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Gape Worm of Fowls

(*Syngamus trachealis*);

THE EARTHWORM

(*Lumbricus terrestris*),

ITS INTERMEDIATE HOST.

ALSO,

On the Prevention of the Disease in Fowls called the Gapes, which is Caused by this Parasite.

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SYNGAMUS TRACHEALIS.

EXPLANATION OF FIGURES.

Fig. 1.—Adult, male and female *Syngamus*, united (natural size and enlarged 12 diameters). A, male; B, female, each showing the head, esophagus and intestine. In the female may be seen the uterus and ovarian tubes filled with eggs. In the male, the semeniferous tube.

Fig. 2.—Smallest pair of *Syngami* ever seen (enlarged 50 diameters). A, male; B, female.

Fig. 3.—Embryo of *Syngamus* removed from the earthworm and kept in the blood serum of a calf, in an incubator, at 105° Fahr., between four and five days. About moulting the second time after being placed in the serum. Embryo lying within the exuviae. See structure of mouth of embryo, and also in the exuviae (enlarged 200 diameters).

Fig. 4.—Embryo of *Syngamus* removed from the earthworm and kept in the blood serum of a calf, in an incubator, at 105° Fahr., for 24 hours. About moulting the first time after being placed in the serum (enlarged 200 diameters).

Fig. 5.—Embryo of *Syngamus* removed from the lung of a chick fed earthworms containing the embryos. This embryo had just entered the lung (enlarged 200 diameters).

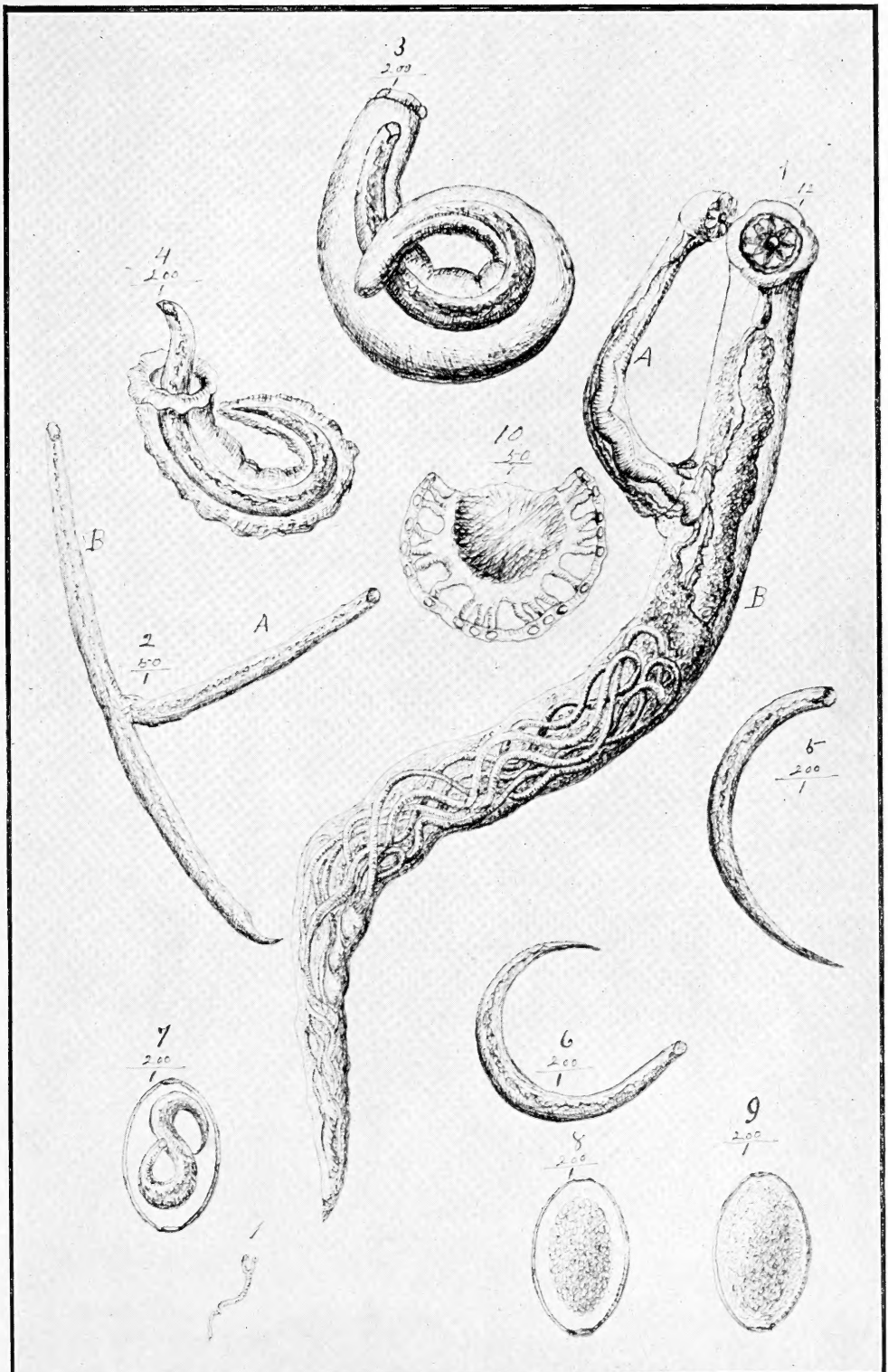
Fig. 6.—Embryo of *Syngamus* removed from the intestinal canal of an earthworm (enlarged 200 diameters).

Fig. 7.—Embryo of *Syngamus* within the egg (enlarged 200 diameters).

Fig. 8.—Egg of *Syngamus* in the mulberry state (enlarged 200 diameters).

Fig. 9.—Perfect egg of *Syngamus* immediately after passing out of adult female (enlarged 200 diameters).

Fig. 10.—Caudal pouch of male. Observe the eight principal ribs which are subdivided so there are eighteen divisions at the circumference, each extremity of which is expanded into a sucker. These suckers project through the broad margin of the pouch which is closely applied around the vulva of the female, to which they enable it very firmly to adhere. The posterior part of the circumference of the pouch is cut out and has no suckers. Here is where the eggs pass out.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PREFACE.

Fourteen years having elapsed since I first commenced the study of the gapes in fowls, it cannot be asserted that the conclusions now arrived at are hasty and have not stood the test of time and mature consideration. My first paper on the subject was read before the Buffalo Microscopical Club, November 11th, 1884. In 1886 I published a paper in the Bulletin of the Buffalo Society of Natural Sciences, Vol. V., No. 2. The present publication is a revision of that paper, with extracts from articles written for various journals, and additional matter heretofore unpublished in regard to the life history of the parasite causing the gapes. The illustrations are from drawings made by Mrs. Helen M. Judd from microscopic slides. I send forth this small pamphlet with the earnest desire that science and the poultry and game bird raisers throughout the world may be benefitted thereby.

H. D. WALKER.

Franklinville, N. Y., November, 1897.

INTRODUCTION.

In the following pages we present the results of experiments made for the purpose of determining the intermediate host of the gape worm of fowls. We have endeavored at the same time to trace out the life history of this parasite, in its various stages from the egg to the perfect worm, also to devise means for the prevention of the disease caused by it among fowls.

