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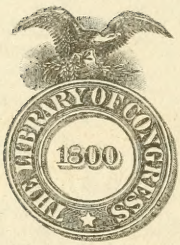
The turkey, an important factor in the spread of gapeworms.



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JOHN R. MOHLER, Chief

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THE TURKEY AN IMPORTANT FACTOR IN THE SPREAD OF GAPEWORMS.[1]

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EXAMINATION OF MARKET CHICKENS AND TURKEYS.

FOR THE PURPOSE of collecting some statistics on the prevalence of gapeworms (*Syngamus trachealis*) in the vicinity of Washington, D. C., and of obtaining material for use in experiments, examinations were made of the tracheas of 635 chickens killed for sale at poultry stalls in Center Market during the latter half of December, 1916, and the months of January and February, 1917. Nothing definite is known as to the ages of these chickens except that the chickens were all obviously large enough for food purposes. Probably none were less than six months old, most of them likely were older, and no doubt many were a year old or more. No gapeworms were found.

At the same time the tracheas of turkeys from the same market were similarly examined. The ages of the turkeys, as in the case of the chickens, were uncertain, but undoubtedly all the turkeys were at least 6 months old, and many of them were probably more than a year old. During the period mentioned the tracheas from 386 turkeys were examined. The next year, beginning March 2, 1918, an-

[1] The writer is greatly indebted to Dr. Lawrence Avery, of the Bureau of Animal Industry, for assistance rendered in carrying out the investigations reported in this paper.

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other series of 115 was examined, and during the month of November, 1918, a final series of 178; in all, 679 turkey tracheas were examined. In the case of the chickens practically the entire trachea was obtained from each bird, but in the case of the turkeys usually only a portion of the trachea was secured, so that as a rule an examination of the entire trachea could not be made.

In the first series of turkey tracheas (386 examined in December, 1916, and January and February, 1917) gapeworms were found in 89, and characteristic lesions marking the former location of gapeworms in 3 others, a total of 92, or 23.8 per cent. In the second series (115 examined in March, 1918) worms were found in 17 and a gapeworm lesion in 1 other, a total of 18, or 15.7 per cent. In the third series (178 examined in November, 1918) worms were found in 43, or 24.2 per cent. The percentage of turkey tracheas infested out of the total number examined was 22.5 per cent. It is possible that the lower percentage observed among the tracheas examined in March as compared with those examined in December, January, and February, and in November following, was the result of having more incomplete specimens of tracheas than were generally secured in the two latter series. In any event, in view of the fact that throughout the three series incomplete tracheas were the rule, it appears quite certain that more cases of infestation would have been found if the entire trachea could always have been secured. It is, therefore, fair to conclude that the percentage of infestation among the turkeys examined was in reality higher than the 22.5 per cent actually found. Counting the gapeworm lesions found without worms attached as representing worms, and counting the paired male and female as a single worm, a single worm was present in 91 cases, 2 worms in 36 cases, 3 worms in 14 cases, 4 worms in 6 cases, 5 worms in 3 cases, 7, 9, and 18 worms in 1 case each.

In view of the complete absence of gapeworms from a large series of adult and approximately adult chickens, and their common occurrence in a similar series of adult and approximately adult turkeys, all obtained at the same market and at the same season of the year, it would appear that adult chickens are poorly adapted as hosts for gapeworms. Evidently the occurrence of gapeworms in adult chickens in the general locality of Washington, D. C., must be exceedingly rare, though, as is well known, gapeworms are of frequent occurrence in young chicks in this as well as in many other localities. On the other hand, it is evident that not merely young turkeys may harbor gapeworms, but that in the locality mentioned these parasites are very common in adult turkeys. Although, as noted, the ages of the various turkeys from the Washington market were uncertain, many of the turkeys examined were no doubt considerably more than

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a year old. That turkeys above 3 years of age may harbor gapeworms is established by the fact that a turkey which was kept at the Bureau of Animal Industry Experiment Station, Bethesda, Md., for three years after it was brought there was found after its death to be infested with a pair of gapeworms.

EXPERIMENTAL WORK.

