ON THE CONTROL OF TAPEWORM INFESTATIONS IN CHICKENS WITH NOTES ON THE PATHOLOGY OF THE INTESTINES OF THE HOST

A THESIS

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By

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On the Control of Tapeworm Infestations in Chickens with Notes on the Pathology of the Intestines of the Host.

Errata

Page 9. The quotation from Hawn, indicated by brackets should come at the end of the first paragraph, page 10.

Page 36. The fifth line from the top should read: The next day there was none again and the bird was dosed with negative results.

Page 40. The line at the top of the table should read: Dosed with 1 oz. of Iodine Vermicide (Merck) 12-5-34 and 3-13-35.

Page 52. The second sentence from below should read: The intestines were opened in 15 to 70 minutes after the bird was killed.

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The prevalence of tapeworm infestation.

That tapeworms are common parasites in the small intestines of chickens is evident from the various reports dealing with poultry diseases. Dearstyne, Kaupp and Wilfong (1) found 13.8 per cent of the birds examined at the North Carolina Agricultural Experiment Station infested with tapeworms. Niemann (2) found tapeworm infestation in 45.16 per cent of 93 paralyzed birds at the Kansas Agricultural Experiment Station. Published data from the Michigan Agricultural Experiment Station deal with birds from the College Poultry Farm, the Egg Laying Contest and diseased ones sent in for diagnostic examinations. Chandler and Ferguson (3) working with the College flock found tapeworms in 26 of 298 birds or an infestation of 8.7 per cent. Stafseth and Weisner (4) made a study of the mortality in 10,000 laying hens in the Michigan Egg Laying Contest covering a period of 8 years beginning November 1, 1922, and found tapeworms in 36 of 1,898 birds autopsied (1.9 per cent). This rather low infestation may have been due to the fact that a considerable number of the birds had been treated with Iodine Vermicide (Merck) as they entered the contest. Table 1 gives us an idea as to the prevalence of tapeworms in domestic fowls in Michigan (5).

Table 1.

Occurrence of tapeworms in fowls sent to the Michigan Agricultural Experiment Station for examination from 1927 to 1934.

Year	Number of specimens	Number of specimens showing tapeworms	Approximate Percentage tapeworm infestation
1927	2421	104	4.3
1928	2482	188	7.6
1929	2576	168	6.5
1930	3351	302	9.0
1931	2567	165	6.4
1932	2760	473	17.5
1933	2901	481	16.5
1934	2226	266	11.9
Total	21284	2147	10+

This figure is undoubtedly low because many of the specimens were too decomposed for a proper examination and many of the birds were too diseased to serve favorably as hosts, the parasites no doubt having been shed before the birds reached us. There is also a marked seasonal variation in the prevalence of tapeworm infestation, the peak being reached in the fall and early winter. Our figures cover the entire year. There is also a considerable difference in the prevalence of tapeworms in different localities and our specimens come from all parts of the state. While tapeworm infestations may not be as prevalent here as in some other states it seems reasonable to suppose that the average infestation of chickens in Michigan would be about thirty per cent. Ferry (6) made a survey of the prevalence of cestoda in and around Douglas County, Kansas and found that 62 per cent of specimens examined were infested with Raillietina cesticillus, 40 per cent with Hymenolepis carioca, 38 per cent

with Raillietina tetragona, 4 per cent with Raillietina echinobothrida and 2 per cent with Choanotaenia infundibulum. Thus considering the poultry industry of the country as a whole, it seems that, if tapeworms are at all pathogenic, the control of tapeworm infestation is one of the major problems of the poultryman.

The problem.

The control of tapeworm infestations in chickens may be undertaken in three ways:

1. An attempt may be made to control or eliminate, as far as possible, the intermediary hosts which transmit tapeworms from one chicken to another.

2. One may treat chickens with the various remedies recommended for the purpose of removing the worms or at least the strobilae,* which, in a sense, consist of many individual worms, the proglottides.

3. These two methods of control may be combined.

The work recorded here deals largely with the treatment of infested birds with Iodine Vermicide (Merck). Some attention was also given to the biological saturation point of tapeworm infestation and the pathology of the intestines of infested birds.

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* The word strobila will be used to designate the chain of proglottides rather than the whole tapeworm. When it is stated that the strobilae were removed it is to be understood that a chain of proglottides, in some cases, may have been broken off, leaving some of the proglottides imbedded in the mucosa with the neck and scolex.

Historical.

Life Cycles. In 1889 Grassi and Rovelli (7) showed that the slug, Limax cinereus, is the intermediary host of Davainea proglottina. Three years later these men (8) found in the body of the Musca domestica larvae, whose scoleces closely resembled those of Choanotaenia infundibulum. Gutberlet (9) in 1916, produced further evidence showing that the house fly (M. domestica) is the intermediary host of Choanotaenia infundibulum (Goeze). Ackert (10), in 1918, let house flies eat live onchospheres of R. cesticillus, then, after a suitable length of time fed those flies to parasite free young chickens. On autopsy he found these chickens to harbor R. cesticillus. In 1919 Guberlet (11) studied the life history of Hymenolepis carioca (Magalhaes) and found the intermediary host to be the stable fly, Stomoxys calcitrans. He found the infestation to be greatest in November and December. During this period the stable fly is very numerous and sluggish, hence easily caught by chickens (Oklahoma). Ackert (12), in 1920, studied the life history of Davainea tetragona (Molin). He caught flies (M. domestica) on manure piles and fed them to chickens thereby apparently producing an infestation with this cestode in some of his birds. Evidently large numbers of flies were necessary for the transmission of this parasite from one chicken to another. He was, however, unable to find larvae in the flies. It was noted that flies will rupture the egg masses and suck the embryos out of them. Joyeux (13), in 1920, reported on some studies of life cycles of cestodes in poultry. He

described cysticercoids of Choanotaenia infundibulum obtained from beetles, Geotrupes sylvaticus, which had been fed with eggs of this tapeworm.

Chandler (14), in 1923, confirmed an earlier report of Grassi and Rovilli by demonstrating that slugs serve as intermediate hosts for Davainea proglottina. He found a specimen of Agriolimax agrestis with a natural infestation of D. proglottina cysticercoids. Slugs of the same species were infected by laboratory feedings with tapeworm eggs. Immature larvae were found in two specimens of Limax flavus which had been fed eggs of D. proglottina. Chandler was the first to work on the life history of this tapeworm in the United States and noted that one species of slug, Agriolimax agrestis which serves as an intermediate host in Europe, also serves in this capacity in this country.

In 1928 Cram (15) presented a paper at the meeting of the American Poultry Science Association held at Purdue University summarizing our present knowledge of poultry parasites. She stated that the data concerning the life cycle of R. cesticillus with respect to the house fly as the intermediary host are conflicting. A preliminary report was made of having found cysticercoids in the ground beetle and a small dung beetle.

Cram and Jones (16) 1929, have the following to say concerning the life history of Raillietina cesticillus:

"The present report adds a third coleopteran intermediate host, Anisotarsus terminatus, to the two previously reported, Anisotarsus agilis and Choeridium histeroides, and

presents good, though as yet incomplete, evidence that Selenophorus pedicularius is also an intermediate host for Raillietina cesticillus." They also found evidence of Hymenolepis carioca being transmitted by a beetle, Choeridium histeroides, and possibly also the ground beetle, Anisotarsus agilis.

Jones (17), 1929, found that the dung beetle, Aphodius granarius, is an intermediate host for Hymenolepis carioca.

Treatment. Of the several remedies recommended for the removal of tapeworms in chickens the only ones in common use at present are Iodine Vermicide (Merck) and kamala.

Chandler, at the Michigan Agricultural Experiment Station discovered the vermicidal action of iodine. The annual reports of the Veterinary Division of Michigan State College for the years 1924 to 1934 and the Quarterly Bulletin for February 1924 (18) (19) contain accounts of the work which lead to the discovery of a method of producing a stabilized form of colloidal iodine and to the development of Iodine Vermicide (Merck) and Iodine Suspensoid (Merck), colloidal iodine preparations of the hydrosol type.

In 1926 (20) and again in 1929 (21) Chandler summarized his work with iodine on the poultry farm. The method of preparation, preservation by protective colloids and concentration as well as the possible uses and advantages of colloidal iodine were described by Chandler and Miller (22) (23) in 1927. The vermicidal value of colloidal iodine (Chandler) was studied by Alderman in 1928 (24). As a result

of all this work with colloidal iodine (Chandler) it has been shown that it possesses vermicidal action and that it will remove strobilae and sometimes scoleces of tapeworms in a surprisingly short time. As far as the removal of strobilae is concerned it was shown to be 100 per cent effective. However, the tests were not conducted so as to prove its efficiency in removing scoleces. In most cases the efficiency of this product in removing tapeworms was judged by a check dose given 48 hours after the initial dose. If worms had been discharged following the first dose and none were discharged following the second or check dose the efficiency was considered to be 100 per cent. Some birds were also autopsied, usually about 48 hours after dosing. If worms had been expelled as a result of the treatment and none were found left on autopsy the effectiveness of the treatment was considered 100 per cent.

In 1932 Stafseth and Thompson (25) carried out further tests on the effectiveness of Iodine Vermicide (Merck) in the removal of tapeworms from the intestines of chickens. Again no birds were held more than 48 hours after treatment so that the autopsies, which showed that Iodine Vermicide (Merck) possesses a very high efficiency in removing strobilae, actually did not prove anything concerning its effectiveness as regards removal of scoleces.

In 1926 kamala was reported by Hall and Schillinger (26) to be 100 per cent effective as an anthelmintic for tapeworms when given in adequate doses. The dose for chickens weighing as much as 1.5 pounds was found to be one gram. These conclusions

were drawn from work on a very small number of birds and the tests carried out would again not prove whether scoleces had been removed. The same year, shortly after the work of Hall and Schillinger was reported, Beach and Warren (27) published the results of their work declaring kamala to be an efficient teniacide. They used 46 birds in their tests and judged the effectiveness of the drug by the "segments" discharged. Nothing was said concerning removal of scoleces nor is any information given concerning the length of time that was allowed to elapse between treatment and autopsy.

Schlingman (28) in 1927 reported on the anthelmintic efficiency of kamala and tetrachlorethylene in the treatment of chickens. When these two remedies were given simultaneously their efficiency was reduced to 61.8 per cent for tapeworms and 28.5 per cent for roundworms. However, when given separately kamala was 100 per cent efficient for tapeworms and tetrachlorethylene 100 per cent efficient for roundworms. Neither one of the remedies had any effect on cecum worms. Some birds suffering from tuberculosis, coccidiosis and roup died following the treatment. Nineteen birds were used in the test on these drugs when used separately. The birds were held 4 to 11 days following the treatment before being autopsied. There is nothing in the report to show that the birds, that had apparently shed all their tapeworms as a result of the treatment, were held long enough to permit the tapeworms that were left to develop strobilae of sufficient size to be detected on autopsy.

In 1932 Rebrassier (29) showed that 7.5 grains and 10 grains of kamala did not remove all tapeworms from the intestines

of chickens. Three birds, given 1.5 grains of kamala, completely eliminated all their tapeworms; 16 birds passed fragments of tapeworms but proved infested on autopsy and 27 birds passed no tapeworms after treatment but all were found to harbor them on autopsy. All birds were held 14 days or more following treatment before the autopsy was made. In all, 128 chickens were used in these experiments. The tapeworms encountered were: Davainea proglottina, Choanotaenia infundibulum, Raillietina cesticillus and Hymenolepis carioca.

Bleecker and Smith in 1933 (30) found Iodine Vermicide (Merck) and also Pulvus No. 142 (Lilly) plus 15 grains of kamala of about equal efficiency. Iodine Vermicide (Merck) was not found difficult to administer but was the more expensive of the two. When birds are in poor condition Iodine Vermicide (Merck) or Pulvus No. 142 (Lilly) are safer than kamala. Thomas (31) in 1933 found worm treatment as practiced in Florida, "worthless, harmful and expensive". His work was done in the field and no attempts were made to protect the treated birds against reinfestation. [Hawn (32) in 1933 found kamala neither safe nor effective against tapeworms in young turkeys weighing 2.5 to 80 ounces.] The remedies used were kamala and tetrachloethylene (Given as suggested by Schlingman (28))and Iodine Vermicide (Merck). He concluded that none of these possess any merits. The results were judged by the egg production of treated and untreated birds, the latter producing on an average 1.5 per cent more eggs than the former. An examination of his work as a whole shows that the mortality of the untreated birds was somewhat higher than that of the treated ones. There is no record

of the cause of death and to wind up the experiment only 2 birds from each pen or 16 birds out of a total of 1,629 were autopsied as a check on the efficiency of the treatment. Thus it seems that little was learned from this work except that the results of poor poultry management cannot be improved by merely administering a worm remedy once a year and doing nothing else to control the spread of tapeworms.

Maw (33) in 1934 showed that one gram of kamala given to pullets shortly after starting to lay caused a decline in the rate of egg production and a decrease in the egg weight. There was considerable variation in the reaction of individual birds and the recovery from the ill effects of kamala was quite rapid.