The object of undertaking the work was two-fold. First, it was thought if its intermediate host could be discovered the disease might be prevented to a great degree, and much good result therefrom. Second, the love of original investigation and a determination to work out the life history of this parasite, which, although well known in its mature condition in the trachea of fowls for about one hundred years, had thus far, in its embryonic state in nature, remained unknown. The work has been exceedingly difficult, for several reasons. When the investigation was begun, I knew nothing about Entozoa. Microscopical work was also comparatively new. Living in a small village, I had no public libraries to consult, and was dependent for the literature of the Entozoa on a few books which I procured during the investigation. My profession also left me little leisure, and the most of this work has been done at such odd times as I could spare from other duties. I wish here to express my thanks to that eminent naturalist, the late Dr. Joseph Leidy, of Philadelphia, for many favors in inspecting my microscopic slides, and for advice and encouragement in the work. Valuable, indeed, were the services he rendered me. I am under obligations to Lord Walsingham, of England, for books to aid in the investigation. Friends in the Buffalo Microscopical Club, and neighbors have also assisted me in various ways. I have freely consulted Dr. T. Spencer Cobbold's work on "Parasites," also Professor L. G. Neumann's treatise on "Parasites and Parasitic Diseases of Domesticated Animals," and Dr. Pierre Megnin, "On the Gapes Disease in Gallinaceous Birds." Finally, I trust these pages will not be scanned with too critical an eye, for, doubtless, imperfections will be found. I can only say that I have honestly endeavored, according to the best of my ability, to place before the reader the life history of one of the humblest of creatures, a worm, but which, nevertheless, plays well its own part in this world of animated nature.

ZOOLOGICAL CLASSIFICATION AND HABITAT.

The Animal Kingdom is divided into several sub-kingdoms. One of these is called Worms (*Vermes*). This sub-kingdom is separated into classes, one of which is named Round Worms (*Nemathelminths*). Another division into orders is made, among which are the Nematode Worms (*Nematodes*). This order contains, among other genera, that of *Syngamus*, which is represented by two species, *Syngamus bronchialis* and *Syngamus trachealis*, the last of which is the subject of our present work.*

Another name for this worm is *Sclerostoma*, or *Strongylus syngamus*. *Syngamus trachealis* is stated to have been found in the trachea of the turkey, domestic fowl, pheasant, partridge, black stork, magpie, hooded crow, green woodpecker and starling. I have, myself, found it in the robin, and believe most if not all worm-eating birds serve as a host for this parasite.

HISTORICAL REFERENCE.

The first public record of the Gapes was made by Dr. Wiesenthall, Professor of Anatomy at Baltimore, Md. In a communication dated May 21st, 1797, and published in the Medical and Physical Journal in 1799, he says: "There is a disease prevalent among the gallinaceous poultry in this country called the gapes, which destroys eight-tenths of our fowls in many parts, and is most prevalent among young turkeys and chickens bred upon established farms. Chicks and poults, in a few days after they are hatched, are frequently found to open wide their mouths and gasp for breath, at the same time sneezing and attempting to swallow. At first the affection is slight, but gradually becomes more and more oppressive, and ultimately destroys; very few recover; they languish, grow dispirited, droop and die. It is generally known that these symptoms are occasioned by worms in the trachea. I have seen the whole windpipe completely filled with these worms, and have been astonished at the animal's being capable of respiration under such circumstances." The above is a truthful description of the disease as it prevails in this country to-day. In 1808, Mr. George Montagu gave an account to the Wernerian Society of a species of Fasciola, which infests the trachea of poultry, with a mode of cure. This led to its being noticed in the systematic works of the day. Dr. Cobbold, from

*The name of the genus *Syngamus* is derived from two Greek words, σ υ ν, with, together, and γ α υ ο ς, marriage, and has reference to the peculiar union of the sexes.

whose work on parasites this brief history was taken, has made some observations on this worm. In 1879, Lord Walsingham, of England, offered a prize of two hundred and fifty dollars, to be awarded by the Council of the Entomological Society of London, for the best essay, comprising a complete life history of the parasite causing the gapes. Mr. Charles Black and Dr. Pierre Megnin, a well-known French scientist, competed for the prize. The latter received the award. The conclusions at which he arrived in regard to the propagation of the disease are as follows: First, that birds pick up mature *Syngami* filled with eggs, which are coughed out by those having the disease, or the eggs are taken in their food, or the embryos after they are hatched in water, and they are developed within them to the perfect form. Second, that no intermediate host, as perfect insects, larvae, mollusks, or any other living agent, has any share in spreading the disease. In a supplement to the above, after discovering a nymph of *Syngamus* in the pulmonary tissue of a red partridge, he says: "In the preceding memoir, written about twenty months ago, we pointed out that the eggs ejected during the coughing fits hatch in the water, and that the embryo, resembling an anguillula, may live in this medium for many months, because we have kept some alive almost a year, in a low temperature. The birds are infected by drinking the water containing these embryos. But how are they developed in the body of birds, and in what way do they reach the trachea, where they are found in the adult stage, fixed to the mucous membrane, like leeches, the two sexes united in a permanent manner, and the females crowded with eggs?" He closes the supplement as follows: "This discovery of the nymph enables us to say that all the developmental phases of *Syngamus trachealis* are now known. The only two media which this parasite inhabits during its entire existence are the water or moist earth during its embryonal condition, and the respiratory organs of its victim during its nymphal and its adult phase. It is developed without the aid of any other medium than the water, corresponding in this respect to the immense majority of verminous parasites." This, then, is the conclusion at which Dr. Megnin arrives, after five or six years' study of the gapes in the various pheasantries of Central France, and around Paris. Dr. Cobbold says, in his work on "Parasites," page 445: "A change of hosts is probably necessary, but in the first instance they either enter the substance of fungi or other

vegetable matters, or they bury themselves in the soil a short distance from the surface." In Lord Walsingham's preface to the essay by Dr. Megnin, he says: "By Dr. Megnin's permission, his memoir is now published in a separate form, the subject of it being one which could not rightly be included amongst the publications of the Entomological Society, although at the time of offering the prize I was led, by information gathered from various sources, to think it possible that the larvae of some insect acted the part of host to the embryonic form of *Syngamus*." Dr. Joseph Leidy believed the embryos would be found in some intermediate host. The above comprised our knowledge on the subject when this research was begun.

PRESENT INVESTIGATION.