Experiments in artificially infecting chickens of various ages with gapeworms were carried out as follows: To provide material for infecting the chickens, cultures were made at first from gapeworms collected from the tracheas of turkeys. Later many of the worms collected from the artificially infected chickens were also used in making cultures. The worms were chopped into small pieces and the eggs released by tearing apart the fragments of the uteri in a small quantity of water. The water containing particles of worms and the eggs was spread on the surface of a sterilized medium culture made from chicken feces mixed with powdered animal charcoal. This was kept moist in a petri dish and allowed to incubate at room temperature. After about two weeks' incubation a large proportion of the eggs contained fully developed larvæ, many of which commonly hatched and continued active for long periods after hatching. The cultures were then ready for use and were fed to the chickens by placing small portions scraped from the surface of the culture medium directly into the mouth and making sure that the birds swallowed the material. The chickens used in the experiments, except the adults, were hatched in incubators and kept from exposure to gapeworm infection until used. Usually only one feeding was given, and in most cases the chicken, if it did not die earlier, was killed two weeks after feeding the infectious material. Occasionally chickens were killed for examination in less than two weeks after infection. The tracheas and lungs were examined for gapeworms, the latter by dissection in physiological salt solution, a lens being used for the discovery of small, incompletely developed worms. Altogether 139 chickens of different ages were thus fed infectious gapeworm material. The results are shown below.

Results of artificially infecting chickens with gapeworm material.

Age of chickens when fed.	Number fed.	Number infected.	Per cent infected.
1 to 4 weeks	47	41	87
5 to 8 weeks	32	27	84
9 to 20 weeks	32	21	66
21 weeks to adult	28	8	29

From the data shown in the table it seems evident that as chickens grow older they tend to become less susceptible to infection with gapeworms. Apparently, therefore, the most likely reason no gapeworms were found among the 635 chickens from the Washington market was that these chickens when examined had reached an age at which they were no longer favorable hosts for gapeworms. Probably some of them had been infested earlier in life but had afterwards lost their parasites. How long gapeworms will persist in young chickens that do not succumb to the infestation is uncertain. That adult chickens, however, in those unusual cases in which they become infested with gapeworms, are likely to harbor the parasites only temporarily is indicated by some of the findings in the following experiments:

Twelve adult chickens a year old or more were fed gapeworm material from cultures on April 26, 28, 30, May 2, 4, 7, 9, and 11, altogether receiving 8 feedings, except one which was killed May 7, before feeding time, and hence received only 5 feedings. Material from the same cultures was fed to 12 1-week-old chicks April 24, 28, 30, May 2, and 4. All the young chickens died of gapes in 11 to 27 days after the first feeding, and all were found infested with gapeworms. Except the one killed May 7, 11 days after the first feeding, the adult chickens were killed 16 to 29 days after the first feeding and 1 to 14 days after the last feeding. Gapeworms were found in only 3 out of the 12. The lungs of one killed 16 days after the first feeding and 1 day after the last feeding contained an unpaired female 2.5 mm. long, and in the trachea were two pairs, the females being 6.5 mm. and 10 mm. long, respectively. The 10 mm. female was producing eggs. Another chicken that was killed 18 days after the first feeding and 3 days after the last feeding harbored in the trachea a single pair of worms. The female of this pair measured 13 mm. in length and was depositing eggs. In the trachea of the third chicken, killed 29 days after the first feeding and 14 days after the last feeding, there were 7 dead males without females, 4 living males without females, 3 living females with dead males, 1 living female with a living male, and 1 living female without a male. The last two females contained apparently viable eggs, but in the other three females the eggs were apparently nonfertile, dark, and unnatural in appearance. All the worms, alive and dead, were firmly attached to the trachea. The living worms were enveloped in a thick layer of mucus.

