BIOLOGY, PATHOGENESIS AND CONTROL OF SYNGAMUS TRACHEA INFECTION IN CHICKEN

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "BIOLOGY, PATHOGENESIS AND CONTROL OF SYNGAMUS TRACHEA INFECTION IN CHICKEN" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or any other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled "BIOLOGY, PATHOGENESIS AND CONTROL OF SYNGAMUS TRACHEA INFECTION IN CHICKEN" is a record of research work done independently by Kumari M. Devada under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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To my mother

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ABBREVIATIONS USED

an.	- anus
b.c.	- buccal capsule
b.r.	- bursal rays
de. l.	- developing larva
int.	- intestine
l.	- larva
n.r.	- nerve ring
oe.	- oesophagus
op.	- operculum
pha.	- pharynx
seg. em.	- segmented embryo
sp.	- spicules
te.	- teeth
ut.	- uterus
v.	- vulva

Introduction

INTRODUCTION

Poultry has currently become one of the most essential commodities in our day to day life. Since world war II, changes in poultry production have paced the whole field of livestock through a highly specialised and efficient system of management by which better gains and rare losses are obtained.

According to the 13th All India Livestock Census of 1982, our country possesses more than 200 million domestic fowls belonging to different species and breeds. The laying stock consists of 82 million birds of which 52 million are hybrids, 10 million cross-bred and 20 million desis. So far we could achieve a production of only 14,200 million eggs and 75 million broilers (Indian Poultry Industry Year Book, 1986). The State of Kerala, is deficient in egg production by 7 lakhs per day according to the census - 1982. We make good this deficit by purchasing eggs from neighbouring States like Tamil Nadu and Andhra Pradesh.

It is of little doubt, that poultry-keeping in India, if conducted on the right lines, can turn to be a pleasant and profitable business. At this moment, when there is acute shortage of food and when the prices of both eggs and poultry manure have rocketted sky-hi_h, a couple of dozen hens will provide sufficient number of eggs to any small household and furnish an occasional chicken for the pot. The family gets

essential nutrition and any surplus food will enhance the family income. Such few hens fed on table scraps and kitchen waste will save the cost of feeds and will be beneficial to the poor farmers who are not able to risk the high cost of installing buildings and equipments.

The contributions of an industry towards the economy of the society depend upon the care and attention given to the various factors affecting it. One such factor often encountered in poultry industry is disease. We have seen that even the best fed, housed and genetically ideal chicken will not grow or lay eggs upto its potential if diseased or infected with parasites. Thus diagnosis, treatment and prevention of diseases are of crucial importance and are subjects of much research and investigation. Parasitic diseases can cause considerable mortality, poor growth rate and production losses in chicken. Hence they should be treated at a younger age so as to avoid further complications.

Considering the various unavoidable circumstances by which birds are exposed to diseases, a detailed study on the biology, pathogenesis and control of one of the most disastrous nematodes of poultry, Syngamus trachea, having its predilection site in the trachea, has been undertaken.

Review of Literature

REVIEW OF LITERATURE

Prevalence of the Infection

Several scientists have recorded the prevalence of the gapeworm, *Syngamus trachea* in a variety of birds. The earliest work regarding syngamiasis in birds, goes back to 1811, in which year, Montagu set up the first record of this species.

In 1921, Ransom reported that turkeys about one year old remained infected with gapeworms for as long as 81 days following infection. He recorded an incidence of 22.5 per cent of *S. trachea* infection in turkeys in and around Washington, D.C. After 16 years, the percentage of infection had reduced to 14.7 as reported by Wehr (1937b). This reduction in infection was attributed to the fact that better methods of rearing turkeys and sanitation were being applied by the poultry keepers. Ransom showed experimentally that younger chicks were more prone to the infection. Clapham (1935b) also agreed that young chicks were highly susceptible to syngamiasis. He detected heavy infection in pheasant chicks reared under hens. He was able to recover three to nine pairs of worms from these infected chicks. Davies (1936) stressed the importance of starlings as distributors of the infection. Clapham (1930) concluded that there were no physiological strains in *S. trachea* because he could establish infections in chicken from a variety of wild birds.

In India, only very limited works have been conducted on the biology of the parasite. Srivastava (1938) was able to recover specimens of *S. trachea* from two chicken at Bareilly with no further investigation. Whitlock (1937) and Clapham (1939c) proved that female birds were more prone to this infection.

