infections to stay in a flock where the principles of age resistance and acquired immunity are at work, the question of how the infections shall be controlled arises. That is to say that poultrymen will want the worms removed from their flocks.

In considering control measures for worm parasites, it is well to remember that day-old chickens are free from worms. Worm parasites are acquired by each chicken during its own lifetime and the parasites which enter the chickens are those present in older birds or on the premises where each flock is maintained. Removal of all the parasites from older birds, even if that were possible, would not prevent younger birds from becoming infected if parasites at an infective stage were present in the brooder houses or on the ranges and yards. Actually, as this is written, it is possible to remove by treatment only 2 of the 21 species of worm parasites found in Tennessee chickens. These 2 worms are *Ascaridia galli*, against which various commercial preparations such as carbon tetrachloride and nicotine sulfate are effective, and *Heterakis gallinae*, which can be removed by administration of phenothiazine.

The most successful measures for controlling worm parasites are those outlined by poultry specialists which relate to improved methods of starting, brooding, feeding, maintenance of laying flocks, and modern methods of sanitation. These methods are given in free circulars, pamphlets, and bulletins, which may be obtained, upon request, from county agents or the Agricultural Extension Service of the University of Tennessee.

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