On another occasion 6 adult chickens probably a little less than a year old were fed with a gapeworm culture. Seven days later one was killed. No worms were found. A second chicken, killed 8 days after feeding, had one unpaired worm, one pair of coupled worms in the lungs, and 14 pairs of coupled worms in the trachea, all imma-

ture, those in the trachea evenly distributed from bronchi to larynx. The females in the trachea measured 3 to 6 mm. in length. The worms in the trachea were enveloped in masses of very viscid, tenacious mucus and none apparently were attached to the wall of the trachea. Another chicken was killed 11 days after feeding and was found to be free from parasites. Twenty-eight days after feeding, microscopic examination failed to show gapeworm eggs in the feces of the three surviving chickens. The following day one of them was killed and found to be free from parasites. Thirty-one days after the first feeding the two surviving chickens were fed with a gapeworm culture. Eight days after this feeding the chickens were killed. One of them was free from parasites, the other had one young worm in the lungs, and a pair of coupled worms in the trachea. The female of this pair was ruptured in removal but measured 15 mm. or more in length and contained eggs ready for oviposition. This pair of worms was enveloped in a mass of tenacious mucus. Evidently the worms in the trachea came from the first feeding of gapeworm material, 39 days before the chicken was killed.

The findings in the case of one of the chickens referred to suggest very strongly that the worms that had succeeded in establishing themselves in the trachea were having difficulty in maintaining themselves, as 10 of the 15 males present 29 days after infection were dead though firmly attached to the trachea, and as the living worms, both males and females, were enveloped in a thick layer of mucus, indicative perhaps of a strong reaction, on the part of the host, that would soon destroy them. In two of the other chickens also the unusually large masses of mucus enveloping the worms suggest the likelihood of the early death or expulsion of the parasites. In any event it is evident, since in the one instance a large proportion of the gapeworms present 29 days after infection had died after reaching maturity, that gapeworms in adult chickens, when they succeed in establishing themselves in the trachea, sometimes die within a month after infection, infestation with gapeworms in such cases thus being of brief duration. Further evidence of the transient nature of gapeworm infestation in adult chickens is given by Waite (1920, p. 115), who fed about 150 earthworms from gapeworm-infested chicken runs to three yearling hens. Fifteen days later gapeworms could be distinctly seen in the tracheas of two of them by looking down their throats in a good light. Two weeks later the worms had disappeared, and when the hens were killed and examined 72 days after the feeding with the earthworms, no signs of gapeworms were found.

In view of the difficulty of infecting adult chickens with gapeworms, the likelihood of the brief duration of infestation in cases in

which the worms succeed in developing to maturity in adult chickens and the failure to find any gapeworms among a large number of adult chickens obtained from a certain market, though the parasites were of common occurrence in adult turkeys from the same market, it seems evident that adult chickens are not likely to be of great importance as carriers of gapeworms. On the other hand it is certain that sometimes they may harbor gapeworms for brief periods at least.

Besides the fact that adult chickens occasionally may be infected experimentally may be cited the following instance of infestation following exposure to infested ground. A chicken at least 22 months old and probably considerably more than 2 years old died at the Bureau of Animal Industry Experiment Station with a history indicating that it had been kept at least a year in a pen that had previously been used in gapeworm experiments. This hen was in poor condition, greatly emaciated, and devoid of the usual subcutaneous and visceral fat. Besides nematodes and tapeworms in the intestine there were found in the trachea a female gapeworm 21 mm. long with a male 5 mm. long, and another female about 10 mm. long, with a male 4.6 mm. long. The smaller female contained eggs, but well-developed eggs were not found in the larger female.

This case perhaps should be taken as an indication of the possibility that as chickens become old and debilitated their susceptibility to gapeworms tends to increase again after having diminished as they approached maturity. Such an explanation would be in harmony with the frequently observed fact that certain parasites are more common in young and very old animals than in those of middle age. No definite conclusion, however, is possible from a single case.

In marked contrast to adult or nearly adult chickens, adult turkeys can easily be infected experimentally with gapeworms, as would be expected from the fact that the worms have been found to be naturally common among adult turkeys. The following experiment shows the results of attempts to infect chickens approaching maturity, young chickens, and adult turkeys, respectively, using infective material from the same source.

Three chickens 21 weeks old at the beginning of the experiment were fed portions of gapeworm cultures November 29, December 18, 20, 27, January 3, 31, February 28, and March 31. Beginning February 28 the chickens were kept on ground that was contaminated with gapeworms. The feces of these three chickens were examined January 3, 13, 17, 25, 31, February 8, 15, 22, 28, and March 28, and the feces of two of them also on April 22, always with negative results. One of the chickens was killed on April 8 and was free from gapeworms, as were also the other two, killed on May 24.