The present investigation was commenced during the summer of 1883. Great numbers of young poultry dying of the gapes, some of my neighbors applied to me for aid to arrest the disease. Knowing very little about the gapes, but having heard it was caused by worms in the trachea, I made a careful examination of their windpipes, and found numbers of the worms attached thereto by their sucker-like mouths. Never having studied the Entozoa, and having no works on them, I sent a specimen to Dr. Joseph Leidy, of Philadelphia, asking him its name, and where I would find information on the subject. He kindly replied, and referred me to Dr. Cobbold on "Parasites," and an article by Dr. N. H. Paaren, in the American Entomologist, Vol. 2, page 149. I immediately procured these, and reading the articles on that subject, could find nothing regarding its origin. I therefore again addressed Dr. Leidy, asking him for the desired information. On August 15th, 1883, I received his reply as follows: "The source of the gape worm (*Syngamus trachealis*), of chickens, has not been discovered. If you have an opportunity of investigating and determining its origin, you may do much service to science. It would be found only in the embryonic or larval condition, in some intermediate host." I thought this was not only a good field for microscopic examination, but also one which, should I succeed in the work, would be productive of much good. Therefore, I commenced an investigation of the coops and their vicinity, where the chicks suffered most from the gapes. About these I found three not improbable sources of the disease: First, the common earth worm (*Lumbricus terrestris*);

second, the sow bug (*Oniscus asellus*); third, the garden slug *Limax flavus*). My attention was especially directed to one coop where the chicks all had the gapes. This was placed on a grassy plot, but close by its side was a small space of bare ground, a few inches square. It seemed quite probable that here was the place where they obtained the parasite, so I dug into it and found it full of earthworms. I took some of these home and examined them with the microscope, as I did also Oniscus and Limax. I found that both the slug and earthworm contained various kinds of parasites in abundance. None were found in Oniscus. To determine which one, if any of these, was the intermediate host of *Syngamus trachealis*, I procured some young chicks from a neighborhood where no gapes existed, and fed each separately to the chicks. In neither of the chicks fed with sow bugs or slugs was any result produced, but the chick fed with earthworms developed symptoms of the gapes. To guard against error, all the chicks were kept in a barn where they had no access to the ground, and their food was cornmeal mixed with pure water.

EXPERIMENTS IN FEEDING EARTHWORMS.

Exp. 1. On September 29th, 1883, at 8:30 a. m., a marked chick, about one week old, was fed ten earthworms from the bare spot of ground by the side of the coop where the chicks had the gapes. The worms were carefully washed in water to remove all the dirt adhering to them, which might contain the eggs or embryos of *Syngamus*. On October 6th, at 7:30 a. m., six days and twenty-three hours after the feeding, I observed the first symptoms of the gapes. On October 7th, at 10:30 a. m., eight days and two hours after feeding the chick, and twenty-seven hours after the first symptoms of the disease, I killed it and found twenty-six gape worms. Of these worms, two only were found in the trachea; they were at its upper part, and were the largest. Ten or twelve of them were in the pharynx. The remainder were in the esophagus, from its upper part half way down to the crop. All these were united in pairs, except one male and female.

Exp. 2. On October 9th, at 8 a. m., another chick, a little over two weeks old, was fed four earthworms from the same place, with like precautions. At the same time of day on the 10th it was fed six worms. On the 11th, 12th, 13th, 14th and

15th it was fed ten worms daily. At the same time from the first feeding, a little less than seven days, it had the gapes. It was killed in eight days and twelve gape worms found, all in the trachea.

Exp. 3. November 13th three chicks, two days old, were fed earth worms from my garden, eight, nine and ten days, respectively. No symptoms of the gapes were produced, but to determine positively, the one fed nine days was killed, and no gape worms found. This experiment shows that all earthworms do not contain the embryo of *Syngamus*. To confirm this, earthworms from the same place have been repeatedly examined with the microscope, and none of the embryos found.

Exp. 4. Two mature *Syngami* were broken in pieces, so as to free the eggs. They were then placed on the surface of a dish filled with dirt, well moistened with water. After two weeks some earthworms were placed in this dish and allowed to remain ten days. Three of these were fed to a chick, which was carefully watched for two weeks. No symptoms of gapes were discovered. Evidently the embryos had not obtained access to the earthworms in sufficient numbers to produce the disease in chicks.

Exps. 5 and 6. On December 13th, two chicks, four weeks and four days old, were each fed six earthworms from the infected spot, with the same precautions as before. On the 14th, 15th and 16th the feeding of six worms was repeated, making twenty-four to each chick. On December 20th, about seven days, as before, they had the first symptoms of the gapes. One was now killed, and twenty-two *Syngami* were found. On December 24th, eleven days from the first feeding, the other was killed, and sixteen found. All of them were united, and in the trachea. None were found in the lungs, but it is probable they were there, and want of experience in the search prevented their discovery.

Exps. 7, 8 and 9. On April 21st, 1884, fed three chicks, two days old, each five worms from the same place where the others were obtained. Repeated the feeding on April 22d, 23d, 24th, 25th, 26th and 27th. On April 28th, about seven days from the first feeding, all had the gapes. One was now killed and *Syngami* found in the trachea, also three pairs in the lower part of the left lung and one pair in the lower part of the right lung. Continued to feed the two remaining chicks earthworms until May 5th, just two weeks from the first feeding, when one was killed and the

lower part of the trachea found crowded with *Syngami.* One of these measured seven-eighths of an inch in length, and two or three others three-fourths of an inch. They contained fully developed eggs, as did also the excretions of the chick just before it was killed. This proves that the embryo of *Syngamus* in the earthworm is developed to maturity in two weeks from the time it obtains entrance to the chick. The last chick was killed seventeen days from the first feeding, when *in articulo mortis.* In the lungs of each of those killed at fourteen and seventeen days from the first feeding, embryo *Syngami* were found in various stages of development.

Exp. 10. On July 16th, fed a chick ten earthworms, and repeated the feeding for nine successive days. The gapes observed on the seventh day, as usual. On July 26th, ten days from the first feeding, I killed this chick and found a large number of *Syngami* in the trachea, and also the embryos in different stages of growth in the lungs.

Exp. 11. In order to see if Dr. Megnin's theory was correct, that the eggs would develop within the fowl, I fed a chick about three weeks old, on July 29th, three perfect *Syngami,* containing many thousands of eggs. This chick was carefully watched for five weeks, and no symptoms of gapes observed. That this result is correct, we have additional proof in exp. 8, in which large numbers of perfect eggs were found in the excretions of the chick, on the fourteenth day after feeding earthworms containing the embryos of the gape worm. I believe however, if the eggs should in any manner be retained so as to hatch before they passed into the proventriculus,* the gapes would be produced, but think such a case must be very rare, and would be unlikely to occur unless the embryos were fully developed in the egg before they were taken by the fowl.

Exp. 12. Three young robins (*Turdus migratorius*), in the nest, were fed several infested earthworms each, daily for twelve days. These earthworms were taken from the same place as those given the chicks. No well marked symptoms of the gapes were observed. Two of them were killed, and three or four gape worms found in the trachea of each. A number were also found in process of development in the lungs. These birds live almost entirely on earthworms during a part of the year, and I wished

*The proventriculus is the first or glandular stomach where the gastric juice is secreted, the gizzard being the muscular stomach where the food is triturated.

to know whether they would serve as a host for the parasite, and thus be instrumental in spreading the disease from farm to farm. The trachea of robins differs, in its size and anatomical structure, from that of poultry, especially at its lower part, where the last ring dilates and forms a second larynx. *Syngami* generally collect from the lower part of the trachea to its middle, and the gapes is simply the effort of the bird to obtain more air through this passage, which is obstructed by these worms. It is evident, therefore, that birds which have a larger trachea would harbor a greater number of *Syngami* without suffering from the gapes. We see this is the case in chicks after they are several weeks old, for *Syngami* can often be seen in their windpipes by opening their mouths and straightening out their necks. Several worms can thus be seen in large chicks, with very little embarrassment to respiration. It is also not improbable that, although the embryos may penetrate the esophagus, pass to the lungs and thence to the trachea, the greater part may be coughed up and swallowed before they are able to obtain a hold on its mucous membrane. We know from an examination of chicks that very many of them are thrown off in this way.