Wehr (1939) reported chickens, guinea-fowls and turkeys, as the important hosts of *S. trachea*, and that the domestic pigeon and duck were unsuitable as hosts for the parasite. An investigation conducted by Crawford (1940) concluded that even adult fowls could be easily infected with *S. trachea*. Thuraisingham (1940) was also of the same opinion. Thin... (1941) successfully produced infection in chicken, ducks and goats. Olivier (1943) recorded the infection in adult hens. He recovered 94 pairs of worms from a single bird. In 1949, Stephan recorded the occurrence of *S. trachea* in Natal in South Africa.

In Kerala, the first report on *S. trachea* was of Sundaram *et al.* (1962). Varghese (1966) obtained an average infection of 0.9 per cent on examining the desi birds. He recovered a maximum of three pairs of worms from the trachea of the birds. Barus (1966) revealed that *S. trachea* existed for 92 days in chicken and 126 days in turkeys. According to Enigk and Dey-Hazra (1971), the infection occurred in summer in North-West Germany since the optimum temperature for the development of the eggs was 15°C. A survey conducted in the

Anges areas of Rumania revealed the occurrence of *S. trachea* in goslings (Verdes *et al.*, 1973).

Transmission studies and intermediate hosts

Ortlepp (1923), gave a detailed description on the mode of transmission and infection of *S. trachea* in chicken. He discovered that no intermediate hosts were required for the spread of infection and that infection could be brought about by direct feeding of infective eggs to chicken. But the same author was inclined to the view that under natural conditions more chicken would contact the disease by eating earthworms than by taking in eggs or larvae in contaminated food.

Clapham (1934) suggested that earthworms could play a definite role in the transmission of the infection. He was able to demonstrate that chickens of ten weeks of age were resistant to syngamiasis but when fed on vitamin A and calcium deficient diet, infection could be set up. Morgan and Clapham (1934) stated that they could establish infection in chicks with *S. trachea* by feeding them with infected earthworms, *Eisenia foetida*, thereby transmitting the material from rooks and pheasants to chicken. Only occasional successes could be obtained by the direct feeding of eggs. Clapham (1935a) produced 100 per cent infection in chicken with gapeworms derived from starlings using the earthworm, *E. foetida*. Taylor (1935) established that the gapeworm larvae could remain viable and infective in earthworms for $3\frac{1}{2}$ years. He

also attempted to transmit the infection by means of snails, slugs and flies and emerged successful. Wehr (1937a) made a detailed observation on the development of _S. trachea_ in eggs, earthworms and chicken. He described the developmental stages till the infection became patent. He established that the larvae obtained from infected earthworms were similar in morphology to the third stage or infective stage obtained from the cultures. Taylor (1938) recorded the longevity of the gapeworm in earthworms as 4 to $4\frac{1}{2}$ years and in snails as more than one year.

Clapham (1939a) succeeded in demonstrating a number of dipterous flies as carriers of _S. trachea_. Clapham (1939b) also showed that dipterous flies like _Scolopendra_ species, the leather jacket-Tipula species and _Sminthurus viridis_ were naturally infected with the larvae of _S. trachea_. Rizhikov (1941) successfully completed the life cycle of gapeworm using _Lymnaea stagnalis_. Clapham and Middleton (1948) reviewed the reservoir hosts of _S. trachea_ and its developmental stages. They established that age immunity occurred in birds by 8 to 10 weeks and that turkeys had no natural age immunity. Hwang (1961) established the role of cockroaches as transport hosts. Barus (1967) demonstrated that flies like _Fania canicularis_ and _Paregle cinerella_ also acted as transport hosts. In 1968, the same author declared that the infectivity could be enhanced by passage through earthworms. Bates Jr. (1972) was unsuccessful to produce infection in chicken by

directly feeding them infective eggs. Mosinsh (1973) studied the role of earthworms in the transmission of _S. trachea_. He recovered eight worms per chick fed with earthworms like _Allolobophora caliginosa_ and _Lumbricus terrestris_.

Winward (1976) was able to establish infections of _S. trachea_ by prenatal inoculation of chicken embryo. He sterilized the ova and inoculated the infective material into albumin or into allantoic sac. Some of them entered the trachea and established patency while some were retarded in development. Winward and Russel (1976) attempted parenteral inoculations of the infective material into experimental turkeys. Among the different routes tried, intraperitoneal was found to be the most successful.