Pathology of the intestines. There is very little literature available on the micropathology of the intestines of chickens infested with tapeworms and there is not much more of a definite nature dealing with macroscopic changes. Kaupp (34) in 1914, merely mentions a catarrhal condition of the bowel produced by tapeworms in general. He states that Davainea tetragona causes nodular disease in the intestines. The lesions produced resemble tubercles. Tubercular lesions are visible on the serous as well as on the mucous surface. From the lesions in the mucosa some of the worms may protrude. In the later stages of the infestation the nodules may show ulcerations on the mucous surface. A greenish-yellow necrotic material may be seen in these nodules. Secondary infection with pyogenic bacteria may take place, in which case pus will be present. Before the nodules are formed these worms may be seen

between the villi. Ward and Gallagher (35), 1920, have the following to say about the morbid anatomy of the intestines of tapeworm infested chickens: "They (the tapeworms) are attached to the mucosa by their heads and may cause more or less inflammation. The most serious pathological changes are caused by infestation with Davainea echinobothrida which results in the formation of nodules in the intestine. The condition has been described by Moore (36) under the name of nodular taeniasis. The nodules are most numerous in the lower third of the small intestine. Exceptionally they occur in the duodenum and colon. In severe infestation the presence of nodules causes numerous protuberances from the serosa, varying in size from those barely perceptible to elevations 4 mm. high. The color varies from pale or dark yellowish in the larger ones, to the normal gray of the serosa shown by the smallest ones. Similar elevations are observed on the mucosa of the intestine. Small tapeworms occur attached to the mucosa over the nodules. Over some of the nodules there are areas in which the mucosa has sloughed, leaving ulcers.

The contents of the larger nodules consist of greenish yellow, necrotic material which on section has a glistening, homogeneous appearance. Surrounding this there is a thin layer of infiltrated tissue. The smaller nodules contain a substance more resembling pus, and in these the microscopic study of sections most readily reveals the presence of tapeworm heads. The penetration of the intestinal wall by the heads induces infiltration and eventually results in the formation of nodules."

Kitt (37), 1923, merely states that severe inflammations are produced because the tapeworm fastens itself deeply and firmly in the mucosa by means of the scolex. They may even reach the muscular layer. Reinhardt (38), 1925, states that there are different grades of intestinal inflammation varying from simple intestinal catarrh to severe hemorrhagic enteritis. At times there are also chronic inflammatory changes such as the tubercle like nodules. Rarely is there a perforation with consequent peritonitis.

According to Otte (39), 1929, the reddish colored intestinal contents suggest the presence of cestodes. The intestinal mucosa is more or less inflamed and shows small punctiform hemorrhages. Once in a while we may observe formation of nodules. VanHeelsbergen (40), 1929, says that the disease manifestation depend on the number, kind and location of the tapeworms. Young birds are, in general, very susceptible and suffer most from the infestation. A mild infestation may cause no trouble. If very many tapeworms are present food material is withdrawn from the intestine. The poisonous metabolic products of these parasites may act on the host. If the intestinal mucosa is irritrated by the armed tapeworms which fasten themselves to it by suction and frequently change their place of attachment, intestinal catarrh will be produced. Some tapeworms produce a severe intestinal inflammation, as for example, Davainea proglottina which lives mainly in the duodenum, often causing a severe chronic duodenitis. The mucous membrane is thickened and in many cases markedly hemorrhagic. The serosa

is heavily injected. Later, as a result of hemorrhagic inflammation, it is even brownish yellow. The tapeworms, by fastening themselves to the mucosa, produce small defects and hemorrhages in it. Through such injuries arises the possibility of secondary bacterial infection of the submucosa, muscularis and serosa. The tapeworms which remain fastened in one place may produce tubercular nodules, as in the case of Raillietina tetragona in chickens. According to Manninger and Katlan (41) Davainea echinobothrida produces pathological changes only in the small intestines. In the region of Meckel's diverticulum pinhead sized single or confluent grayish white slightly elevated foci are found. They develop as a result of the young D. echinobothrida penetrating deeply into the mucous membrane. The mucous membrane is swollen and reddened. Peculiar foci with heavy, hard craters may be seen when the intestinal contents are washed away. These lesions simulate those of tuberculosis. In adult birds tapeworms are of significance only when present in large numbers and when other disease producing factors can be eliminated. Emmel (42), 1934, claims that he has isolated a microbe which causes fowl paralysis and allied diseases. This microbe, he says, depends upon the predisposing action of intestinal parasites for its success in causing the diseases concerned.

Experimental

Treatment. As has already been mentioned, in our previous work sufficient time was not allowed to elapse between treatment and autopsy for remaining scoleces to develop

strobilae large enough to be detected on postmortem examination. Hence, it looked as if Iodine Vermicide (Merck) removed nearly 100 per cent of the ascaridia and cestodes. In the experiments to be recorded here the birds were kept various lengths of time (as indicated in each experiment) following the treatment before the postmortem examination was made. The chickens used were kept in wire cages with 3/4 inch hardware cloth bottoms. Under each cage a shallow pan partly filled with water was kept in order to collect the droppings and parasites discharged as a result of the treatment. A few of the birds were kept in a battery in which there were individual cages with 3/4 inch hardware cloth bottoms, but instead of water pans there were flat trays for collecting droppings. The droppings were scraped off, moistened in water and then washed repeatedly in shallow glass dishes as in the case of the droppings collected in the water pans.

The birds were treated, placed in the cages and watched as indicated below. Examinations for discharged parasites were as a rule made in 1/2 hour, 2, 17 and 48 hours following the treatment. In fact many of the birds were watched constantly for over two hours in order to see how soon Iodine Vermicide (Merck) would pass through the intestines and also how soon parasites might be discharged.

In examining the droppings they were thoroughly stirred in water and the mucous casts were broken up by means of forceps or other suitable instruments. Since the tapeworms and especially the scoleces may be hidden within these mucous casts this step is very important. The pans or glass dishes were filled

with water and allowed to stand until the worms had a chance to settle to the bottom. The water was then carefully poured off and a search was made for parasites in the bottom of the glass dish or metal pan as the case might be. This procedure was repeated until enough extraneous matter had been removed to permit a satisfactory examination for tapeworms. The birds were not kept in screened cages but they were kept in rooms where young birds have been kept year after year for weeks or months at a time without becoming infested with tapeworms. Furthermore, most of this work was done during the late fall and winter when intermediary hosts are apt to be scarce. On postmortem examination careful search for tapeworms was first made in the mucous membrane as the intestines were being slit open. In doubtful cases the contents and the superficial layers of the mucosa were placed in water in shallow glass dishes and washed, as indicated above, to facilitate the detection of parasites. When it is stated that a given number of tapeworms was passed it means that that many looked as if they might be entire worms, not that the scoleces were necessarily attached. In the course of the experiments on treatment a large number of birds was encountered that failed to pass worms as a result of the dosing and also showed no worms on being autopsied. These birds will not be mentioned further unless they were used for observations on the fate of colloidal iodine in the intestines.

Experiment 1.

Six chickens were dosed with 1 ounce of Iodine Vermicide (Merck) diluted as directed, October 19, 1934. One bird died in 20 hours. No worms passed, no worms found on autopsy.

Results found on autopsy October 27, 1934.

Bird No. 1. Formed droppings passed a few minutes after dosing. These contained live unstained proglottides. Passed iodine stained watery feces and stained nonmotile proglottides in 5 to 10 minutes.

Autopsy. Moderate enteritis, one Raillietina cesticillus 3/4 inch long. Condition of bird seemed improved.

Bird No. 2. Passed normal droppings containing live proglottides a few minutes after being dosed. No iodine passed until 1 hour and 45 minutes after the dosing, when about 2 dozen R. cesticillus were expelled in mucous casts. These casts are formed by the jellying of the mucus of the intestines by the iodine. About one-half of the number of worms passed were noticeably stained with iodine. None of the proglottides of these worms showed motility. The eggs in all the stained proglottides examined failed to show motile onchospheres. Unstained proglottides in which the eggs were also unstained showed motile onchospheres.

Autopsy. Moderate duodenitis, 81 R. cesticillus, condition of bird seemed improved.

Bird No. 3. Passed normal droppings containing live proglottides a few minutes after being dosed. About 1/2 dozen tapeworms found in pan 24 hours after the treatment.

Autopsy. Duodenitis, 16 R. cesticillus. This bird was thin.

Bird No. 4. Passed formed droppings with a few live proglottides a few minutes after dosing. A small number of

fragments of strobilae were passed in 20 hours.

Autopsy. Duodenitis, 6 R. cesticillus. This bird was thin.

Bird No. 5. Passed formed droppings and live proglottides in 15 minutes after the dosing. A number of fragments of strobilae were passed in 20 hours.

Autopsy: Duodenitis, 17 R. cesticillus. This bird was in fair flesh.

The reason for the expulsion of unstained live proglottides and larger fragments of strobilae soon after the dosing is that the iodine markedly increases peristaltic movement causing the emptying of the lower portion of the bowel before the contents there are reached by it.

The strobilae passed were so broken up that an attempt to estimate the number of tapeworms passed seemed practically useless. In none of these birds does it seem likely that the number passed would exceed two dozen. Attempts to locate scoleces failed and the number of worms found on autopsy compared with the apparent number expelled indicate that few or no scoleces had been removed in these birds. The tapeworms found on autopsy were small, the size being 3/4 inch or less.

The cause of the enteritis may be assumed to be tapeworm infestation or secondary bacterial infection. It is interesting to note that the bird having the heaviest infestation seemed to be somewhat improved in condition.

A number of proglottides passed by these birds were carefully dissected and examined microscopically. The results have already been given. In addition to observing the motility

of onchospheres of stained and unstained eggs, counts were made of the eggs in 3 proglottides. The results were: 249, 229 and 164 or an average of 212 eggs per proglottis.

Experiment 2.

This group of six birds were dosed not only to check on the ability of Iodine Vermicide (Merck) to remove tapeworms but to study the effects of the treatment on body weight.

Details as to results of dosings and autopsy in Experiment 2.

Bird No. 1. discharged a few tapeworms and iodine stained casts from ceca in 24 hours after the second dosing. On autopsy 4 tapeworms 8 to 10 proglottides long were found in the duodenum. The mucous membrane showed some sloughing and the serous coat was thickened. There were numerous pit like erosions of the size of a pinhead.

Bird No. 2. The condition of the intestine was similar to that of bird No. 1. Numerous tapeworms were passed in 24 hours following the first dosing and several were discharged in 1 hour and 53 minutes. On autopsy a considerable number of tapeworms was found.

Bird No. 3. (Control) passed no tapeworms while under observation but showed numerous tapeworms on postmortem examination. The condition of the intestine was similar to that of Bird No. 1.

Bird No. 4. (Control) one entire tapeworm (with scolex) was passed during the first night in the cage. None were passed later but numerous tapeworms were found on postmortem examination. Pathology of intestine approximately as above.

Table 2.

Efficiency of Iodine Vermicide(Merck)in removing tapeworms and effect on body weight.

Dosed * 10-29-34 Dosed * 11-5-34 Birds No. 3 and 4 controls, not dosed.

No. of bird	Weight 10-29-34		Results in 24 hours	Weight 11-5-34		Difference in weight since 10-29-34		Results in 24 hours	Weight 11-12-34		Difference in weight from 10-29-34 to 11-12-34		Tapeworms at autopsy** 11-12-34
	lbs	oz.		lbs	oz.	lbs	oz.		lbs	oz.	lbs	oz.	
1	3	4.5	-	3	4.75	G-0	0.25	x	3	5.5	G-0	1.0	x
2	2	0.5	xx	1	1.3	L-0	3.5	x	1	11	L-0	5.5	xx
3	2	4	control -	2	3	L-0	1.0	-	2	2.5	L-0	1.5	xx
4	2	15.75	control 1 entire tape	3	0.25	G-0	0.5	-	2	15.75	0	0	xx
5	2	5.25	-	2	6.0	G-0	0.75	-	2	8.75	G-0	3.5	-
6	3	1	x	3	0.5	L-0	0.5	x 1 tapeworm	2	15.75	L-0	1.25	x

* 1 ounce of Iodine Vermicide Merck
** See below for detailed autopsy record

x Less than 20 tapeworms - No tapeworms
xx from 20 to 50 tapeworms
G - gain L - loss

Bird No. 5. No worms passed, none found on autopsy.

Bird No. 6. A few tapeworms passed in mucous casts following first dosing and one tapeworm following second dosing. The autopsy showed a rather normal condition of the duodenal mucosa. The middle portion of the intestines showed some sloughing. Several tapeworms were found in this portion.

It will be noticed that after the first treatment the total gain for the treated birds was 5 ounces while the total loss for the 2 controls was 1 ounce. At the end of the experiment the treated birds had lost a total of 2.25 ounces and the controls 1.5 ounce. Thus there was not much difference between gain or loss of weight in the treated and untreated birds. The number of birds was too small to be of any significance in determining the effects of treatment on body weight. Furthermore these birds were visibly diseased as a result of parasitism and the condition of their digestive tracts indicated that the infestation was of rather long standing. Hence their recuperative power may have been impaired.

Scoleces could not be found following treatment except on the one tapeworm which was discharged naturally by one of the controls. This fact together with the number of tapeworms found on autopsy again indicates that, while strobilae are removed by treatment the majority of the scoleces remain. The tapeworms encountered were R. cesticellus.

Experiment 3.

Since it seemed obvious that we were not having much success in removing scoleces, nine birds were given drinking water containing one level teaspoonful of $NaHCO_3$ per quart for

Table 3.