Exp. 13. On July 4th, at 5 p. m., fed a chick, about four weeks old, a large number of *Syngami*, just hatched, by turning the water containing them down its throat. On July 11th, at 7 p. m., this chick commenced to have the cough or sneeze characteristic of the gapes. July 12th, coughed much more. On July 13th, at 9 a. m., eight days and sixteen hours after the feeding, I killed this chick and found one single and twenty-nine pairs of *Syngami*.

Exp. 14. On August 14th, at 7 p. m., fed a young robin, just from the nest, a large number of embryo *Syngami*, hatched in water, as in the preceding experiment. It was kept in a cage hanging under a tree, and fed by the old bird. August 22d, morning: Robin had some symptoms of the gapes, such as rapid breathing, an occasional gape and shake of the head, and was inclined to sit on its perch, instead of standing up, as usual. August 23d: Breathed more rapidly, and evidently quite ill. August 26th: Robin continued to grow weaker and breathed more rapidly, and at times gaped, but the gaping was not as prominent a symptom as in the case of chicks. The robin died the morning of the 29th, the fifteenth day from the feeding. On examination three fair sized *Syngami* were found in the trachea,

not enough to fill it up, so as to produce much gaping. The rapid breathing, which was the most prominent symptom, was readily accounted for by extensive deposits in both lungs, more especially the right. The lower part of each lung was affected, and the diseased condition doubtless resulted from the irritation of the parasites.* Many other feeding experiments with chicks have been made in different years since the above. All of them thoroughly confirm the foregoing ones in every respect, and it is deemed unnecessary to detail them here. Experiment 13 proves that the embryo of *Syngamus* does not have to pass through an intermediate host to obtain any change in structure, or increase in development, that the earthworm is simply a bearer, in which it lives in its embryonic condition, and through which it obtains access to its final host, the fowl. This chick was kept in the barn and all other sources of the disease excluded, which was not the case with the robin. The time from the feeding to the production of the disease in the chick was the same as when earthworms were fed, which is good evidence that it is the embryo instead of the egg in those which causes the disease. It may further be stated that in the examination of many infested earthworms I never yet found one to contain the eggs of *Syngamus.* In dissecting the robin I found an embryo just emerged from the esophagus into the lung. It was a short distance above the proventriculus, was sexually developed, being a male, and thus affords convincing proof that they enter the lung this way. In a chick I also found a pair of *Syngami* just united, on the posterior part of the esophagus, which had the appearance of having been penetrated by these worms. I have also found the embryo lying beneath the mucous membrane of the esophagus.

ARTIFICIAL CULTURE.

Exp. 15. On September 23d, 1883, a mature *Syngamus* filled with eggs was placed in a small glass dish with a little water, for the purpose of observing the development of the embryo, the structure of the young worms and the time required for them to hatch. We also thought that by comparison in this way they could be more positively identified in the earthworm. The dish

*This condition resulting from parasites is mentioned by Dr. N. H. Paaren, in the American Entomologist, Vol. 2, page 149; also, by Dr. George M. Sternberg, from M. Larrlaine, in an article on the "Production of Tuberculosis by Inoculation," in the American Journal of Medical Sciences, Vol. LXXXIX, page 18.

was kept covered in a warm room (65° to 70° Fahr.), and occasionally placed several hours in the sun. On October 14th, three weeks from placing them in water, they commenced to hatch.

Exp. 16. June 11th, 1885, placed two mature *Syngami* in a small glass dish of water, and kept them in a room where they were not exposed to the direct rays of the sun. On June 28th, seventeen days from the time they were placed in water, they commenced to hatch.

As will be seen from the above experiments, the time required for the eggs to hatch varies under different circumstances. When they have been mature for several days and kept moist and in a moderately warm place they will undergo segmentation and the embryo commence to form. If these eggs are now placed in water in a warm place it will take but a short time for the embryos to hatch. Again, eggs kept in moderately warm water will mature their embryos much quicker than those kept cooler.

Exp. 17. December 1st, 1884, placed several embryos found coiled up in the muscular sac of the segmental organs of the earthworm, in a small glass dish of water and kept them loosely covered, in a warm room. These embryos were thought in the beginning of the investigation to be those of *Syngamus*, and this method was adopted to see if any growth or development of structure would take place in water, whereby we might decide the question. In from five to seven days they grew to many times their original length, and were developed into male and female. A small number of eggs were also seen in different stages, within the oviducts and scattered about the bottom of the vessel. These worms correspond with the description and figures in the Micrographic Dictionary under the head of *Anguillulidiae*, and are thus excluded from being the embryos of Syngamus.

Exp. 18. Several embryos taken from the intestinal canal of the earthworm, where they were found surrounded by mucus, were placed in a glass dish of water and kept, as in the foregoing experiment, seven days. These embryos, after a few hours, coiled themselves up at the bottom of the dish, and for the most part of the time remained in this condition, occasionally uncoiling and moving about a short distance. No growth or development of structure took place. These embryos correspond in size and structure with those hatched from the eggs of *Syn-*

gamus, and later in the investigation were fully identified as being the same.

Exp. 19. Placed several embryos from the intestinal canal of the earthworm, like those in the preceding experiment, in a covered glass dish of water, and then in an incubator, and kept them at 105° Fahrenheit for seven days, at which time they were alive, but no change of structure or development had taken place.

Exp. 20. One pint of blood from a calf was allowed to stand in a glass fruit jar until the solid portion had settled, leaving the serum at the top. On May 5th, at 9 a. m., one dram of this serum was placed in a Syracuse solid watch glass, with ground edges, containing twenty of the last described embryos. These embryos had been kept in the watch glass in water one week, and were nearly all lying quietly coiled up about its center. The most of the water was removed by a pipette before the serum was added. As soon as this was done the embryos uncoiled and became quite lively, as though they had at last found their natural element. The watch glass was placed in an incubator, covered by another one with ground edges, but leaving a small space for air. The temperature had previously been regulated so as to remain at 105° Fahr. At 9 p. m., on examining them with the microscope, they had slightly increased in size and were commencing to moult. On May 6th, at 9 a. m., they were again taken from the incubator and examined, when the process of moulting had still further advanced. At 4 p. m. I found them all dead. The culture fluid had become putrid.