Some of the culture fed on January 31 was fed on February 7 to three chicks 8 weeks old, and these chicks when killed 14 days later

harbored, respectively, 92, 75, and 36 pairs of gapeworms in their tracheas, the females ranging in size from 4 to 11 mm. Besides the worms in the trachea there were a few immature gapeworms in the lungs of each chicken.

Some of the same culture was fed on February 7 to three turkeys nearly a year old. Nineteen days later one of the turkeys was observed to be sick and was killed. There were no gapeworms found in the lungs, but 483 pairs were present in the trachea, the females averaging 24 mm. in length. The feces of the two remaining turkeys were first examined 21 days after infection and at this time contained large numbers of gapeworm eggs. The birds were coughing and there was a brown crust on their bills, formed by the drying of expectorated mucus. On March 17, 38 days after infection, these two turkeys were still coughing, but the brown crust was no longer present on their bills. On April 14, 66 days after infection, gapeworm eggs were still present in the feces. April 29, one of the turkeys which had been ailing was killed, the lungs and one bronchus being found affected with a gangrenous necrosis. The trachea contained 22 pairs of gapeworms, the females averaging 33 mm. in length; also many broken pieces of dead worms were found. The third turkey was kept alive. December 16, 10 months after infection, an examination of the feces of this turkey failed to show gapeworm eggs.

In this experiment adult turkeys (nearly a year old) and young chickens (8 weeks old) became heavily infested as the result of a single feeding with gapeworm material, while chickens approaching maturity (21 weeks old) that were fed repeatedly with gapeworm material (including material from the same culture as that fed to the turkeys and the young chickens) failed to become infested. Evidently, therefore, adult turkeys and young chickens are much alike in their susceptibility to gapeworm infection, and in this respect both are quite different from adult chickens or chickens approaching maturity.

FACTORS IN THE SPREAD OF GAPEWORMS.

From the results of the investigations briefly recorded above, it would seem that turkeys are an important factor in the spread of the gapeworm, and that adult chickens are relatively unimportant as carriers of the parasite. In the perpetuation of gapeworms from year to year on infested poultry farms the two chief factors appear to be turkeys and contaminated soil. Whether guinea fowls are like turkeys in commonly harboring gapeworms throughout life or whether they are like chickens and tend to lose their susceptibility as they become mature is uncertain. Little is known also as to the relation of peafowls, ducks, geese, pigeons, and various wild birds to the spread of

gapeworms. There is little question, however, that the turkey is more important than any other bird as a reservoir of infection, and it is essential, if losses from gapes are to be avoided, that the part played by the turkey in spreading and perpetuating gapeworms should be borne in mind by the poultry raiser. The relation of the turkey to gapes in chickens is commonly overlooked, largely, no doubt, because young turkeys are usually less seriously affected by gapeworms than young chickens, and because old turkeys harboring the parasites rarely show any visible evidence of infestation, so that they are not likely to be suspected as a source of the disease that plays havoc among the young chickens.

Whether, in the absence of turkeys from a farm, gapeworm disease among chickens will regularly disappear has not been definitely established, but it seems probable that it may often do so. Though it is certain that contaminated soil will remain infectious for a long time and that infection in the soil may persist from one year to the next, nevertheless it may be that, as a rule, chickens alone will not perpetuate the infection. A large proportion of the young chickens that become infested die of gapes before there has been much opportunity for scattering the eggs of the gapeworms, and since chickens as they grow older tend to become not only less susceptible to infection but also more and more unfavorable as hosts of the gapeworms acquired at an earlier age, the infested chickens that do not die of gapes probably do not continue long to harbor the worms and so are unlikely to spread much infection. In view of these apparent limitations to the reinfection of the soil by chickens it seems not unlikely that gapes will be found to have a tendency to disappear from places where no turkeys are kept.

INVESTIGATIONS ON MARYLAND FARMS.