Effect of Iodine Vermicide(Merck)following a preliminary treatment with $NaHCO_3$

$NaHCO_3$ from 11-12-34 to 11-14-34

Dosed with 1 oz. of Iodine Vermicide(Merck)11-14-34

No.of bird	Weight 11-12-34		Effect of $NaHCO_3$	Time of iod.ver. treatment	Results of Iod.Ver.Treat		Weight 11-25-34		Dif. in wt. from 11-12-34 to 11-25-34	Autopsy 11-23-34
					Same day	Next day				
	lbs	oz.					lbs	oz.	ounces	
1	2	14.5	Mucus Proglottides	9:45 A.M.	I.in droppings in 25 min.several A at 1:30 p.m.	Many R.C.	2	9.5	L 5	Numerous H.C.
2	2	14.25	Mucus	none - control	-	-	3	0.25	G 2	15 or more tapeworm mostly R.C
3	2	8.5	Mucus	9:50 A.M.	-	1 large R.C.	2	7.5	L 1	No worms
4	2	6.0	Mucus	9:45 A.M.	I.in droppings in 25 min.several R.C.by 1:30 P.M.	100 + R.C. and H.C. many with scoleces	2	4.0	L 2	26 H.C.
5	1	14.5	Mucus	None - control	-	-	1	4.5	0	20 tapew. mostly R.C
6	1	10.25	Mucus 1 tapeworm*	9:50 A.M.	Died at 12 noon					Very poor, diphtheritic enteritis, few R.C.
7	2	14.0	Much mucus	9:55 A.M.	I.in drop. in 25 min. Few R.C.by 1:30 P.M.	A few R.C.	2	12.75	L 1.25	18 tapeworms mostly H.C.
8	2	11.75	Mucus	9:55 A.M.	-	1 small R.C. a few progt.	2	10.75	L 1	No worms
9	2	15.5	Mucus	9:55 A.M.	-	Numerous H.C.	2	13.75	L 2.25	21 H.C.

*40 proglottides long (R.cesticillus)

A- Ascaridia R.C. - Raillietina cesticillus

I- iodine H.C. - Hymenolepis carioca G-gain L-loss

two days immediately prior to the treatment with Iodine Vermicide (Merck). No other drinking water was given. This was done in order to remove mucus and otherwise clean and prepare the intestine for the treatment. It was hoped that by doing this the tapeworms might be more readily reached. Some of the birds discharged large amounts of mucous casts and the droppings passed gave unmistakable evidence of enteritis.

From this table it will be noticed that only two of the birds became free from tapeworms as a result of the treatment and these two birds discharged only one worm apiece within 24 hours after being dosed. Since most of the worms found on autopsy were H. carioca and rather few of these were discharged following the treatment it may be possible that it is more difficult to remove than R. cesticillus. Evidently the preliminary administration of $NaHCO_3$ made very little improvement in the efficiency of the treatment. The birds treated with Iodine Vermicide (Merck) lost a total of 12.5 ounces, one untreated bird gained 2 ounces and the other control bird neither gained nor lost. It will be evident from a study of Table 3 that there was no relationship between loss or gain in weight and the number of tapeworms present. The mucous membrane of the intestines of these birds seemed smooth and clean, but the thinness of the intestinal wall indicated that a considerable amount of sloughing had taken place and that the apparently healthy condition of the mucosa was due to the cleansing effect of the sodium bicarbonate.

Experiment 4.

Early in January 1935, 26 Buff Orpingtons, 22 cockerels

and 4 pullets, were purchased from a nearby farm where tapeworm infestation had been found to be rather heavy. These birds, while not noticeably sick, were in poor flesh and the owner had been unable to dispose of them on that account.

On January 3, 1935, 15 of these birds were weighed, placed in individual cages and treated as shown in Table 4. One ounce of Iodine Vermicide (Merck) was again used and since it was evident from the work done so far that very few scoleces are removed by this treatment, it was decided to attempt to make an improvement in its penetrating power. A sample of sulphoichthyolate of ammonium had recently been submitted to us by H. C. Montgomery and Company of Detroit, Michigan for experimental use. This oil substance has a very low surface tension and it was thought that it might aid the penetrating power of Iodine Vermicide (Merck) if used as part of the diluting fluid. Iodine Vermicide (Merck) was therefore diluted with a 10 per cent emulsion of sulphoichthyolate of ammonium in the usual proportion, e.e., 1 pound of Iodine Vermicide (Merck) to enough water to make 1 gallon. One ounce of this material was given to each bird. Besides examining the droppings of these birds for tapeworms and proglottides, weights were taken several times to serve as indications of the influence of the treatments on the birds. The birds were selected in such a way as to have as even a weight distribution as possible for the controls as well as for the two groups of treated birds.

Table 4

Efficiency of Iodine Vermicide(Merck) diluted in water compared with its efficiency when diluted in 10 per cent sulphoichthyolate of ammonium.

Dosed as indicated January 3, 1935.

No. of Bird	Weight 1-3-35	Kind of treatment	Results in 24 hours	Weights and exam. for progl. 1/9/35	1/18/35	2/7/35	2/14/35	2/21/35
548	4.85	None	P (few)	5.25	5.5	6.1	6.4	6.4
549	4.3	None	-	4.5	4.9	5.3	5.6	5.65
550	2.7	I.V. in S.A.	-	3.1	3.3	3.2	3.5	3.6
551	4.7	I.V.	-	5.1	5.7	6.7P	7.1P	7.0
552	3.2	I.V. in S.A.	6 R.C.	3.6	4.1P	4.9	5.2P	5.5
553	3.55	"	-	3.9	4.3	4.9P	5.2	4.5
554	5.2	"	-	5.0	6.1	7.2P	7.6P	7.4
555	4.2	I.V.	3 R.C., 33A.	4.3	4.6	5.1P	5.4	5.6
556	3.5	None	-	3.6	3.8	4.5	5.0P	4.65
557	4.2	I.V. in S.A.	-	4.6	4.8	5.3P	5.4	5.5
558	3.3	None	-	3.6	3.9	4.7	4.9	5.0
559	3.2	I.V.	21 A.	3.65	3.7	3.9	4.25	4.2
560	3.85	I.V.	4 R.C.	4.05	4.4	5.5P	6.0	5.6
561	2.85	None	-	3.2	3.5	3.9	4.3P	4.6
562	2.75	I.V.	10 A.	3.1	3.2	3.1	3.2	3.3

I.V. - Iodine Vermicide (Merck)
S.A. - Sulphoichthyolate of ammonium
P. - proglottides
- - negative
R.C. - Raillietina cesticillus
A - Ascaridia

Several proglottides from birds number 552 and 560 were examined for motile onchospheres 24 hours after the treatment was given but none could be found. The proglottides as well as the onchospheres were still faintly colored with iodine.

On February 21 the 9 birds, which had been passing proglottides, were again treated as indicated in Table 5. Neoarsphenamin was given alone to see if it would, by any chance, cause the expulsion of tapeworms. It was given six hours before administering Iodine Vermicide (Merck) to see if it might make this remedy more efficient. The dose of neoarsphenamine (.03 gram) was based on the weights of the birds as compared to the weight of a man of average weight for whom the maximum dose is .9 gram. Neoarsphenamine was given intravenously.

Table 5.

The vermifugal effect of Neoarsphemanine and Neoarsphenamine followed by Iodine Vermicide(Merck)
Neoarsphenamine given 10 A.M. Feb. 10, 1935
Iodine Vermicide(Merck)given 4 P.M. Feb. 10, 1935

No.of Bird	Kind of treatment	Results in 48 hours	Weight 2/28/35	Autopsy First 8 birds 2/28/35 Last 7 birds 3/1/35
548	None	-	6.5	12 H.C.
549	"	-	5.6	20 R.C.
550	"	-	3.8	-
551	N and I.V.	-	6.95	5 H.C.
552	"	2 S.T.	5.5	2 R.C., C.W. (xxx)
553	"	-	4.6	H.C. (x) C.W. (x)
554	"	-	7.2	1 H.C.
555	"	-	5.5	C.W. (x)
556	N.	-	4.85	1 R.C.,12 H.C., C.W. (x)
557	N.	-	5.5	20 x H.C., C.W. (xxx)
558	None	-	5.3	14 A., 1 H.C.
559	"	-	4.6	C.W. (x)
560	N.	-	5.6	6 H.C., C.W. (xx)
561	"	-	5.0	17 x H.C., 1 R.C., C.W. (xx)
562	None	-	2.95	24 adult A.

N - neoarsphenamine 0. 03 gm.
I.V. - Iodine Vermicide(Merck) 1 ounce
- - negative
S.T. - small tapeworms
H.C. - Hymenolepis carioca
R.C. - Raillietina cesticillus
A - Ascaridia
C.W. - cecum worms
x - few
xx - moderate number
xxx - numerous

Further details as to the results of the postmortem examination of these birds:

Bird No. 548. There were areas of cell infiltration, petechial hemorrhages and numerous small nodules in the mucous membrane of the intestine. There was also some sloughing of mucous membrane.

Bird No. 549. Severe enteritis with sloughing of mucous membrane.

Bird No. 550. Coccidiosis (Eimeria acervulina), enteritis.

Bird No. 551. Enteritis, cell infiltration areas large enough to look like tumors (leucosis), sloughing of mucous membrane.

Bird No. 552. Numerous small calcareous nodules.

Bird No. 553. Many petechial hemorrhages and areas of cell infiltration.

Bird No. 554. Extensive enteritis, sloughing, many small tumors (leucosis).

Bird No. 555. Intestinal mucosa in fairly good condition.

Bird No. 556. Mild form of enteritis.

Bird No. 557. Areas of cell infiltration.

Bird No. 558. Mild form of enteritis.

Bird No. 559. Intestinal mucosa normal.

Bird No. 560. Areas of cell infiltration.

Bird No. 561. Enteritis with cell infiltration areas.

Bird No. 562. Mild form of enteritis.

Considering the weight of these birds we find that those which served as controls in the first part of this experiment

gained from January 3 to February 28, 1935 a total of 8.45 pounds or 1.69 pounds per bird. Those treated with Iodine Vermicide (Merck) in 10 per cent sulphoichthyolate of ammonium gained 7.75 pounds or 1.55 pounds per bird and those given Iodine Vermicide (Merck) alone gained 6.90 pounds or 1.38 pound per bird. The table also shows that there was no marked change in the trend of gains or losses as a result of the second treatment. Thus again it seems that untreated, infested birds do as well if not better than treated birds as far as gain in weight is concerned. It is of course obvious that the groups worked with are rather small and the data obtained may not, therefore, be of great significance. Also the difference between the average weight of the controls and that of the group treated with Iodine Vermicide (Merck) was only 0.31 pounds. However, it is interesting to note that the controls have tended to outweight the treated birds throughout.

Experiment 5.

In order to compare the gain in weight made by birds kept in the battery with that of birds kept in a pen, 7 of the Buff Orpingtons were placed in a small pen and their individual weights were checked each time the birds in the battery were weighed. These eight birds were not treated at the start of this experiment. The reason for doing this was that it seemed desirable to know if keeping the birds in cages (batteries) would produce any marked ill effects on them, and, thus, alter the results.

Table 6.

Gain in weight of untreated birds kept in a pen.

No. of Birds	Weights						
	1/3/35	1/9/35	1/18/35	2/7/35	2/14/35	2/21/35	3/4/35
563	3.6	3.8	4.0	4.3	4.1	4.15	4.19
564	4.75	5.2	5.7	6.2	6.5	6.4	6.38
565	4.4	4.9	5.4	6.2	6.6	6.3	6.64
566	3.1	3.4	3.7	4.3	4.95	4.8	4.63
567	3.3	3.6	3.8	3.6	3.4	3.45	2.88
568	3.3	3.5	3.95	4.8	5.2	5.0	3.95
569	2.9	3.1	3.35	3.4	3.5	3.6	3.73

In general these birds gained during the period from January 3 to March 4, 1935. Some of them lost a little toward the end of the observation period and it is interesting to note that, during the last 4 days, they were kept in a roomier and much better pen than the one in which they were held from January 1 to February 28. The feeding was exactly the same as for those in the battery and all the birds were in the same building and practically in the same room as there was no complete partition between any of the rooms used. Six of the seven birds gained a total of 7.47 pounds and one lost 0.42 pounds. Thus, the gain for the group from January 1 to March 4, 1935 was 7.05 pounds or 1.007 pounds per bird, in other words 0.683 pounds less than the untreated birds and 0.543 pounds less than the iodine treated ones kept in the battery. The birds kept in the pen were also given 4 more days in which to gain than those held in the battery. Thus, any loss in weight suffered by treated birds kept in batteries cannot have been caused by the manner of housing.

On March 4 these 7 birds were taken to another building, placed in a battery (supplied with water pans for collecting droppings and parasites) and dosed with one ounce of Iodine Vermicide (Merck). The same method of feeding was continued. The results are given in Table 7.

Table 7.

Effect of treatment with Iodine Vermicide (Merck)

Dosed with 1 ounce of Iodine Vermicide (Merck) March 4, 1935.

No. of bird	Results of dosing in 17 hours	Results of dosing in 41 hours	Weight 3/11/35	Weight 3/18/35	Autopsy 3/18/35
563	84 ascaridia*	4 more ascaridia	4.44	4.61	no worms
564	-	-	6.58	6.67	no worms
565	2 fragments of R.C. 1/3 in	-	7.63	7.05	2 small R.C. 1 H.C.
566	3 large R.C. 1 small	-	4.88	4.69	6 R.C. ½ grown
567	-	-	died 3/8	-	no worms
568	-	-	3.83	4.22	3 small R.C.
569	5 ascaridia (adults)	6 more ascaridia	4.11	4.25	22 H.C.**

* About one-half of this number were adults.
RC - Raillietina cesticillus.
HC - Hymenolepis carioca
** All but 4 were very small.

Further detail on results of autopsy:

Bird No. 563, 564 and 565. Intestinal mucosa in fair condition.

Bird No. 566. Slight amount of cell infiltration in intestinal mucosa.

Bird No. 567. Pneumonia, some sloughing of intestinal mucosa.

Bird No. 568. Intestinal mucosa in fair condition.