Exp. 21. May 7th, 4 p. m., completely satisfied that I was on the right track, I removed four more embryos from an earthworm and placed them in another portion of serum, and in the incubator as before. On May 8th, at 9 a. m., removed them to another watch glass containing fresh serum, by taking them up under an inch objective with a small splinter of wood whittled to a fine point. At 9 p. m. the same day they were again removed to fresh serum. One was found dead, another had moulted, and the two others had nearly completed that process. May 9th, 9 a. m., they were seen to have increased in size, and were removed to another portion of serum. These embryos lived between four and five days in the incubator, and were about moulting the second time. They were sufficiently developed to show the peculiar structure of the mouth of *Syngamus trachealis*. One of them

measured .0139 inch in length, and the exuvia, in which it still remained, .0227 of an inch. (See figure 3.)

Exp. 22. Four of the embryos from the earthworm were placed in one dram of egg albumen, after it was beaten to render it fluid. They were placed in the incubator as before, and changed to fresh albumen daily. After being kept in this way six and one-half days, they were alive, but there was no change in their structure or size, or any appearance of moulting perceptible. Evidently the proper food for their metamorphosis and growth was not contained in this fluid. In these culture experiments the incubator used was one in which the heat could not be thoroughly controlled. It is believed with a good one and more experience better results could be attained. It is also thought the blood serum of a fowl would be best adapted for this purpose. This method of artificial culture of animal parasites is believed to be new, and if varied according to the different circumstances in which they are found in nature will, we think, render easy the solution of some of the most difficult questions as to the life history and embryonic forms of many of these creatures. The subject is of great importance, for large numbers of both human beings and animals perish each year through their agency. Moreover, it is not far removed from that great question which occupies so prominent a position before the medical profession at the present time. I refer to the germ theory of disease. The one is an animal, the other a vegetable parasite. The method of artificial culture is now being used for working out the latter; I see no reason why it cannot be successful in the former.

EMBRYOLOGY AND DEVELOPMENT OF SYNGAMUS.

The egg is formed out of the granular material seen near the extremity of the ovarian tubes. It is shaped into small round bodies which pass down towards the uterus, within the horns of which they are supposed to become impregnated, and receive the hard external coat called the shell. Within the body of the female *Syngamus*, about fourteen days after its entrance into the fowl, are found several thousand eggs in various stages of development, from the granular material of which they are formed, as it exists in the ovaries and ovarian tubes, to the perfect egg in the uterus. The perfect egg is oval, about .004 inch in its long,

and .0025 inch in its short diameter. At each end is a valve or lid which drops off when the embryo emerges from the egg. It has been the general opinion among naturalists that the mature eggs of *Syngamus* were never discharged through their natural outlet during the life of the female, that being rendered impossible by the intimate union of the genital organs of the sexes, whereby the outlet of the vagina was completely closed. They believed that only at the death of the worm and disintegration of its body were the eggs set free. That such is not the case in some instances, *I know*, for I have distinctly seen, under the microscope, with a power of fifty diameters, the eggs pass out at the posterior part of this union in a living pair, just removed from the trachea of a chick. Two or three eggs were discharged at regular intervals, each minute. On close observation there was clearly observed movements of the worm, showing the natural expulsive efforts, followed by the extrusion of the eggs. Now, in about fourteen days after the feeding of earthworms containing the embryos of *Syngamus*, we have, in several later experiments, some of which are not herein recorded, observed the perfect eggs of *Syngamus* in the excretions of the chicks. These chicks were then killed and the living pairs of *Syngami* found attached to the mucous membrane of the trachea. Some of these pairs had not yet attained their complete growth, yet the eggs, near the genital outlet, were fully developed. None of them were found dead and their bodies breaking up in the trachea. From these observations we have no doubt that the living worm, contrary to the opinion heretofore entertained, does, during its life, extrude a large number of perfect eggs, but always dies while many yet remain in its body, which are set free when that decomposes. I have never been able to press the eggs out through the vagina in a dead *Syngamus*. This *may be* one reason why naturalists have thought they did not pass out when living that way, but I believe all dead animals have their genital passages contracted in the same manner. It has also been the general opinion that the eggs furthest advanced in a mature *Syngamus* while living and just removed from the trachea of a fowl contain the perfect embryo already moving actively about within the shell. That such is not the case we believe and will briefly give our reasons for this opinion. In experiment No. 8, it will be seen that a chick fed earthworms containing the embryos of *Syngamus* developed the gapes, and in fourteen days

from the time of the first feeding great numbers of the eggs of *Syngamus* were found after they had passed through the fowl's intestines. These eggs passed from perfect worms, which were found attached to the trachea of the chick, killed the same day. Now, the eggs which passed through the chick, and those found about the perfect worms in the trachea, showed no sign of embryonic formation. Moreover, we will say that after the examination of many perfect worms removed from the trachea, we have never found the embryo developed within a single egg at that time. In our experience, it takes these eggs not far from three weeks, varying somewhat with the temperature, to mature and bring forth their embryos. We believe *Syngami*, in which active embryos were found within the egg, had been for many days mature, and probably kept in a moist condition, either within the body of the bird or external to the same. The embryo of the lung worm of calves (*Strongylus micrurus*), is fully developed in the egg while in the lungs of the calf. Possibly, reasoning by analogy has had something to do with this opinion heretofore entertained concerning *Syngamus*. It is evident the eggs, scattered over the ground in the natural way, hatch much quicker during the hot months of summer than later in the season. Indeed, it is quite probable that most of these last perish on account of the cold, without the formation of an embryo.

DEVELOPMENT OF THE EMBRYO.

The process of development from the egg is as follows: The yolk undergoes segmentation; that is, becomes divided into 2, 4, 8, etc., round masses or spheres, this division being continued until it assumes the mulberry state. The embryo is developed from this around the inner part of the shell, in the form of a circle. Before it emerges the embryo usually coils itself within the egg, like the figure 8, from which it generally comes out head first. The time required for the perfect egg to pass through the different stages, until the embryo issues from it varies, as heretofore stated. On one occasion a few of the embryos came forth in seventeen days. The embryo on emerging resembles an Anguillula, but its movements are not as rapid as most of the worms belonging to this order. It is about .011 inch in length, and .0005 inch in width at its middle. The posterior half of the body is filled with a fine granular matter. After the

embryos have been in water a few days they moult, losing about .0005 inch in length; their tails are then more blunt. Sometimes they pass through the first moult while coming out of the egg, leaving the old skin within.

THE EMBRYO IN THE EARTHWORM.

After many careful microscopic examinations of the embryo, as found in the earthworm, I have arrived at the conclusion that it does not differ in its structure, so far as can be discovered, from the embryo which has passed through one moult, after the egg has hatched in water. The method of finding them in the earthworm is as follows: Select a poultry yard where chicks have had the gapes for several years, so that the earthworms may have plenty of the parasites. From near the surface of bare spots of ground, which chicks with the gapes have frequented, take some of the earthworms and examine them with the microscope. The following method is recommended: Throw the earthworm to be examined into a solution of common salt (chloride of sodium), having the strength of about two ounces to the pint of water. When it ceases to move, rinse in pure water; then, with sharp-pointed scissors, slit the worm its entire length. Spread out on each side, to expose the alimentary canal. In order to intelligently proceed, we will briefly describe the organs contained therein. They consist of the mouth, pharynx, esophagus, crop, gizzard and intestine. Directly connected with the esophagus, about its middle and posterior part, are found six white bodies, three on each side called the esophageal or calciferous glands. The esophagus passes directly into the crop, which is just in front of the gizzard. Following this is the intestine, which passes through the remaining portion of the worm. We cut off the intestine, just back of the gizzard, and taking small pieces, about one-eighth inch long, place them on a watch glass with a little water, pick them well in pieces, and examine carefully with an inch objective. We generally find the embryos a short distance below the gizzard, not often more than half way to the tail. There are numerous kinds of parasites which inhabit the earthworm, some of them numbering thousands in a single worm. We have also found the earthworms in different localities to harbor very different kinds of parasites. The method of distinguishing the embryo of *Syngamus* is its size, description as here given, and

general appearance as seen in the engravings. We believe it is taken in by the earthworm with its food, and passes down into the intestine, where it remains until transferred within its host to the digestive organs of some bird, or after a time passes through into the soil and perishes. This method of taking in the embryo by the earthworm is the common law in nature, through which all creatures, man included, obtain their intestinal parasites.