Evidence gathered from inquiries by Dr. Lawrence Avery and the writer among poultry raisers in several localities in Maryland is insufficient to show that gapes will usually die out on farms where there are no possible hosts other than chickens, but it is corroborative of the statements that have been made as to the great importance of the turkey as a source of infection. In fact, it was found that in the absence of turkeys either no gapes occurred among the chickens or the trouble from this cause was practically always slight. On the other hand, where turkeys were present considerable losses among the chickens as a result of gapes were almost always reported. Inquiries were made on 41 farms. On 16 farms where there was no history of the association of turkeys with the chickens, gapes was reported in eight instances, no gapes in the other eight. On one farm where there were said to be numerous cases of gapes among a flock of 500 chickens, turkeys were kept the preceding

year, but it was said that they never came near the chicken yards. A dozen guinea fowls were kept on this farm and mingled with the chickens. On two other farms where there was said to be considerable trouble with gapes, guinea fowls were kept in one case, but there were neither guinea fowls nor turkeys in the other. On the other 5 farms where gapes was reported in the absence of turkeys, few cases were said to have occurred. On 25 farms where there was evidence of the contamination of the chicken runs by turkeys, gapes was reported in all but one case. Here there were about 300 chickens and 70 turkeys roaming at will over the farm. The turkeys and chickens, however, were housed on different plots of ground, neither of which had been used for poultry during several years preceding. On two farms there were said to have been no cases of gapes until after turkeys were brought to the place. In another instance a man who for five years had been on a farm where turkeys were kept by the former occupant, had gapes among his chickens for a year or two after coming to the farm, but had had none since. On two farms where only a few cases of gapes occurred among the chickens, it was stated that the turkeys were kept in the fields, and never or rarely were brought into association with the chickens. On another farm where there were a few cases of gapes no turkeys were kept, but turkeys from the neighboring farm frequented the place. In a number of other instances no turkeys were kept, but turkeys from neighboring farms were accustomed to mingle with the chickens.

Two neighboring farms that were visited during the season of the year when gapes is prevalent among young chickens afforded a striking contrast. On one farm where turkeys were kept entirely away from the chickens and never mingled with them nor came to the place where the chickens were kept there had been no gapes among the chickens. On the other farm several broods of young chickens were confined in small pens on the lawn in front of the farmhouse. Turkeys of various ages were feeding on the same lawn. Many of the young chickens were showing the characteristic symptoms of gapes.

Though the data that have been collected concerning gapes on farms are necessarily more or less inaccurate because of the uncertainty as to the reliability of the information given by the persons of whom inquiries were made, the evidence obtained from this source nevertheless indicates that in the localities in which the question has been investigated gapes is more common and more serious on farms where turkeys and chickens are kept together than on farms where only chickens are kept, that the disease has a tendency to die out in the absence of turkeys, and that it commonly does not appear on a farm until after the introduction of turkeys.

SIGNIFICANCE OF TURKEYS IN RELATION TO GAPES FORMERLY UNRECOGNIZED.

From the literature on gapes one may gather further evidence of the importance of the turkey as a carrier of gapeworms, though the peculiar significance of the turkey in relation to gapes has not been recognized by former writers. In the first published record of gapes Wiesenthal (1799) called attention to the frequent occurrence of the disease in Maryland and stated that it was most prevalent among young turkeys and chickens bred upon old-established farms. The first published record of gapes in England is that of Montagu (1811), who notes that it generally attacks chickens at the age of a month to 6 weeks, and that it "seems to be peculiar to the young of the common domestic fowl, since neither my turkeys nor ducks, all of which are reared together upon the same spot, have even been attacked."

Von Pocci (1904), in discussing an outbreak of gapes among young pheasants in Bavaria, which killed about 60 per cent of the birds, incidentally remarks that turkeys were used as brood hens for young pheasants. The first record of gapes in Norway (Horne, 1910) is based upon the discovery of gapeworms in two young turkey poults and two young chickens from the same poultry farm. How frequently turkeys have been associated with the occurrence of gapeworms among chickens, pheasants, and other birds in Europe is not indicated in the published reports that have come to the writer's attention other than those just mentioned. These, however, are very suggestive and, together with the observations recorded in the present paper, may be taken as an indication of the probability that the turkey has been chiefly, if not entirely, responsible for the spread of the gapeworm to various parts of the world.