Bird No. 569. Intestinal mucosa showed areas of marked cellular infiltration in several places through the anterior half of the intestines.

Table 7 shows that following the treatment 4 birds gained a total of 0.79 pounds or 0.147 pounds per bird in 7 days while two birds lost a total of 0.77 pounds or 0.385 pound per bird during the same period. The bird from which 88 ascaridia were removed by the treatment gained a little following the administration of the iodine, and in this connection it is of interest to note that the two birds that lost weight after being treated were not as heavily infested as birds number 563 and 569, both of which gained. The difference in these weights is hardly great enough to be of any significance especially since the table shows that there were fluctuations of about equal magnitude prior to the time of treatment.

The bird that died, number 567, had begun to show signs of disease before March 4 and at the time of treatment he was in very poor condition.

Again a considerable number of H. carioca was found on autopsy. None of these parasites were found in the droppings after the treatment.

Experiment 6.

Four of the Buff Orpingtons were subjected to experimental treatment with various remedies or combinations of remedies and were observed wery closely as shown in the following records. This was done to see if it might be possible to find

some agent that would remove more scoleces than any used heretofore.

Bird No. 570.

January 3, 1935, weight - 2.7 pounds.

January 4, 1935; Treated with Iodine Vermicide (Merck) diluted with 10 per cent sulphoichthyolate of ammonium in water as mentioned above. The dose of this mixture was one ounce and was administered at 5:40 P.M. By 8:30 P.M. the same day 53 R. cesticillus and about 20 cecum worms had been discharged. Scoleces could not be found. No worms were expelled the next day.

January 18, 1935 weight - 2.66 pounds.

February 7, 1935 weight - 2.88 pounds.

February 14, 1935 weight - 3.03 pounds.

February 14, 1935; Dosed with Iodine Suspensoid (Merck) diluted with fresh skim milk. (One bottle full (1 lb.) of Iodine Suspensoid (Merck) in sufficient milk to make one gallon). One ounce of this liquid was given at 9:30 A.M. By 2:30 P.M., the same day, 9 young ascaridia and numerous cecum worms had been discharged. Twenty-four hours later 7 more youngg ascaridia and about 100 more cecum worms had

been expelled.

February 22, 1935 weight - 2.98 pounds.

February 28, 1935 weight - 2.97 pounds.

February 28, 1935; Autopsied: 41 R. cesticillus of various sizes, none very large; numerous cecum worms, but no ascaridia were found. There was severe inflammation of the rectum.

Bird No. 571.

January 3, 1935; weight - 2 pounds.

January 4, 1935; Treated with the same remedy as bird number 570 at 5:40 P.M. In 17 hours (10:40 A.M. the next day) 20 R. cesticillus, 11 ascaridia and about 30 cecum worms had been expelled.

January 18, 1935 weight - 2.02 pound.

February 7, 1935 weight - 2.17 pounds.

February 14, 1935 weight - 2.11 (one ascarid passed during the night)

February 14, 1935, Treated with Iodine Suspensoid (Merck) in milk (diluted as before), 1 oz. at 9:30 A.M. By 2:30 P.M. the same day 50 young ascaridia had been passed. Twenty-four hours later 10 more ascaridia were found in the droppings of this bird. There was also a moderate number of cecum worms in the pan at this time.

February 28, 1935 weight - 2.14

February 28, 1935; Autopsied. The intestinal mucosa was in fairly good condition, except for a moderate amount of cellular infiltration. Numerous cecum worms were found but no tapeworms nor ascaridia.

Bird No. 572.

January 3, 1935 weight - 3.3 pounds.

January 4, 1935; Treated with Iodine Vermicide (Merck) (diluted as used in treating birds for worms) and 10 per cent sulphoichthyolate of ammonium, equal parts. One ounce of this mixture was given at 4:40 P.M. In 18 hours (11 A.M. the next day) 4 ascaridia but no tapeworms had been passed.

January 7, 1935; Dosed again with same material. In two days 10 ascaridia had been expelled.

January 7, 1935 weight - 3.17 pounds

January 18, 1935 weight - 3.16 pounds

February 7, 1935 weight - 2.88 pounds

February 14, 1935 weight - 2.86 pounds

February 22, 1935 weight - 2.67 pounds

February 28, 1935 weight - 2.73 pounds

February 28, 1935; Autopsied: 5 young ascaridia, 2 H. carioca and numerous cecum worms

were found. There was hemorrhagic enteritis and rather definite signs of leucosis in the intestinal mucosa. This bird had iritis and was partly blind.

Bird No. 173.

January 3, 1935, weight - 4.8 pounds

January 4, 1935, Treated with one ounce of 10 per cent sulphoichthyolate of ammonium at 4:40 P.M. No worms were expelled during the following 48 hours.

January 7, 1935 weight - 4.66 pounds

January 18, 1935 weight - 5.00 pounds

February 7, 1935 weight - 5.39 pounds

February 14, 1935 weight - 5.38 pounds

February 14, 1935, Treated with Iodine Suspensoid (Merck) in milk, as indicated above. No worms were expelled in 48 hours.

February 15, 1935. Dosed with one ounce of Iodine Vermicide (Merck) at 4:55 P.M. No worms expelled in 48 hours.

February 22, 1935 weight - 4.97 pounds.

February 27, 1935 weight - 5.00 pounds.

February 27, 1935, Autopsied. No tapeworms and no ascaridia were found but there were some cecum worms.

This bird had been passing proglottides of R. cesticillus

from January 7 to February 14. Usually about one-half dozen proglottides were found each day. However, some days none could be found. During the week of February 7 to 14 none could be found until February 13 when 3 proglottides were noticed in the pan. The next day there was none again and the bird was dosed. No tapeworms could be found on autopsy. It is possible that this bird may have shed his tapeworms during the week of February 1 to 7 when the pans were not regularly inspected due to an attack of influenza affecting two of the workers. How to account for the 3 proglottides found February 13 is not so easy unless it might be that these proglottides may have been retained for some reason or another. These proglottides contained no motile onchosphores. In Table 8 will be found a summary of the data obtained from these four birds.

Table 8.

Summary of the data obtained in Experiment 6.

No. of bird	570	571	572	573
Kind of treatment	I.V. in S.A.*	I.V. in S.A.*	I.V. diluted* 10% S.A. aa	10% S.I.A.*
Results	53 R.C. 20 C.W.	20 R.C. 11 A. 30 C.W.	4 A.	-
Kind of treatment	I.S. in* milk	I.S. in milk	I.V. dil. and 10% S.I.A. aa	I.S. in milk
Results	16 A 100 C.W.	60 A.	10 A.	-
Autopsy	41 R.C. C.W. xxx	-	5 A. 2 H.C.	-
Change in weight. Jan. 3 to Feb. 28	G 0.27 lb.	G 0.14 lb.	L 0.57 lb.	G 0.2 lb.

*See description of this experiment for detail concerning remedies used.
I.V. - Iodine Vermicide (Merck)
S.A. - Sulphoichthiolate of ammonium
aa - equal parts
R.C. - Raillietina cesticillus
H.C. - Hymenolepis carioca
C.W. - Cecum worms
A. - Ascaridia
I.S. - Iodine Suspensoid(Merck)
xxx - numerous
G - Gain
L - Loss

This experiment shows that large numbers of strobilae may be discharged in a very short time after treatment with Iodine Vermicide (Merck).

While this is not a study of roundworm infestation it must be noted that young ascaridia may be so deeply imbedded in the mucosa that they cannot be reached by a vermicide or vermifuge. In the case of bird number 571 only 11 ascaridia were removed following the first treatment while 60 were expelled after the second one and none was found on autopsy showing that all ascaridia had been removed from this bird. At times large numbers of cecum worms are removed also.

With the exception of bird number 572 which suffered from leucosis and partial blindness, all these birds gained a little during the experiment in spite of the fact that they were kept in cages too small for such large chickens as orpingtons. Bird number 571 was completely freed from its tapeworms by one treatment and large roundworms by two treatments while only a few less Raillietina cesticillus were found on autopsy in bird number 570 than were estimated to have been expelled following the first treatment. This bird also failed to discharge any ascaridia after the first treatment but expelled 16 of them following the second one. Bird number 572, from which 14 ascaridia were removed by 2 treatments failed to discharge tapeworms, but showed 2 H. carioca on autopsy. Thus it seems that not even the strobila of this tapeworm is easily removable by this mixture of iodine and sulphoichthyolate of ammonium.

Experiment 7.

Most of the birds used in the experiments recorded up to this point were more or less visibly sick or in rather poor condition. In order to see if we would have better results by treating normal birds, 30 pullets were secured from the Department of Poultry Husbandry. These birds were rather typical of pullets that have not yet come into production. Tapeworms are not uncommon in the College stock and some of these birds, while certainly not sick, looked as if they might be proper subjects to work on. Thirteen of them were placed in one pen and seventeen in the other. Treatment was applied as follows:

Pen 6.

The thirteen birds (Barred Rocks) in this pen were given drinking water containing 2 tablespoonfulls of $NaHCO_3$ per gallon, on December 5, 1934. On December 6 at 4:30 P.M., and again March 13, 1935, at 4:20 P.M. they were dosed with one ounce of Iodine Vermicide (Merck). The results are given in Table 9.

Table 9

Results of dosing with 1 ounce of Iodine Vermicide(Merck) following the administration of sodium bicarbonate for 24 hours

Dosed with 1 oz. I.V. 3-13-35

No.of Bird	Weight 12/6/34	Results in 24 hours	Weight 12/28/34	Weight 3/13/35	Results in 16 hours	Weight 3/29/35	Autopsy 3/29/35
527	4.0	-	3.5	3.65	-	2.8	7 H.C., 1/4 inch, leucosis
526	4.3	-	4.4	4.4	1 A.,1 R.C. 6 H.C.	4.6	20 R.C. and H.C.
525	4.0	-	4.1	Died 2/17/35			Pickout
524	4.3	33 R.C.	Died, pickout, 12/27/34 about 25 R.C. on autopsy				
523	4.0	1 R.C.	4.0	Died 12/30/34 Eviscerated			
522	4.1	xx f R.C.	3.7	3.6	1 H.C. 3/4 inch. Leucosis, no worms	Died 3/15	
521	4.15	12 R. C.	4.3	Died 2/4/35 Lymphomatosis. No worms			
520	3.9	-	3.8	3.85	4 R.C. No. Sc.	3.85	3 H.C., 2.5 inches
519	4.25	-	4.1	Died 2/15/35 Mycosis, no worms			
518	4.0	-	4.2	Died 2/3/35 Enteritis, emaciation, no worms			
545	6.6	-	6.8	6.8	-	7.1	About 100 H.C.
546	4.85	30 x R.C.	4.75	4.1	-	2.8	2 H.C., 1/2 inch Leucosis
547	46	-	4.9	Died 2/3/35			Tapeworms

H.C. - Hymenolepis carioca
R.C. - Raillietina cesticillus
- - No worms passed
xxx f R.C. - Numerous fragments of Raillietina cesticillus
A - Ascaridia
Sc - Scolex

Leucosis and lymphomatosis as well as pickouts or evisceration destroyed eight of these birds. H. carioca was expelled by two birds as a result of the treatment and seven birds discharged R. cesticillus. Three birds showed tapeworms on autopsy but had not expelled any following either one of the treatments. Two birds had shed all their worms prior to the autopsy. Bird number 545 is of interest since it showed about 100 H. carioca on autopsy and had never expelled any of these worms as a result of the treatments. Furthermore this bird gained in weight up to the close of the experiment.

Three proglottides from each of three unstained worms expelled by bird number 524 were dissected and examined microscopically for motile onchospheres. About one-fourth of the number of eggs examined showed motile onchospheres. These worms had evidently been expelled ahead of the iodine. Since Iodine Vermicide (Merck) stimulates peristalsis it is reasonable to assume that worms located in the posterior part of the intestines may be passed with the droppings before the iodine has reached the point of their location.

The worm expelled by bird number 523 was about two inches long. It did not look as if it possessed mature proglottides. No iodine stain was found in the proglottides of this worm examined nor could any motile onchospheres be found. An examination of some mature looking fragments of tapeworms expelled by bird number 322 showed that several (4 out of 8) of them had scoleces. There may, of course, have been many more. Since this bird showed no worms on autopsy it seems reasonable

to suppose that, in this case, all scoleces of R. cesticillus at least had been removed by the treatment. Fragments that seemed to be mature *, as judged by their shape were dissected and examined microscopically. Of more than a dozen examined none showed motile onchospheres. The position of the pre-embryonic hooks and the shape of the onchospheres showed that many of them had been motile; hence they may be taken to have been killed by the iodine. No iodine stain could be found in the eggs 24 hours after treatment.

The worms expelled by bird number 521, while showing apparently mature proglottides, failed to show motile onchospheres. In this case there was no indication that they had ever been motile. It seems therefore that motility develops as one of the last stages of maturation.

Iodine stain could be found in some of the worms expelled by bird number 546. Only one motile onchosphere could be found in several hundred eggs examined.

Most of the worms found on autopsy were H. carioca.

It is possible but not probable that these birds may have become infested following the treatment. The conspicuous absence of worms in other chickens kept in this house for months and in some cases for years, makes this assumption improbable. Also H. carioca was seldom expelled following treatment, but was frequently found on autopsy not only in the birds kept in pens 6 and 7, but in batteries located in two different buildings as well. Therefore, as already stated this tapeworm seems

*The word mature is used to indicate not merely sexual maturity as shown by fully formed male and female sex organs, but the presence of infective onchospheres.

to be even more difficult to remove than R. cesticillus.