THE EMBRYO OF SYNGAMUS IN THE FOWL.

The embryo passes into the crop within the intestine of the earthworm. We wish to determine at what point it leaves the digestive canal and passes into the lungs and trachea of the chick. We have never been able to trace the embryo below the esophagus, after many examinations of chicks dead of the gapes. If we admit that they do not pass through the proventriculus and gizzard alive, which I have no doubt is the truth, there are only two organs, the crop and esophagus, through which they could gain admission to the lungs. The crop is simply a dilatation of the esophageal structures, and acts as a reservoir for the food. We believe the embryo passes through the esophagus just above the proventriculus, for the following reasons: The distance to the lung structures is very short, only the thin wall of the esophagus intervening. The orifices of the lenticular glands of the esophagus are of greater diameter than the embryo, so it could readily enter through them. That it does so we believe, for we have found them beneath its mucous membrane. The pulmonary bronchi ramify over the outer surface of the esophagus, through the substance of which there are numerous tubular structures, which, it is not improbable, may be connected with them. We have seen the embryo just emerged from the esophagus into the lung, and have in all the chicks carefully examined for that purpose, after dying of the gapes, found several echymosed spots, which looked as though the embryos had passed through. We have also found them recently united on the outer wall of the esophagus, one pair being the smallest we ever saw. In dissecting chickens dying of the gapes, we have, many times, found the esophagus adhering to the lungs, as we believe from the inflammation caused by the passage of the embryos. This condition of echymosis, and adhesion of the esophagus to the lungs, *we have never found in any chicks we have dissected which did not have*

the gapes. Both male and female embryos do not develop beyond a certain point until union takes place. After this they pass up into the trachea, where they attach themselves to the mucous membrane and attain maturity.

ANATOMICAL DESCRIPTION.

We shall not attempt any extended anatomical description of *Syngamus trachealis.* The illustrations accompanying this investigation will show its appearance in the different stages of its existence. We will briefly say that the mouth in this Genus is large, circular, and surrounded by four outer membranous and six inner chitinous lips. The young worm has eight inner lips, two of which uniting with two others, reduces the number to six in the adult worm. Within it is hollowed out, and contains around the opening to the digestive apparatus, eight lance-like organs, which are supposed to pierce the mucous membrane for extracting the blood of its host.

THE MALE.

The male has been found coupled on the external wall of the esophagus of the chick when .035 inch long, and .002 inch wide. At maturity it attains the length of about .24 inch, and a breadth of about .02 inch. The diameter of the head exceeds that of the body, which is round, and its posterior part, containing the genital organs and anus, is united to the anterior part of the vulva of the female by a membranous hood-like organ, called the caudal pouch. This organ is elongated in front, with about one-third of its diameter cut out on its posterior part, where it is free from the female. It is supported by eight principal ribs, which are subdivided as follows: The posterior ribs on either side are double; next to these on each side they are trifid, followed by a single rib, between which are the two anterior ribs, also trifid. These divisions of the ribs, eighteen in number, each have at their extremity, which reaches to the circumference of the caudal pouch, a disk or sucker, by means of which the male attaches itself to the genital organs of the female and maintains so strong a hold, that even after death they are separated with much difficulty. There is no actual growing together of the organs, as has been the commonly received opinion, for they can be separated entire by careful manipulation in diluted glycerine. Within is seen the digestive and internal genital organs.

THE FEMALE.

The female has been found united with the male on the esophagus when .055 inch long and .0025 inch in width, and in its adult state sometimes measures .875 inch in length, by nearly .045 in width. It is of a bright red color from the absorption of the hematin of the blood upon which it lives. When mature it is irregularly cylindrical, curved, and often variegated by the white winding uterine horns filled with eggs. The tail is conical and just in front of its extremity is the anus. The vulva is a short distance back of the head and is attached at its anterior part to the caudal extremity of the male. At its posterior part this union is incomplete, the perfect eggs passing out here through the vagina. The digestive and genital organs can be traced within.

PREVENTION OF THE GAPES.

The very best results which can be attained from the study of disease is its prevention. If the only way in nature by which fowls contract the gapes is from eating earthworms containing the embryos of *Syngamus*, it follows if none of these were eaten the disease would become extinct. We believe, after many years' study of the gapes, that this is the only natural way in which fowls contract the disease, but, should they take in the embryos in any other way the disease would be equally liable to occur. *We have never observed this to take place, and believe it never does except through the instrumentality of man.* Adopting this view, there are two methods of prevention, either one of which will prove effectual. First, keep young fowls from the ground where earthworms are infested by the embryos. Second, destroy the earthworms containing them, when the fowls could be allowed their liberty. We had thought a third method might be added, namely, to mix with the bird's food some anthelmintic, which, if worms containing the embryos were eaten, would destroy them without injuring the fowl. This opinion was changed after the experiments detailed below were concluded. The first method consists in either keeping them on wooden floors, or some grassy plot or ground where the disease has never existed. The second method, that of destroying the earthworm, involves the question as to what is the best method of doing this. The article to be chosen must be cheap, effective, readily applied, and safe to use. We have experimented with three different substances, each of which

possesses to a considerable degree these qualities. They are common salt (chloride of sodium), lime (oxide of calcium), and wood ashes (mostly composed of potassa and its carbonate). In the experiments medium-sized earthworms were used, and the embryos of *Syngamus* were taken from the intestine of the earthworm.

EXPERIMENTS WITH EARTHWORMS AND EMBRYOS OF SYNGAMUS.

Exp. 1. An earthworm just dug, and with the dirt still adhering to it, was thrown into dry lime which had been slacked for several weeks. At the end of twelve minutes it was dead.

Exp. 2. Another earthworm was thrown into lime water; in seven minutes it ceased to move.

Exp. 3. An embryo of *Syngamus trachealis* was placed in lime water; it was observed for two hours, at the end of which time it was still alive and active.

Exp. 4. An earthworm was placed in a solution of common salt having the strength of one-fourth pound to the gallon of water. In six minutes it was dead.

Exp. 5. An embryo of *Syngamus* placed in the above solution lived thirty-three minutes.

Exp. 6. An earthworm placed in a solution of salt having the strength of one-half pound to the gallon of water lived four minutes.