TURKEY THE PREFERRED HOST OF THE GAPEWORM.

It would seem quite probable that the gapeworm, like the turkey, was originally limited to America and that it has reached other countries only as it has been carried by the turkey, which, because of the tolerance it has to infestation with the gapeworm, may be looked upon as the natural host of this parasite.

The fact that the gapeworm in turkeys grows to a larger size than it does in chickens may be taken as evidence, in addition to that already given, that the turkey as compared with the chicken is the preferred host of the parasite. The difference in the size of the worms may be a simple correlation with the size of the trachea, but it seems more likely that other conditions than the mere size of the trachea play a part in bringing about the differences in the size of gapeworms in chickens and turkeys. The maximum length of gape-

worms observed by the writer in chickens 14 days after infection has been 17 mm. Usually the length attained in this period is less, commonly being 12 to 14 mm. The longest gapeworm observed by the writer in chickens measured 21 mm. in length. This was found in an old, debilitated chicken, mentioned on page 6, which had been infested for an unknown period. Some of the gapeworms present in an adult turkey 19 days after infection measured nearly 30 mm. in length, and worms measuring 24 mm. were common. In natural cases of infestation gapeworms in turkeys have been found commonly to measure 30 to 40 mm. in length, and have been found as long as 50 mm. The measurements given are those of mature females that had begun oviposition or that contained eggs ready to be deposited.

HOW TO AVOID LOSSES IN CHICKENS.

From what has been determined as to the frequent occurrence of gapeworms in turkeys, the susceptibility of old as well as young turkeys to gapeworm infection, the diminishing susceptibility of chickens to infection as they grow older, and the rarity of gapeworms among adult chickens, it would seem that the chief element in the spread and maintenance of gapeworm infection, leaving infested soil out of consideration, is the turkey. The eggs of the gapeworm are scattered over the soil in the feces of infested turkeys. Later some of these eggs or the larvæ that have hatched from them are picked up again by the turkeys and more egg-producing worms develop in them to add to the number of those already present. Thus the stock of young worms in the soil and adult worms in the turkeys is maintained. Meanwhile young chickens may also pick up gapeworm eggs or larval worms from the ground where the eggs have been distributed by the turkeys, with the result that they soon show symptoms of gapes. As chickens young enough to be readily susceptible to infection with gapeworms usually die from gapes soon after they begin to show symptoms of the disease they are not likely to add much to the infection already in the soil. Older chickens likewise do not scatter much infection because the eggs and larval worms that they pick up either do not develop on account of the diminished susceptibility of the chickens or, if the worms do succeed in developing to egg-producing maturity, they are unlikely to survive for more than brief periods. Chickens, therefore, may be considered to play a small part, compared with turkeys, in infecting the soil with gapeworms, and to be of minor importance as reservoirs of infection. By keeping turkeys away from young chickens and providing the latter with runs where there have been no turkeys within a year or two and where, if used previously by young chickens, there have been no cases of gapes in recent years, the danger of losses

from gapeworm can be greatly reduced, inasmuch as infection of the runs by the brood hens is not often likely to occur because of the rarity of gapeworms among adult chickens. As the eggs and larvæ of gapeworms have been kept alive in the laboratory for more than eight months at a temperature ranging from 70° to 95° F., and for more than a year at a temperature of about 50° F. (writer's observations), it is advisable not to allow young chickens to run on once-contaminated ground until after a considerable period of time has elapsed, not less than a year at least, since its exposure to contamination. Consequently it is important in locating new runs for young chickens on farms where gapes has been prevalent to select a spot that is known to have been but little, if at all, frequented by turkeys within at least a year. Naturally also it would be unwise to select a spot where chickens with gapes had been the year before, even if in the meantime there had been no chance of contamination by turkeys. As a rule, in order easily to secure immunity from gapeworm losses among chickens, it may be found necessary to abandon the keeping of turkeys on farms where chickens are raised, because of the difficulty of controlling the turkeys so as to prevent contamination of the chicken runs. In fact the simplest way of preventing gapes among chickens seems to be to exclude turkeys from farms where chickens are raised.

CONCLUSIONS.

The turkey is probably the natural host of the gapeworm.