Pen 7.

The 17 birds in this pen were given one ounce of Iodine Vermicide (Merck) December 4, 1934 at 2:30 P.M. They were given $NaHCO_3$ in the drinking water (same as pen 6) December 6 at 4:00 P.M., then dosed again with one ounce of Iodine Vermicide (Merck) December 7 at 7 P.M. On March 3, 1935 they were treated with kamala and a kamala - nicotine-calomel-pyrethrum compound and finally on March 27 they were given a one ounce dose of Iodine Vermicide (Merck), the autopsy being performed the next day. This was done for two purposes. First, to see if repeated treatments would cause the expulsion of all tapeworms present, and second to see if Iodine Vermicide (Merck) really removes the strobilae as had been indicated by previous experiments. The sodium bicarbonate was given to the birds in pens 6 and 7 to see if the removal of the mucous coating, which is often abundant in infested birds, would increase the effectiveness of the treatment. The results are shown in Table 10.

Table 10.

Effect of repeated treatments as to removal of tapeworms and influence on body weight and egg production

Given Iodine Vermicide(Merck)12/ 4/34, $NaHCO_3$ 12/6/34, Iodine Vermicide(Merck)12/7/34, Iodine Vermicide(Merck) 3/27/35

No. of Bird	Weight 12/4/34	Results after 1st dose 12/5/34	Results after 2nd dose 12/8/34	Weight 12/28/34	Weight 3/11/35	Treated (**) 3/11/35	Results in 17 hours	Weight 3/28/34	Results 3/28/35	Autopsy 3/28/35
							M			No worms
544	3.5	-	-	3.5	3.9	K	-	3.6	-	Intest.Normal
543	3.1	-	-	3.7	Died 3/ 8/35 Nephritis,			3 small	tapeworm	
542	3.2	-	-	3.4	3.5	KN	M -	3.4	-	No worms, diverticulum in
541	3.3	R.C. x	-	3.25	3.4	KN	M	3.3	-	No worms Duodenal coccidiosis
540	3.5	R.C. x	-	3.8	4.1	KN	M -	3.9	-	No worms, intestine normal
539	2.9	R.C. x	-	3.45	3.9	KN	M	3.6	2 R.C.	No worms Intest.normal
538	3.05	-	-	2.8	Died 2/17/35 Lymphomatosis, 4 tapeworms					
537	3.7	-*	-	3.65	4.0	KN	M -	3.7	6 R.C.	No worms, intest.normal
536	3.35	-	-	3.4	3.3	K	M	3.2	1 C.I.	No worms Intest.normal
535	3.125	R.C. x	-	2.55	Died 2/1/35 Cause unknown, no worms					
534	4.35	-	-	4.2	4.55	K	M	4.3	-	No worms Hyperemia in intestines
533	3.5	R.C. x	-	3.5	3.2	K	N -	3.2	1 R.C.	No worms, cell infiltra. areas
532	5.8	-	-	6.5	6.1	K	M	5.7	-	No worms Intest.normal
531	4.65	-	-	3.15	Died 2/19/35, acute enteritis. No worms					
530	4.3	-	-	4.85	4.7	KN	M	4.2	-	No worms intest.normal

Table 10 continued

529	4.6	-	-	5.1	5.2	K	M	5.5	-	'No worms,	
							-			'intest.normal	
528	5.1	-	-	5.7	5.6	K	M	5.4	1 R.C.	'No worms.	
										'Cell infiltra	
										'areas	

R.C. - Raillietina cesticillus, x - less than ten C.I. - Choanotaenia infundibulum
* - Iodine given into the crop ** K - 15 grains of kamala, K.N. - Nicotine-kamala compound containing 7.5 grain kamala, 0.5 grain nicotine sulphate, 0.5 grain colomel and pyrethrum.
M - Diarrhea with mucus N - no diarrhea or mucus W - Watery diarrhea - - No worms passed

This table shows that repeated treatments with Iodine Vermicide (Merck) even when sodium bicarbonate is given to remove the mucous coating in the intestine will not remove all tapeworm scoleces. Kamala and the kamala-nicotine-calomel-pyrethrum compound did not cause the expulsion of a single tapeworm in 17 hours. Iodine Vermicide (Merck) was shown again to remove 100 per cent of the strobilae of the tapeworms present as judged by the fact that four birds passed strobilae of R. cesticillus and one bird voided a strobila of Choanotenia infundibulum in less than 24 hours after being dosed. The fact that these strobilae were passed gives further evidence to show that the kamala treatment had been ineffective.

With the exception of birds number 538, 536, 535, 533 and 531 all showed gains or held their weight from December 4, 1934 to March 11, 1935. During this period they were also subjected to vaccination against laryngotracheitis. All showed takes and none developed any signs of this disease. All this offers proof that the worm treatment, as administered, cannot be harmful. Even after the administration of kamala followed by Iodine Vermicide (Merck) in 17 days these birds looked well and, while they had lost some weight by March 28, no harm was evident. Bird number 529 had gained as much as most of them had lost.

Additional data on the birds in Pen 9.

Bird No. 528. There were no motile onchospheres in 6 proglottides examined microscopically. The last two proglottides in the strobila showed by the shape and position of the

onchospheres and the preembryonal hooks that about one-half of them had been motile. Since this examination was made within 24 hours of the dosing it may be assumed that the onchospheres had been killed by the iodine.

Bird No. 536. Mature proglottides of the worm discharged, Ch. infundibulum, were examined microscopically and it was found that the majority of the eggs had had live onchospheres. Many had broken through the inner shell partly or completely. Likewise a number of them had gotten partly or completely through the outer shell. Seventeen free onchospheres were found in one microscopic field (low power). In these four proglottides only one faintly motile onchosphere could be found. This one was still in the inner shell.

Effect on egg production.

Two birds in pen 6, and only 3 of them producing at the time of treatment, went out of production for 11 days and one did not produce again before the autopsy was made. There had been so many sick birds in this pen that the data obtained are of little or no significance.

The birds in pen 7 slowed down in production following the kamala treatment and there was also a reduction in egg weight, the greatest reduction being shown by bird number 533 which, during the period of March 1 to March 12, had shown an average egg weight of 23 ounces to the dozen. She had laid 6 eggs in that period. Following the treatment she laid no eggs for 8 days, then she laid 3 eggs on successive days, skipped 2 and then laid 2 more on successive days. She was autopsied the

day she laid the last egg. The egg weights of the 5 eggs laid following the kamala treatment were 18, 21, 23, 24 and 24, in the order given, showing as has been shown by Maw (33) that the effect of kamala is, in most cases, of short duration. The rest of the producing birds in this pen, 8 in all at this time, showed similar effects of the treatment with kamala except that the decrease in egg weight was less pronounced. As far as number of eggs is concerned one bird, number 541, having laid, on the average, a little more than one egg in 2 days, ceased producing following the kamala treatment and did not come back into production again before being autopsied. Bird number 529 stayed out of production for 15 days. The rest of them lost about one weeks production. Three birds dropped to an egg weight of 18 ounces per dozen, the smallest drop being from 21 to 18. On the day of the autopsy 6 eggs were produced with the following egg weights, 21, 22, 23, 23, 24, 24 and the day previously 8 eggs had been produced weighing 21, 22, 22, 23, 23, 23, 24 and 24 further corroborating Maw's observations. Since these birds would have been classified by a poultryman as inferior chickens and since no control pens were avilable, no further data on the effect of Iodine Vermicide (Merck) and kamala on egg production can be offered as a result of the observations on the birds in these two pens.

Experiment 8.

Another opportunity offered itself to observe the effect of Iodine Vermicide (Merck) on egg production. Fifteen birds were brought to the College for treatment with Iodine Vermicide

(Merck) from a farm 25 miles from East Lansing. There were 13 females and two males in this flock. Before being brought here the production had been, on the average, about 53 per cent. A number of chickens had died and a male was first brought in for examination. This bird was heavily infested with roundworms and tapeworms. Not being able to treat these birds the owner offered to let us "experiment on them" if we would stand the cost of the treatment. The 15 birds brought in were placed in the battery and dosed with one ounce of Iodine Vermicide (Merck).

Table 11 shows that only 3 birds suffered a slight loss in weight. This loss did not exceed 0.2 pounds per bird and thus does not exceed the limit of normal fluctuation of weight observed in other chickens. All the rest of the birds either held their weight or gained, 7 showing a gain. During the stay at the College the egg production ceased. Two days after being brought home these chickens began to lay again. The average production for the 12 surviving hens was 5 eggs (41.66 per cent) per day until March 22 when they laid 7 eggs (58.3 per cent). This offers rather convincing proof of the harmlessness of Iodine Vermicide (Merck).

The fact that there may be a slight loss in weight following the use of Iodine Vermicide (Merck) may be due to an increased metabolic rate. In all these tests on Iodine Vermicide (Merck) an increase in appetite was noticed together with an improvement in general appearance on the part of those birds which did not show marked signs of leucosis, lymphomatosis or other diseases on autopsy.

Table 11.

Effect of shipment and Iodine Vermicide (Merck) on egg production and weight of birds brought 25 miles for treatment

Dosed Feb. 15, 1935 at 4 P.M.

No. of Bird	Weight 2/15/35	Passed iodine in	Results in 24 hours	Weight 2/19/35
1.	3.65		9 A(stained) *	3.8
2.	3.7	25 min.	-	3.5
3.	3.5	10 min.	3 A(stained) *	3.5
4.	3.85		-	3.9
5.	4.55	10 min.	-	Died, hung in wire mesh
6.	4.1	10 min.	-	4.0
7.	4.5		-	4.5
8.	4.8		1 A(stained)	4.8
9.	4.5		-	4.5
10.	3.9		-	3.85
11.	6.1		-	6.2
12.	3.1		-	3.2
13.	4.5		-	5.1
14.	5.1	20 min.	-	5.3
15.	3.4		-	3.8

A - ascaridia - * stained with iodine
- - no worms discharged

Average egg production before shipment and treatment - 53 %
" " " from 2 days after return to March 21 - 41.66%
" " March 22 - 58.33%

It appears that the attempts to improve on the Iodine Vermicide (Merck) treatment did not meet with marked success. Of all the birds worked with in these experiments only four shed all their worms as a result of the treatment. Thus it is obvious that few scoleces are removed.

What are the reasons for the failure to remove the entire tapeworms?

Location of the scolex

It has been noted above (37) that tapeworms penetrate very deeply into the crypts of the mucosa, even down to the mucularis mucosae. The sections of intestines of infested birds to be described later will bring convincing evidence of the ability of tapeworms to penetrate deeply into the intestinal crypts. Therefore, one reason for the failure to remove scoleces is, no doubt, that they cannot be reached by the remedy.

Biological sautration point

It was thought possible that one reason for the appearance of numerous tapeworms one or two weeks following treatment might be that, due to a heavy infestation, some of the worms had been retarded or even completely checked in their development and proceeded to grow when the mass of more or less matured worms had been removed. In other words, a biological saturation point of tapeworm infestation had been reached.

Experiment 9.

An attempt was made to prove whether such a condition exists. All visible tapeworms in heavily infested birds were pulled out and counted, and an examination was made for scoleces in cleared pieces of intestines. It was assumed that, if we could

demonstrate more scoleces than visible worms in a number of birds, evidence would have been brought forth in favor of the existence of a biological saturation point as regards the tapeworm infestation in these birds. Therefore, pieces of intestine from which all visible tapeworms had been removed were compressed by means of a tissue comparator, fixed in 4% formaldehyde, washed in water, dehydrated and finally cleared in benzyl benzoate until clear enough so that one could see through them by the aid of a low power microscope. By this procedure it was found that scoleces could be observed in the tissues. Preparations, adequate for the study of such details as hooks and suckers, were obtained. It was thought that the detail was sharpened by placing about one per cent picric acid in the benzyl benzoate. However, while this method was practical for the demonstration of a few scoleces in tissues, it was found that many of them were lost as the tissues were being compressed. Attempts to prevent this by placing celophane over the mucous membrane before compressing the pieces of intestine failed to make this procedure serve the purpose for which it was intended, although it did help to retain more scoleces. Fixation before compressing the tissue failed because, if sufficient fixation was obtained to prevent the escape of the parasites, the tissues became very firm and could not be compressed enough to permit microscopic examination for scoleces. Efforts to prove the existence of a biological saturation point by this method were, therefore, abandoned after 23 birds had been unsuccessfully studied.

Fate of iodine in the intestines of treated birds.

As has already been shown iodine may be passed in 10 minutes after dosing by some birds while others will fail to pass appreciable amounts of iodine. Such cases represent the extremes in this respect. Usually birds will pass iodine in 20 to 30 minutes after being dosed.

Experiment 10.

In order to see what happens to the Iodine Vermicide (Merck) in the intestines a number of birds were dosed and killed, some 5, some 10 and some 15 minutes after being dosed. The intestines were opened in 15 to 70 minutes after being killed. Table 12 shows the results of these observations.

Table 12.