Exp. 7. An embryo of *Syngamus* placed in the above solution ceased to move in fourteen and one-half minutes.

Exp. 8. An earthworm placed in a salt solution having the strength of one pound to one gallon of water lived about three minutes.

Exp. 9. An Embryo of *Syngamus* placed in the above solution lived three minutes.

Exp. 10. An earthworm thrown on dry salt ceased to move in somewhat less than three minutes.

Exp. 11. An earthworm thrown on dry ashes lived about twelve minutes.

Exp. 12. An earthworm placed in lye made by pouring warm water on wood ashes and letting it stand one hour, the proportion being one-half pound of ashes to one gallon of water. The earthworm ceased to move in three minutes.

Exp. 13. An embryo of *Syngamus* placed in the above solution was apparently unaffected at the end of twelve hours.

Exp. 14. An embryo of *Syngamus* placed in a watch glass containing a mixture of water and asafoetida, many small pieces of the latter being scattered over the bottom. At the end of one hour it was unaffected, although almost constantly in contact with the lumps of asafoetida.

Exp. 15. An embryo of *Syngamus* placed in a watch glass with water, and several small pieces of an onion, making a strong solution, were added to the same. At the end of six hours very little abatement in the vigor of its movements was perceptible. In twelve hours it still lived, but its movements were very slow.

The result of the above experiments may be stated as follows: Lime, salt, and ashes are all effective in destroying the earthworm. Lime water and lye of the strength used seemed to have very little effect on the embryo of *Syngamus*. Doubtless, a stronger solution of ashes would kill it, and it is probable that lime in substance would also be effective. Salt not only destroys the earthworm, but it also kills the embryo of *Syngamus*. The anthelmintic power of asafoetida and the onion has disappointed us much. The latter belongs to the same family (Allium), and has similar properties to garlic, which has been so highly recommended as a specific in the gapes. Ashes, lime or salt may then be used. The first two can be spread over the ground. Lime, in the form of lime water, is exceedingly cheap, but, exposed to the air, or in the soil soon combines with carbonic acid, forming carbonate of lime, which is probably harmless to the earthworm. We believe salt is more reliable, and it has also the additional advantage of destroying the embryo of the gape worm in the soil. It can be used in poultry yards in the proportion of one pound to the gallon of water, or, if the soil is very moist, two pounds would be better. If a large extent of ground is to be treated, the salt could be scattered in substance over the surface and left to be dissolved by rain or plowed under, taking care that none of it is eaten by fowls. This method has been adopted by some with success, no more gapes having developed in their chicks. All poultry dying of the gapes should be burned, and not left upon the ground, or even buried deep, as advised by some, for the eggs may hatch, and the embryos be taken by the earthworm to the surface to propagate the disease.

CONCLUDING REMARKS.

Before closing, we wish carefully to examine a few points concerning the life history of *Syngamus trachealis*, and the propagation of the gapes. First, do fowls contract the disease by picking up the eggs, or mature *Syngami* containing them? Dr. Megnin's parrot was claimed to have taken the disease from eating, on August 7th, four mature *Syngami* filled with eggs. The first symptoms of the gapes manifested themselves on August 28th, twenty-one days after the feeding, and the bird died September 10th, on the thirteenth day of the disease. We believe if the eggs were retained and hatched before they reached the proventriculus, the gapes would result. But we think such a case is exceptional, and not the way in which the disease generally occurs. In proof of this we will not only bring forward the chick fed mature *Syngami* (see feeding exp. 11), but also, the general fact that chicks, about fourteen days after they take in the embryos of *Syngamus*, have large quantities of mature eggs pass through their intestines into the soil. According to first theory, these eggs should hatch within the chick; it would thus become self-infecting, and would almost necessarily die. On the contrary, after chicks are a few weeks old they generally recover, their windpipes being large so that the usual number does not very materially interfere with their respiration. That the eggs are not contained in the earthworm and thus taken we believe is true, for, in the examination of very many infested earthworms during the past fourteen years, we have never found an egg of *Syngamus*. It is also evident that the time required to produce the gapes by feeding earthworms is too short for the eggs to hatch and the embryos to pass through their different stages. Again, the eggs are so small they could not be seen, as they were scattered over the ground, and picked up by chicks, and it is highly improbable that they would retain their vitality through the long winter months in this climate, and propagate the disease in chicks the following summer. We are aware that the eggs of various insects survive the winter, and continue their species from year to year, but we have found by experiment that the eggs of *Syngamus trachealis* will not hatch after being kept a few weeks, fatty degeneration takes place, and their vitality is destroyed. We consider it unnecessary to bring forward further proof on this point. Dr. Megnin himself abandons the theory, and says: "The birds are infected by drinking water containing the embryos." We are

then forced to the conclusion that the living embryo, in some manner, finds its way into birds, and is there developed into the perfect worm. That the gapes can be artificially produced by feeding the embryos of *Syngamus* hatched in water to chicks, we readily admit, for we have proved such is the case by experiment 13. But we deny that this is the natural way in which they contract the disease. In this climate of ours, with a long severe winter, the thermometer is often down to zero, water, when remaining on the surface of the ground would be frozen a hundred times, and during the warm season none would be found except in rainy weather. How then, we ask, would it be possible for the embryo to live through the cold season in water, and be taken by chicks the next spring, in the water they drink from the surface of the ground. Some of the Nematoid worms, to which class *Syngamus* belongs, can be brought to maturity by being taken in water. *Nevertheless they have intermediate hosts which act as a bearer, exactly as the earthworm acts as a bearer to the gape worm.* They differ from most of the tape worms which have to pass through an intermediate host, in which they are partially developed, to prepare them for a final development in their last host. To illustrate: Trichinae belong to the Nematoid worms, the same class as the gape worm, and could be propagated in man by drinking them in water, but did you ever hear of this taking place in nature? No! *They get them from their intermediate host, the hog.* The question is not what might happen, but what does actually occur in nature, without the intervention of man. I do not believe the Creator, in his infinite wisdom, has designed that the gape worm should be without a bearer, for you can easily perceive what would become of the poor worm in these Northern States were such the case. The soil is often frozen to a great depth, and it would be utterly destroyed. Besides this, it could not be picked up by a chick or bird, except by the merest accident, for it is so small it could not be seen. No! this is not so. It has been wisely decreed that the earthworm should be its intermediate host, in the intestine of which it finds all the nourishment necessary to sustain it. When winter comes it is carried deep into the ground, out of all reach of cold, and in the spring is brought again to the surface ready to be picked up in the earthworm, and pass through the remaining portion of its existence in its final host, the fowl. *Now, the proof is positive, and must be acknowledged, that earthworms do contain the embryos of Syngamus trachealis, and*