Adult turkeys as well as young turkeys commonly harbor gapeworms though they may show no symptoms of infestation.

The turkey is apparently the chief agent in the spread of gapeworms to new localities and is apparently the principal source of infection to the soil on poultry farms where gapes is prevalent.

Gapes among chickens appears to be more prevalent on farms where turkeys frequent the chicken runs than on farms where there are no turkeys.

Available evidence indicates that gapes has a tendency to disappear from farms following the removal of turkeys.

Chickens, unlike turkeys, are readily susceptible to infection with gapeworms only while they are young. They become less susceptible to infection as they grow older.

Adult chickens, at least in some localities, rarely harbor gapeworms and hence in such localities are seldom likely to spread infection.

In those instances in which gapeworms develop in adult chickens or chickens approaching maturity the parasites are likely to live only a short time.

Ground contaminated by gapeworms is likely to remain infective for at least a year after further infection of the soil has ceased.

Losses from gapes can be greatly reduced if not altogether avoided by keeping young chickens on ground that has not been exposed to contamination within at least a year and that is protected from further contamination by excluding turkeys from it during its occupancy by the chickens. As gapeworms appear rarely to occur in adult chickens, brood hens may be associated with the young chickens with probably little risk of infection to the latter from that source.

The simplest means of preventing or reducing losses from gapes appears to be the exclusion of turkeys from farms where chickens are raised.

LIST OF REFERENCES.

HORNE.

1910.—Fra veterinaerlaboratoriets daglige undersøkelser. En kyllingsygdom. (*Syngamus trachealis*) <Norsk Vet.-Tidsskr., Kristiania, v. 22 (6), Juni, pp. 159–164, figs. 1–2.

MONTAGU, GEORGE.

1811.—Account of a species of *Fasciola* which infests the trachea of poultry, with a mode of cure. [Read Aug. 1, 1808] <Mem. Werner Nat. Hist. Soc., Edinb. (1808–10), v. 1, pp. 194–198, pl. 7, fig. 4.

VON POCCI, FRANZ GRAF.

1904.—Der Fasan und sein gefährlichster Feind, der Rotwurm <Verhandl. d. ornith. Gesellsch. in Bayern, München (1903), v. 4, n. F., v. 1, pp. 102–118, figs. 1–3, 1 pl., figs. 1–5.

RANSOM, BRAYTON H.

1916.—Miscellaneous investigations of animal parasites <Rep. Chief Bureau Animal Indust., U. S. Dept. Agric., Wash., p. 64.

1917.—Idem <Ann. Rep. Dept. Agric., Wash. (1916), p. 130.

1917.—Miscellaneous investigations of animal parasites <Rep. Chief Bureau Animal Indust., U. S. Dept. Agric., Wash., pp. 56–58.

1918.—Idem <Ann. Rep. Dept. Agric., Washington (1917), pp. 122–124.

1918.—Miscellaneous investigations of animal parasites <Rep. Chief Bureau Animal Indust., U. S. Dept. Agric., Wash., pp. 55–56.

1919.—Idem <Ann. Rep. Dept. Agric., Wash. (1918), pp. 125–126.

1920.—On the life-history of the gape-worm (*Syngamus trachealis*). (*In* Proc. Am. Soc. Zool., 17. Ann. Meet., St. Louis, Mo., Dec. 29–31, 1919.) [Author's abstract] <Anat. Rec., Phila., v. 17 (5), Jan. 20, pp. 330–331.

1920.—Gapeworm in turkeys and chickens. [Note read before 38. Meet. Helminthol. Soc. Wash., Oct. 18, 1919] <J. Parasitol., Urbana, Ill., v. 6 (4), June, pp. 200–201. [Issued Aug. 14.]

WAITE, ROY H.

1920.—Earthworms—the important factor in the transmission of gapes in chickens <Bull. 234, Maryland Agric. Exper. Station, College Park, Jan., pp. 103–118, figs. 1–6.

WIESENTHAL, ANDREW.

1799.—[Gapes in poultry.] [Letter to editor, dated May 21, 1797] <Med. & Phys. J., Lond., v. 2 (8), Oct., pp. 204–205, 2 figs.

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