Fate of iodine in treated birds

No. of Bird	Time in minutes after dosing		Autopsy findings					
				Ascarid			Tapeworms	
	Killed	Int. opened	Iodine to	Dead	Stained	Live	Dead	Stained	Live
1.	10	20	10 in. from ceca*	-		-	-	-	-
2.	10	14	Middle of int.	-		-	-	-	-
3.	10	70	"	51	26	1**	-	-	-
4.	10	26	8 in. from ceca	-		-	-	-	-
5.	10	17	"	11	9	0	-	-	-
6.	5	20	Destroyed	-		-	-	-	-
7.	5	14	Throughout	1	1	0	-	-	-
8.	5	17	" "	8	8	0	-	-	-
9.	5	15	Largely neutralized	1	1	0	-	-	-
10.	5	15	To rectum	-		-	-	-	-
11.	5	16	"	49	49	0	-	-	-
12.	5	19	?	-		-	-	-	-
13.	5	20	6 in. from ceca	6	3	0	-	-	-
14.	5	15	?	-		-	-	-	-
15.	5	10	To middle	4	2	1*			
16.	10	20	To ceca	-		-	-	-	-
17.	10	20	Into rectum	-		-	-	-	-
18.	10	20	To middle of int.	-		-	-	-	-
19.	10	20	6 in. from ceca	-		-	-	-	-
20.	10	20	To ceca	-		-	-	-	-
21.	10	20	?	1	0	0	-	-	-
22.	10		Throughout						
23.	10	20	To middle						
24.	/0	20	10 in. from ceca	3	3	0	6 R.C	6 R.C.	0

*Ten inches from ceca-means level of small intestines at blind end of ceca.
Middle of Int. - middle of small int.
Throughout - entire tract
? Iodine color either gone or so faint that its presence is questionable.
** These two worms were in the posterior part of the small intestine and had not been reached by the iodine
- no worms present
0 none of those present

The following birds were dosed with one ounce of Iodine Vermicide (Merck), held 5 minutes and autopsied as soon as they appeared to be dead. In addition to observations on the fate of iodine in the intestines proglottides were placed in warm 0.6 per cent saline solution and watched to see if they were motile. They were then dissected and examined microscopically for motile onchospheres. This was done to see if Iodine Vermicide (Merck) kills the onchospheres and not merely destroys the motility of the proglottides.

Bird No. 745. Killed 5 minutes after dosing.

Intestines opened 15 minutes after killing. Intestines were distended with Iodine Vermicide (Merck) which had passed down two-thirds of the length of the small intestine. Some fragments of tapeworms (R. cesticillus) were found, some stained deeply, some faintly with iodine. The proglottides of these fragments which appeared to be mature were dissected and examined microscopically. In one of the fragments were found proglottides containing heavily stained eggs. No motile onchospheres were found. Judging by the shape of these onchospheres they could not have been motile. Therefore, these proglottides were probably not as mature as they appeared to be on gross examination. The intestines of this bird contained a heavy mucous cast. It is this kind of a cast that usually contains the tapeworms when they are passed subsequent to treatment with Iodine Vermicide (Merck).

Bird No. 1217. Killed 5 minutes after dosing.

Intestines opened 30 minutes after killing. Iodine had reached a point 8 inches from the juncture with the ceca. There were five short strobilae still attached in the posterior portion

of the duodenum. These tapeworms were not definitely stained, but none of the proglottides showed any sign of motility. There were numerous free, deeply stained mature looking tapeworms or fragments of tapeworms. A heavy mucous cast was found in this bird also. The tapeworms were placed in 0.6 per cent saline and were examined microscopically for live onchospheres about four hours afterwards. By this time the iodine color had disappeared. Five proglottides were examined but no motile onchospheres could be found in or outside the eggs. The fact that onchospheres were found outside the egg shells showed that they had been motile and suggests that they had been killed by the iodine. These worms were R. cesticillus.

Bird No. 428. Killed 10 minutes after being dosed.

Intestines opened 16 minutes after killing. The intestines were distended with iodine down to about 9 inches from the juncture of the ceca. An excessive mass of mucus was found in the duodenum where there also were some small stained and nonmotile tapeworms as well as some unstained ones which still showed the typical expanding and contracting movement of the proglottides. In the ileac portion of the intestine there were numerous tapeworms that were stained and nonmotile. The gizzard of this bird was extremely flabby and it still contained approximately one-fourth ounce of iodine. None of the proglottides examined possessed mature eggs. One of the tapeworms was H. carioca the rest were R. cesticillus.

Bird No. 1065. Killed 10 minutes after dosing.

Intestines opened 25 minutes after killing. Iodine

filled the intestines down to the juncture of the ceca. There were numerous large, deeply stained, loose tapeworms in the ~~lower jejunal or~~ upper ileac portion. A flabby gizzard had again caused the retention of some of the iodine. No movement was observed in the proglottides which, on examination about 6 hours after the autopsy, failed to show any motile onchospheres. At the time of the microscopic examination the stain had disappeared completely from the proglottides. The shape and position of the onchospheres clearly proved them mature and we may again assume that they had been killed by the iodine. This assumption seems reasonable in view of the fact that motile onchospheres have been found in proglottides collected out of the water pans of the batteries in which the chickens were kept. Proglottides so collected and also taken from autopsied birds were shown to have motile onchospheres for a much longer period, in some cases at least 24 hours.

Bird No. 419. Killed 5 minutes after dosing.

Intestine opened 12 minutes after killing. The iodine had reached a point 10 inches from the attachment of the ceca. Numerous tapeworms were found in the duodenal portion. They were deeply stained and nonmotile. The intestine of this bird seem to be normal. A microscopic examination of the still stained proglottides seven hours after the autopsy showed stained eggs and nonmotile onchospheres. The shape of the onchospheres was such as to indicate that they were not yet quite mature.

These observations as well as those recorded above suggest that Iodine Vermicide (Merck), not only destroys the movement of the proglottides but actually kills the onchospheres.

It is also evident that the iodine moves down the intestinal canal rather quickly.

A few birds seem to destroy the iodine in a short time. This accounts for the fact that a comparatively small number of birds fail to pass noticeable amounts of iodine in the droppings.

Since most of the tapeworms found in the intestines following the treatment were stained and nonmotile and yet the scoleces are not all removed it must be assumed that the reason for this is that many of them are so deeply situated that they cannot be reached by the iodine. Rather quick destruction of iodine in the intestines of some birds will of course account for a part of the failures to remove scoleces. It is not known what causes this destruction. The rather large quantity of mucus in the intestines of some of these birds may account for it partly.

In vitro tests on vermicidal action of Iodine Vermicide (Merck)

Experiment 11.

In order to gain more definite knowledge as to the ability of Iodine Vermicide (Merck) to kill worms and their eggs a number of in vitro tests were made by suspending worms, ascaridia and tapeworms in Iodine Vermicide (Merck) containing 0.5, 1 and 2 per cent I_2 in the colloidal state, kept at about 20 and 37° C in shallow Petri plates. Ascaridia suspended in Iodine Vermicide (Merck) (2% I_2) at room temperature were killed (judged by cessation of movement) in 20 to 75 seconds. The larger ascaridia usually moved the longest. No tests were made with warm Iodine Vermicide (Merck) on ascaridia.

Gapeworms died instantaneously when dropped in Iodine Vermicide (Merck) diluted sufficiently to be transparent (room temperature).

Numerous tests on fragments of tapeworms showed that Iodine Vermicide (Merck) diluted so as to contain 1 and 2 per cent I_2 even at room temperature caused them to shrink and stop moving almost instantaneously. Movement could not be brought back by washing in water. The size of the proglottides made some difference in the time required for the stopping of movement, the larger ones continuing to move the longest.

Tests on the killing of onchospheres showed that the best results were obtained with Iodine Vermicide (Merck) containing 1 or 2 per cent I_2 when kept at body temperature. Exposures were made at 2.5, 5, 7.5 and 10 minutes. At first apparently mature or gravid proglottides were collected, either from droppings of infested birds or from the intestines of birds subjected to postmortem examination, in numbers so as to expose some to the different dilutions of iodine and to leave some in 0.6 per cent saline as controls. It was soon discovered that apparent maturity, judged by outward appearance, did not guarantee the presence of motile onchospheres in the proglottides. Evidently, as already mentioned, motility, on the part of the onchosphere, is one of the last qualities developed and, therefore, it was not uncommon to find but one proglottis with motile onchospheres. Now and then 2, 3 or 4 were found and very seldom as many as six. The last proglottis in the strobila usually contained the greatest number of motile onchospheres each

preceeding one containing a smaller and smaller number. For this reason it was found inadvisable to try to judge the killing power of Iodine Vermicide (Merck) by the comparative number of motile or nonmotile onchospheres in the treated and untreated proglottides. It was noticed that no movement had ever been observed in iodine stained onchospheres. In order to check the effect of iodine directly on the eggs, proglottides were dissected in 0.6 per cent saline, placed on a microscopic slide and covered with a cover glass. This preparation was then placed under the low power of the microscope and eggs with motile onchospheres were located. A drop of Iodine Vermicide (Merck) (2 per cent I_2) was placed at the edge of the cover glass. Thus it was found that as the iodine diffused into the microscopic field and came in contact with the eggs, the onchospheres stopped moving in just a few seconds. None moved after showing appreciable iodine color. When the eggs were stained the onchosphere took the stain. The space between the onchosphere and the outer shell remained unstained. Using staining of the onchosphere as a criterion it was determined that Iodine Vermicide (Merck) containing 2 per cent I_2 will kill onchospheres in 10 minutes at about 37°C, i.e. if the iodine adhering to the proglottis is neutralized with sodium thiosulphate before dissection. If, on the other hand, the proglottides are dissected while still stained, even 0.5 per cent iodine will appear to kill the eggs, obviously because the amount of iodine clinging to the proglottis is sufficient to stain and kill the onchospheres as they come in contact with it during the dissection. More than 100 proglottides were used in these test.

Since proglottides have been found to retain the iodine stain for hours in in vitro as well as in in vivo tests it seems certain that large numbers of potential tapeworms are killed by the Iodine Vermicide (Merck) treatment. As already stated counts were made of the number of eggs in 4 proglottides of R. cesticillus and it was found that they contained 164, 212, 229 and 243 eggs respectively. Therefore, by killing proglottides with their numerous eggs one will at least materially reduce the chance for infestation of other birds.

Pathology

Histopathological studies were included in this work for two reasons. First, to gain further information as to the reason for the failure to remove scoleces and second, to determine how much and what kind of damage is caused by tapeworms.

Kotlan (43) in 1925, informed the writer that, as far as he knew, Raillietina cesticillus was perfectly harmless for chickens. Likewise O'Roke (44) more recently made the remark that ducks are apparently not hurt by tapeworms since they have been seen in, what seemed to be, perfect health while being heavily parasitized. Furthermore, I have observed hens in production while heavily infested.

Numerous field observations have taught us that under ordinary conditions chickens may tolerate a fairly heavy infestation. However, young birds, hens in heavy production, and fowls otherwise afflicted do not fare so well under a tapeworm infestation. The fact that birds in apparently good health may be found heavily infested with tapeworms usually means, in my opinion, that

the pathological condition in the intestine has not advanced as far as it ultimately will. Emaciated and noticeably diseased birds, which on autopsy show marked enteritis without tapeworms, may simply have shed the worms after the pathological condition became bad enough to make conditions unfavorable for the parasites, or, as shown by Stoll (45) in the case pf Haemonchus contortus in sheep,a "self cure" or acquired resistance may have been produced causing the expulsion of the tapeworms. This has been brought out in our autopsy work during the past years. One example will suffice. About 15 chickens from the same flock were autopsied one afternoon. All showed emaciation and marked enteritis. None showed coccidiosis or worm infestation. The remark was made to the owner that it would have been well if he had brought along birds that were not in such advanced stages of disease, whereupon he brought out four healthy looking Rhode Island Reds, which he had in a sack at one side of the room, saying, that he had thought it advisable to bring along some better looking specimens for comparison. All these four birds were heavily infested with tapeworms (R. cesticillus). Numerous such observations together with the fact that birds of different ages and in various conditions have improved markedly in a few days following the removal of large numbers of strobilae, have convinced the writer of the harmfulness of tapeworm infestation. Nevertheless it was deemed desirable to seek more definite evidence of local injury.

The gross pathological conditions found have been recorded along with the experiments on treatment and do not

differ from those described by others.

Figures 4, 5, 6, 9 and 11 show why scoleces may not be easily removable. Figure 2, plate 1 shows why all roundworms are not always removed by one treatment. Microscopic studies were made of serial sections from 12 infested chickens.

The pathological changes observed were very much the same in kind although differing in degree. Most of the birds studied were infested with R. cesticillus and some of them had also H. carioca infestation. One bird proved to have either Capillaria or Ascaridia infestation as shown in Plate 1 Fig. 2. None of these worms had been seen on autopsy.

The photomicrographs represent only 5 of the birds studied but they show quite well all the different physical host parasite relationships as well as the types of lesions observed.

Bird Number 12 (Fig. 1) a 10 weeks old white leghorn, had numerous small tapeworms, R. cesticillus. There was not much evidence of enteritis. Microscopic examination showed portions of tapeworms some of which could be definitely identified as R. cesticillus (Fig. 1). Very little inflammatory reaction was noticed in the region infested by the worm shown in the photomicrograph.

Bird No. 13 (Fig. 2) a 10 weeks old white leghorn showed a marked catarrhal enteritis but there were only a few tapeworms present (R. cesticillus). The sections showed the presence of nematodes, either Capillaria or young Ascaridia. These birds will be referred to later in connection with a description of some red bodies commonly found in the majority

of the birds studied histopathologically.

Bird No. 15 (Figs. 3,4,5,6, and 7) a 4½ months old Barred Rock pullet, had 64 R. cesticillus and 23 H. carioca. The former were located mostly in the middle portion of the small intestine while the latter were most numerous in the upper duodenal portion. When portions of the intestines were cleared with benzyl benzoate a worm taken to be a Capillaria was also found imbedded in the mucosa. Besides enteritis this bird showed leucosis.