that the gapes can be produced by feeding the earthworms containing them to chicks (see the various experiments herein detailed). But, some say it is only an accidental host of the earthworm, taken in with the particles of earth, leaves, etc., while boring through the soil, and that the embryos may even be used as food by the earthworm. I have not the slightest faith in its being an accidental host of the earthworm, temporarily taken in with leaves, grass, etc., or used as food. If this was the case, why should we find it, as I have often done, in many earthworms in an infested locality, in midwinter, down deep in the ground, in the same position as in summer, in the intestine of the earthworm? Why did it not pass off with leaves and other matter used as food, instead of remaining throughout the year? I have found twenty in a single earthworm, and often five to ten. If the embryo was taken in as an accidental host, I see no reason why we should not at times find some of the eggs of *Syngamus* in the earthworm, but as before stated, we have never found one. *In all our study of the life history of the gape worm, we have never found any way in nature, without the intervention of man, through which they obtained access to birds, except the earthworm.* There is no food more natural for fowls than these. Chicks, two days old, eat them greedily. *No embryos of Syngamus have ever been discovered, on repeated examinations, in any other forms of animal life about the coops of chicks having the gapes, except earthworms.* These examinations were made with the microscope, and also by feeding experiments with chicks. No embryos like those of *Syngamus*, were found in earthworms which did not produce the gapes by feeding them to chicks. *I have made inquiries in various parts of our country, where no earthworms are found, as to the existence of gapes, and have invariably received the reply that their fowls do not have the disease.* The robin and other worm-eating birds which act as hosts for *Syngamus*, without question disseminate the disease from one farm or part of the country to another. When you remove your chicks to new ground where there has never been any gapes, the earthworms will not contain the embryos, and your chicks will be free from the disease. This has been demonstrated many times in this vicinity. Also, the fact that using a strong solution of salt on the ground, and thus killing the infested earthworms about coops where chicks have previously had the disease, would entirely prevent any outbreak the following year. It is a matter of common observation, that the gapes is more prevalent during wet seasons,

than dry ones. This is easily explained; the reason being that earthworms are more plenty on the surface of the ground, where they are easily picked up by chicks. It is also well known that when chicks are let out in the early morning, they are more apt to have the gapes. This was thought by many to result from their getting wet and cold, but it is easily explained by their finding the earthworms out at that time, when if they were not let out until the moisture was dried off the ground, the earthworms could not be found, they had retired into their burrows. The old adage, "The early bird catches the worm," well illustrates this point. It is also a well-known fact that chicks kept near a chip yard, were apt to have the gapes. This is readily explained by reason of their easily getting earthworms by scratching the chips from the surface of the ground, earthworms being found plenty in such places.

FINALLY, THERE IS NOTHING CONNECTED WITH THE GAPES WHICH CANNOT BE FULLY, AND CLEARLY EXPLAINED THROUGH THE AGENCY OF EARTHWORMS.

We will recapitulate the several points we consider established by this investigation. First, that the earthworm is the intermediate host of *Syngamus trachealis*, is proved by many successful experiments in feeding them to chicks. None of the chicks fed earthworms from an infected spot, failed to have the gapes in seven days. On microscopic examination, the embryos of *Syngamus* were found in these earthworms. That no other forms of animal life about the coops act as a host for *Syngamus*, proved by feeding all those found to chicks and they failed to produce the gapes; also, none of the embryos were found in them on examination with the microscope. That all earthworms do not contain the embryos of *Syngamus*, proved by feeding three chicks earthworms from a place where no gapes existed. They failed to have the gapes, and no embryos of *Syngamus* could be found in the earthworms with the microscope. That the earthworm is only a bearer, or means of conveying the embryo to the fowl, is proved by feeding the embryos hatched from the eggs to a chick, and thus producing the gapes. Also, the fact that the embryos in the earthworm do not develop, either in growth or structure, more than when they emerged from the egg. That the embryo of *Syngamus* is not an accidental host of the earthworm, proved by finding them in considerable numbers, in many earthworms,

in an infected spot, throughout the year. No earthworms, no gapes. This view is supported by inquiries made in various parts of the country where there are no earthworms, in which places, they say the fowls do not have the gapes. The embryo of *Syngamus* has been found in the earthworm, and identified by tracing it through its different stages from the earthworm to the trachea of the chick, and also by artificial culture. That they pass through the esophagus of the chick is demonstrated by finding them beneath its mucous membrane, and just after they had passed through into the lungs; also, by finding the esophagus adherent to the lungs in many chicks which had the gapes, this condition not being found in those which did not have this disease. That the disease is transmitted from one year to another by drinking water containing the embryos, is rendered impossible in a cold climate, where the water is frozen many times during the winter, and often dried from the surface in the summer. That the robin (Turdus migratorius), and probably many other worm-eating birds may act as a host for *Syngamus*, and thus be instrumental in spreading the disease, is proved by feeding three robins and finding full-grown worms in their tracheas. That the union between the genital organs of the male and female is incomplete at its posterior part, so that the eggs can be, and are readily expelled during the life of the worm, proved, by seeing this take place under the microscope. That the mature *Syngamus*, while yet in the trachea of the fowl, lays its eggs, which are coughed up, swallowed, and pass through the intestines of the fowl to the ground. Proved, by finding the eggs in the excretions, and the living worms from which eggs were passing, in the trachea. That the genital organs of the sexes are not grown together, proved, by separating them without rupture, and finding them to adhere by means of suckers on the genital organs of the male. That the mature egg does not contain an embryo is proved by examining them after they are naturally expelled by *Syngamus*, and finding that two or three weeks are required for the embryo to develop in them. That the embryo of *Syngamus* is but slightly affected by the anthelmintics which have been used to prevent and cure the disease, as asafoetida and garlic. They cannot be relied on for this purpose. Lastly, to prevent your fowls from having the gapes, remove them to some spot where the disease has never existed, or destroy the infested earthworms in the ground with common salt.

The life history of *Syngamus* trachealis is as follows: Earthworms containing the embryos are eaten by the fowl. The embryos are liberated from the intestine of the earthworm and work their way through the esophagus into the lungs and bronchi. Here they pass through the nymph stage and acquire sexual maturity. The male and female then unite, work their way into the trachea, and attach themselves to its mucous membrane by their sucker-like mouths. Between six and seven days are required from its entrance into the fowl until its attachment to the trachea. In about seven days more the eggs within the body of the worm become mature. They are coughed up into the mouth, swallowed by the fowl, and pass through it into the soil. In about three weeks, the time varying somewhat according to the temperature, these eggs, exposed to the moisture and sun, hatch; the embryos are taken in their food by the earthworm, where they remain until picked up by some bird, when the above process is repeated. Some years one-half or two-thirds of the young fowls in certain localities are destroyed by this disease. This investigation proves that if they were kept from eating infested earthworms, that terrible scourge of poultry, the gapes, would be entirely prevented. Not only this, but it serves as a key to unlock the mysteries surrounding several other diseases, caused by parasites belonging to this family; namely, the lung worm of calves (*Strongylus micrurus*), the lung worm of hogs (*Strongylus elongatus*), the lung worm of sheep (*Strongylus filiaria*), the grouse disease (*Strongylus pergracilis*). Great numbers of calves, hogs, sheep and grouse are yearly destroyed by these parasites. Their intermediate hosts have never been discovered. From certain inquiries which I have made, I venture to predict that the earthworm will be found to be their intermediate host.*

* Cobbold in his work on "Parasites," page 336-346, after a series of observations states his belief that the earthworm may act as an intermediate host for *Strongylus micrurus*.