Bird No. 16, (Figs. 8,9 and 10) a 14 weeks old Rhode Island Red, had numerous short tapeworms (R. cesticillus) 35 in a piece of intestine 1¼ inch long. There was a marked catarrhal enteritis, with areas of cellular infiltration as well as congestion and hemorrhage. There was a heavy mucous coating over the mucous membrane (Fig. 10).

Bird No. 34 (Fig. 11), a young chicken (exact age and breed not noted) showed a heavy infestation with H. carioca and also a few R. cesticillus. There was marked enteritis.

The pieces of intestinal tissue were fixed in formalin and stained in eosin-haematoxylin. The pathological changes observed in the 12 birds studied were: more or less capillary congestion, lymphocyte and polymorphonuclear cell infiltration in the villi on either side of the crypt occupied by the worms, moderate proliferation of epithelial cells and areas of fibrosis.

The birds were killed by breaking their necks. It is, therefore, possible that the capillary congestion might have appeared more pronounced if the birds had not been pretty well

bled out. The lymphocyte infiltration was in many places very slight. At times it appeared in only one of the villi adjacent to the infested crypt. However there were some rather extensive areas of leucocyte infiltration. The proliferation of epithelial cells was always rather mild.

Some heavily infested birds showed more or less extensive areas of fibrosis, Fig. 7. Active fibroblasts were found in these areas.

Numerous eosinophiles or polymorphonuclear cells were found in some sections.

Hemorrhages were encountered but they were not common. In nearly every one of the birds studied some red bodies were encountered throughout the mucous membrane. At times they were most numerous in the stroma of the deeper part of the mucous membrane, but they were also found in large numbers in the epithelium of the glands and in the villi. These bodies stained in the same way as the cytoplasm of red cells and it was thought that they might represent fragmented erythrocytes. They were nearly always found near nuclei or chromatin material. An exception to this was when they were found in the digestive tract of nematodes. Fig. 2. Wherever they were found there was variation in size and number. In places where there were many of them they were small, almost to the point of being difficult to distinguish individually or they might be of a size similar to the granules of the cytoplasm of eosinophiles or polymorphonuclear leucocytes. Due to their proximity to nuclei or chromatin

material which, at times looked like fragmented nuclei, these structures often looked like granulated cells. When these bodies were alone they were often as large as the nuclei of lymphocytes or a little larger. They were always round.

It was not determined what they are. Since they were found most frequently in the proximity of nuclear structures it was assumed that they are of cellular origin. The fact that they were found in the digestive tract of nematodes indicates that they may have been ingested by these parasites.

Two things argue against their being of erythrocyte origin. One is the fact that they were found in the epithelium and the other that no nuclear structures were ever observed in the digestive tract of the nematodes even when these red bodies were numerous.

The mechanical damage that appears to have been done to the superficial layers of the mucous membrane may be due to handling during the autopsy. All tissues were fixed immediately after removal from the birds which were likewise autopsied as soon as they appeared dead. Hence, little or no postmortem necrosis could have taken place.

Figs. 8 and 10 show rather heavy layers of mucus over the villous portion of the mucous membrane. Some mechanical damage does, however, appear to have been done by the worms as shown in several of the figures and this together with the heavy mass of mucus often encountered may account for what, on autopsy, appears like sloughing of mucous membrane.

Discussion.

It appears from the results obtained in these studies

that R. cesticillus and H. carioca, in the order named, are the two commonest tapeworms in Michigan. Evidence has also been brought forth to show that these two parasites are pathogenic, more particularly to young birds. Both have more than one known intermediate host and they may have others. Control of tapeworm infestation requires attention to the intermediate hosts, since they play an indispensable role in the spread of these parasites. Speaking of tapeworms of poultry in general we have to face the fact that some of the intermediate hosts are winged and others crawl in the dirt and grass. Absolute prevention of tapeworm infestation by sanitary measures means keeping intermediate and definitive hosts from coming in contact with each other, preventing intermediate hosts from getting infected or exterminating the intermediate host.

To attempt to accomplish the first objective the flock would have to be kept in complete confinement in houses equipped with extremely fine screens and if so desired these houses might be supplied with screened concrete porches.

The second objective may be sought by proper disposal of droppings and litter in addition to confinement of the chickens.

Droppings and litter might be placed in finely screened manure pits, they might be burned or they might be taken away far enough to prevent intermediate hosts from bringing the parasites back to the flock. It is not reasonable to believe that the third objective, the extermination of all intermediate host, could be attained.

Even if all these measures were practiced it seems

certain that a certain amount of worm infestation would take place, because slips in the sanitary system would be bound to occur.

Poultry breeders of long experience tell us that the range for young stock is an essential factor in the raising of sturdy, productive chickens. It is the young bird that is most susceptible not only to infestation but to parasitic disease. Most laying flocks are kept in houses supplied with outdoor runs and yards. Hence, comparatively few chickens are kept in such a way that they are entirely out of contact with intermediate hosts of tapeworms.

It seems that reduction in the amount of infestation may be accomplished by using ranges not occupied by chickens for several seasons, by keeping yards and runs free from boards or large leafy vegetation or other objects under which slugs and other intermediate hosts may hide and by disposal of droppings and litter as suggested above.

Some tapeworms are spread by flies and flies may be attracted by keeping liquid milk in troughs. Therefore such a practice must be refrained from. If liquid milk is to be used, only quantities small enough to be quickly consumed should be given at each feeding.

While undoubtedly it is true that much can be accomplished in suppressing tapeworm infestation by the above mentioned sanitary measures, it is more than likely that, under the conditions of practical poultry husbandry, chickens will continue to become infested. When they do, what can be done? Some will say, nothing can be done except to let nature take its

course, or, the chickens that are in marketable condition may be sold for meat. Such statements would be based on the fact that we do not have, at present, a remedy that will remove 100 per cent of the tapeworm scoleces. In this connection it should be remembered that a so-called tapeworm is by some parasitologists, considered to be a colony of worms. Each proglottis is an individual worm capable of reproduction and, indeed, possessing enormous reproductive capacity, since it generally has several hundred eggs. Each tapeworm, strobila (colony), contains numerous proglottides or individual worms. Only the last few of these (1 to 6) are generally motile or infective. Since tapeworms must have intermediate hosts in order to continue their life cycle, and, since the parasite's opportunities to find a suitable host is not very good at the best, it is obvious that anything that will kill a large number of these proglottides will materially reduce the chance for spread. It has been shown in this work that Iodine Vermicide (Merck) will kill proglottides and their eggs, that it acts very promptly and is safe even in the presence of other diseases.

The writer and his associates (46) had an opportunity to give advice concerning a flock of about 1500, two and one-half months old leghorns that had begun to look unthrifty in spite of the fact that they were raised on a supposedly clean range, located nearly one mile from any piece of ground previously used for chickens. In fact, this field had never been used for poultry of any kind. It had a fine stand of alfalfa and had all the qualifications of a good range. On examination these birds

were found to be heavily infested with tapeworms. After some discussion the owner decided to have them treated with Iodine Vermicide (Merck) while on the range, at the time of placing them in the laying house and again at the end of the fly season. This rather drastic procedure was chosen, because heavy losses, apparently caused by tapeworms, had been experienced before. Not only did the young stock recover promptly, but the following season the morbidity and mortality went down to a level considered normal for the average flock.

Several similar experiences could be described and the results are undoubtedly due to the reduction in infective onchospheres by the Iodine Vermicide (Merck) treatment.

The writer believes that until a better remedy is available, Iodine Vermicide (Merck) should be used in infested flocks when there is evidence of infestation in the form of symptoms. On premises heavily contaminated with tapeworms it may seem advisable to treat the birds, before they come into heavy production. It has been suggested that they should be treated as they are placed in the laying house. This does not seem logical, because, as soon as the cold weather sets in, flies and perhaps other intermediate hosts swarm into the poultry houses, and, as they are more or less sluggish at this time, they are readily picked up by the chickens. Thus reinfestation will take place. Unless the birds show unquestionable evidence of being in need of a worm treatment, it seems more logical to defer it until the fly season is over.

Data showing the actual economic importance of tapeworms are not available; yet, in view of the fact that tapeworms are more or less pathogenic, it seems safe to say that infested birds operate on a lowered plane of efficiency. Growing birds may fail to gain satisfactorily in weight, or, they may even lose. Likewise failure to come into or to stay in production are manifestations commonly associated with tapeworm infestation.

The health of the mucous membrane of the small intestines is very important. Such pathological changes as have been shown to occur in the mucosa of infested birds (note especially Fig. 7, Plate 4) obviously interfere with digestion and assimilation. Feed consumed by fowls so afflicted cannot be utilized with profit. There can also be little doubt that tapeworms may act as predisposing causes of or aggravating factors in a variety of diseases. Therefore it seems entirely proper, even in the absence of information as to the exact economic significance of this problem, to urge the practice of a comprehensive system of control of tapeworms such as that suggested above. Here one may logically ask how the expenses associated with this sort of a control system would compare with the losses caused by tapeworm infestation. A definite answer to this question cannot be given at present. However, some comparisons can be made between certain phases of the cost of production and the expenses attached to the treatment of birds with Iodine Vermicide (Merck). For example. The total cost of raising an average hen to the age of 12 months, judged by observations on 200 flocks in Michigan, is 2.35 dollars. Of this amount the sum of 1.50 dollars goes for feed. One treatment with Iodine Vermicide (Merck) would add

approximately 2 cents. At present prices it costs 75 cents to raise a pullet to 6 months of age and that is approximately what the average chicken would bring if sold for meat. The average price of eggs for 1934 and 1935 will be close to 22 cents per dozen. In the 200 flocks under observation by the Department of Farm Management of Michigan State College the average egg production was 155 and the mortality per year was 20 per cent. Now let us say that we are dealing with a flock of 1000 chickens (females) and that 30 of them had been lost as a result of tapeworm infestation before they had come into production. The losses in eggs would amount to 82.50 dollars and in meat 22.50 dollars, or a total of 105.00 dollars. Due to the loss of these 30 chickens the maximum saving in feed cost, at present feed prices (2 1/4 cents per lb.) and at the average yearly consumption per hen of 80 pounds of feed would be 54.00 dollars. Thus the net loss would amount to at least 51.00 dollars. To dose 1000 adult chickens once with Iodine Vermicide (Merck) costs about 20 dollars. In a flock of 1000 hens 200 may be lost per year according to the above mentioned survey. How much of this is due to intestinal parasites is not possible to say, but it is highly probable that, in many flocks, they are a very significant factor in a far too high morbidity and mortality.

The treatment of worm infested chickens with Iodine Vermicide (Merck) may have an even greater cumulative than immediate, beneficial effect due to the killing of proglottides and eggs and a consequent reduction in the source of infestation. Such a reduction will be of benefit not only to the individual poultry farmer who employs this system of control, but to

neighboring poultrymen as well, because intermediate hosts may carry tapeworms over a considerable distance.

If by continued effort along the lines of tapeworm control one could reduce infestation to a harmless level it seems certain that material gains would be made in the form of more economical use of feed, greater gains in flesh and a higher rate of production.

It must be remembered that parasitism is a natural phenomenon and that nature seems as intent upon preserving the parasite as the host. Thus, if man wishes to rid his flocks and herds of parasites he must be willing to pay the inevitable price.

Summary.

It has been shown that Iodine Vermicide (Merck) is highly effective in removing strobilae and that comparatively few scoleces are removed.

All Ascaridia and strobilae of tapeworms reached by the iodine were killed and expelled. However, considerable numbers of yougn Ascaridia may be situated so deeply in the mucosa as to escape the effects of the iodine. These can all be removed by a second treatment when sufficient time is allowed for their development and passing into the lumen of the intestine.

In vitro tests are recorded to add proof to the killing power of colloidal iodine on nematodes and tapeworms.

The majority of onchospheres contained in proglottides acted upon by colloidal iodine in vivo as well as in vitro were killed.

In a certain number of birds the iodine is destroyed

rather quickly after it reaches the small intestine.

Tapeworms and their scoleces were made visible in the deeper layers of the mucous membrane by fixing, washing, dehydrating and then clearing compressed pieces of intestine in benzyl benzoate.

Raillietina cesticillus and Hymenolepsis carioca were shown to be the commonest tapeworms in this locality and that they produce pathological conditions such as catarrhal enteritis, capillary congestion, lymphocyte, polymorphonuclear, and eosinophile cell infiltration, proliferation of epithelium and fibrosis. Some red bodies are described as occuring in the stroma of the mucous membrane as well as in the epithelium. They were also observed in the digestive tract of nematodes.

Conclusions.

1. R. cesticillus and H. carioca are pathogenic for chickens.
2. Their strobilae, are easily removed by Iodine Vermicide, (Merck) while apparently only a small percentage of scoleces can be expelled by this remedy.
3. In view of the ineffectiveness of presently known worm remedies in removing scoleces reliance must not be placed in treatment alone. All phases of tapeworm control must be considered.
4. Since complete prevention of tapeworm infestation is hardly possible under conditions of practical poultry husbandry, and since treatment with Iodine Vermicide (Merck) kills innumerable proglottides

and their eggs as well as causes the prompt removal of strobilae from the intestines, this remedy is recommended as a valuable aid in the control of tapeworm infestation in chickens.

5. Iodine Vermicide (Merck), when carefully administered, is harmless even when given to birds suffering from diseases other than parasitism.

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Explanation of plates.

Plate I.

Fig. 1. Section showing Raillietina cesticillus in a crypt in the mucous membrane. The material attached to the rostellum is debris. The villi and their epithelium were intact in this area, but a moderate amount of capillary congestion and lymphocyte infiltration was noted in the villi adjacent to the infested crypt.

Fig. 2. Cross section of nematodes showing the red bodies, described above, in the intestinal tract. (indicated by arrows)

Plate 1

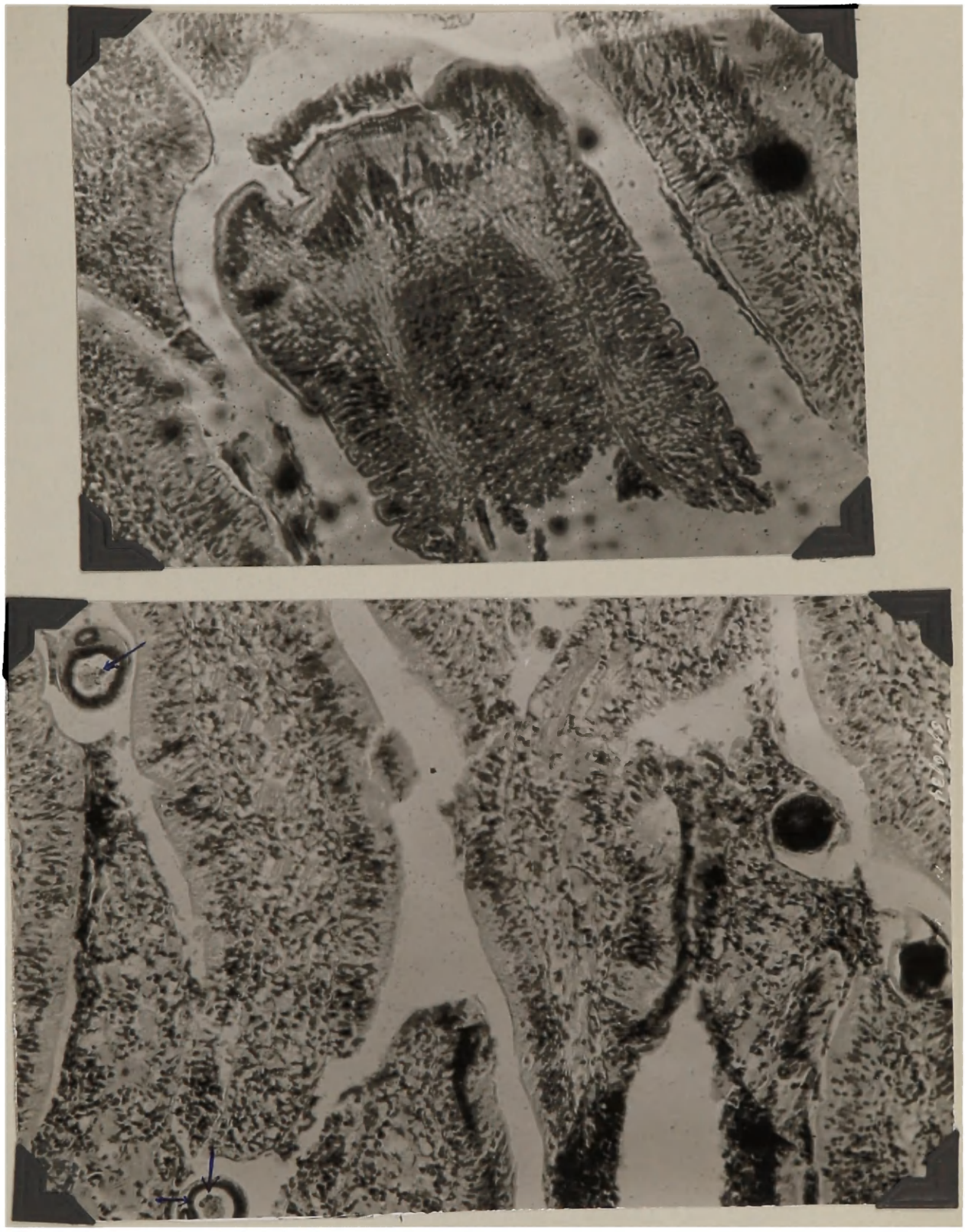

Fig. 1 above

Fig. 2 below

Plate II.

Fig. 3. Portions of tapeworms Hymenolepis carioca apparently superficially located. Some of the damaged condition of the villous portion may be due to handling during autopsy. However, intestines of noninfested birds, as well as sections from other portions of the intestines of this bird, showed the villi to be intact in spite of the fact that they were handled similarily. Therefore, it is assumed that the parasites have caused these changes. Fig. 7, Plate IV shows a more advanced condition of the same kind.

Fig. 4. Longitudinal and tangential sections of tapeworms showing superficial location of what appears to be R. cesticillus and the deeper location of what may be Hymenolepis carioca. The pathological changes are of the same nature as observed in Fig. 3 but not so far advanced.

Plate 2

Fig. 3 above

Fig. 4 below

Plate III.

Fig. 5. Hymenolepis carioca extending deeply into the mucous membrane.

Fig. 6. Tangential sections (one nearly longitudinal) of H. carioca showing how deeply they may extend into the crypts.

Plate 3

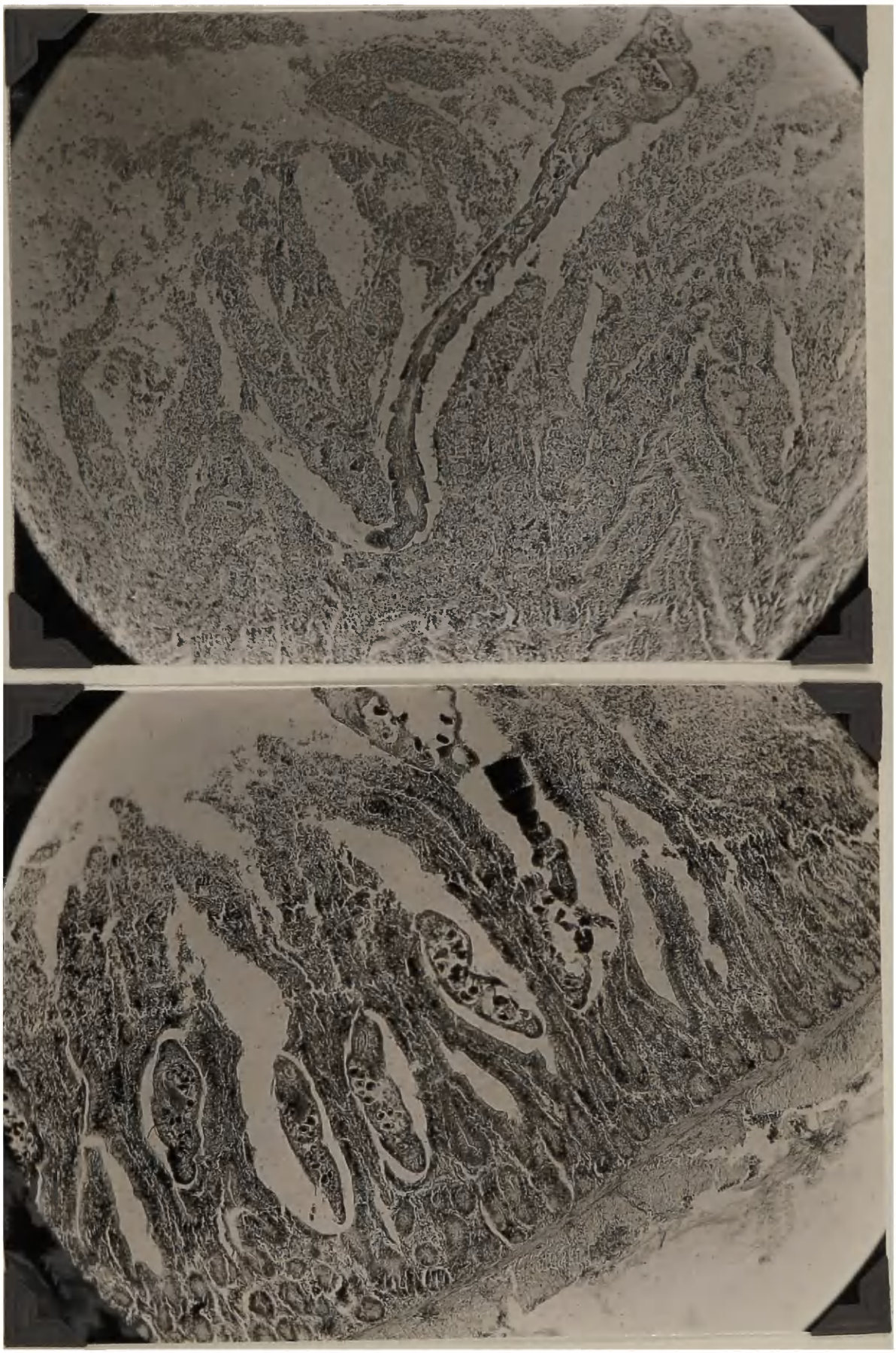

Fig. 5 above

Fig. 6 below

Plate IV.

Fig. 7. Showing large area of fibrosis. The changes observed in this area are similar to but farther advanced than those seen in previous sections.

Fig. 8. Superficially located tapeworms *R. cesticillus*. The villi adjacent to the infected crypt show rather marked lymphocyte infiltration. There is a heavy layer of mucus over the tips of the villi.

Plate 4

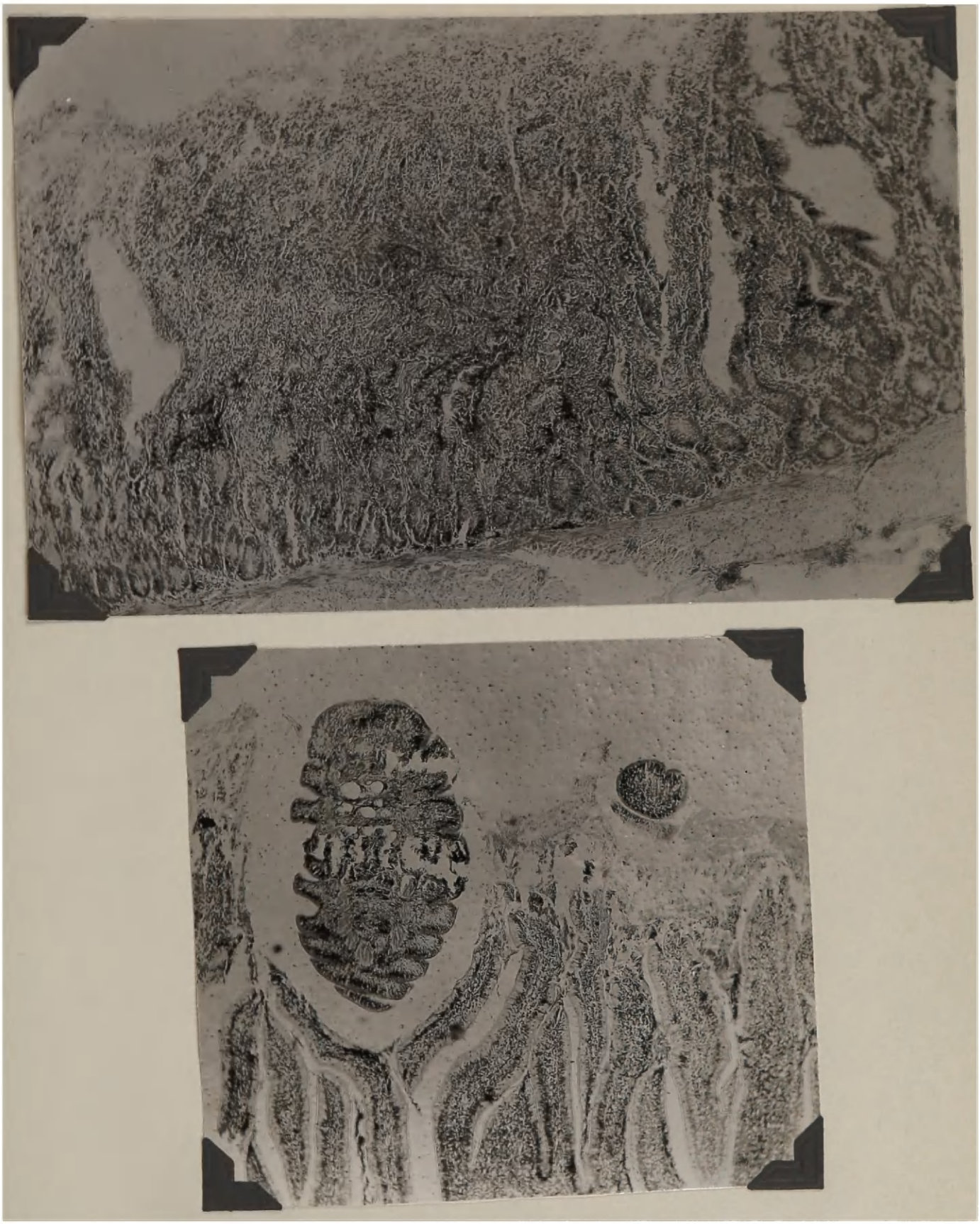

Fig. 7 above

Fig. 8 below

Plate V.

Fig. 9. Scolex of a tapeworm in a position where it could not be reached by a remedy administered orally. The villi are still intact, but there are foci of lymphocyte infiltration in the vicinity of the infected crypt.

Fig. 10. Heavy layer of mucus over tips of villi rather characteristic of birds infested with tapeworms. By the treatment with Iodine Vermicide (Merck) this mucus is formed into a cast and is passed soon after the administration of the dose. In these casts many tapeworms may be found. Should this mucous layer be excessively thick, it might explain the destruction of iodine soon after dosing.

Plate 5

Fig. 9 above

Fig. 10 below

Plate VI.

Fig. 11. Heavy infestation with *Hymenolepis carioca*.

Plate 6

Fig. 11