Preparasitic and parasitic development and the route of migration

Ortlepp (1923) has given various descriptions regarding the different stages of the parasite as well as its characteristic and the migratory pattern in the hosts. Cultures of ova obtained from the uteri of gapeworms were incubated at room temperature or in an incubator at 22 to 27°C. Ova hatched from the nineth day onwards, the hatching being more at 25°C. He observed that only about half the eggs hatched, some remaining unhatched even after a month's incubation. According to him, the larva moulted only once inside the egg and the second stage larva was the infective stage. The chicks were infected experimentally by direct feeding of infective eggs

or larvae. He was unable to find the larvae anywhere in the body between the intestine and the lungs, but he believed that they penetrated the blood vessel and were carried to the lungs by the blood stream in the way that occurred in some other nematodes. He found out that the larvae reached the lungs within 24 hours. On the third day, the larvae became the third stage and were seen in the lungs. Again moulting took place and at the end of the fourth or during the fifth day, the fourth stage or young adults were found in the lungs. They were found in copulo and by the seventh day, they migrated to the trachea. In the trachea, they reached sexual maturity by 10 to 14 days and passed eggs in the faeces 17 to 20 days after infection.

Wehr (1937a) was of opinion that the larva moulted twice inside the ovum on the fifth and seventh day and started hatching on the 11th day. After experimental infection of chicks with infective eggs or larvae, he found out that the larvae reached the lungs as early as 17 hours. The fourth stage larvae were seen in the lungs from the third day onwards and on the seventh day there were immature worms in copulo in the lungs. On the nineth day, worms in copulo were seen in the trachea also. He established that copulation took place in the lungs between the fifth and seventh day after infection. He was able to recover a few third stage larvae from the liver, indicating migration through the blood stream.

Clapham (1939a) believed that the infective ova of

S. trachea had been hatched by the action of the digestive juices in the small intestine and had found their way to the lungs via blood stream. He was able to recover larvae from the lungs of two chicks that died 16 hours following infection and also from the blood pipetted out of the auricles of heart and from the posterior venacava. He was unable to collect any larvae from the liver. According to Shikhobalova and Rhizhikov (1956), the larvae that hatched out were in the third stage. They further studied that after infection, the larvae reached the liver in two hours, the lungs on the second day, the trachea on the 10th to 12th day and started laying eggs from the 17th to 21st day and continued the laying for $2\frac{1}{2}$ to $3\frac{1}{2}$ months. Barus and Blazek (1965) reported that the infective larvae migrated through the wall of the duodenum to reach the liver and lungs and after 7 to 10 days they moved to the trachea where they developed to the adult stage within 14 to 17 days post-infection. According to Enigk and Dey-Hazra (1971) the migratory route was from the proventriculus to lungs via the liver. Fernando *et al.* (1971) proved that the third stage larvae broke out of capillaries in the inter-lobular connective tissue as early as four hours post-infection and migrated via lung capillaries to the parabronchi. They developed to the adult stage within four to seven days and attached to the tracheal wall by 11 days.

Pathogenesis and clinical signs

According to Clapham (1935b), the initial symptoms manifested by the infected birds included sneezing and coughing followed by gaping. Death was due to an asphyxiation caused by the gapeworms, secretion of mucus and also by the development of nodules resulting in a serious blockage of the trachea. These nodules were small pea-sized, firm in texture and light red in colour. The author also detected red abraded areas with tiny papilla due to the attachment of the parasite in young pheasants.

Regarding the tissue changes, the author described a chronic irritation at the site of attachment of worm in the trachea, wherein the glandular cells produced a watery secretion resulting in the hypertrophy of the submucosa. A thick fibrous layer surrounding the nodule, necrosis, caseation and degeneration of the tracheal cartilage were detected. Marked inflammatory reaction with infiltration of leukocytes was present throughout the whole of the nodule.

Wehr (1937b) examined the tracheas of turkeys and reported that the worms attached to anywhere in the trachea in experimental infection while in natural conditions, lower half of the trachea was the usual site of the parasites. He found that the nodules were caused as a result of the irritation of attachment of the male worms, serving as an anchor for the female worms. He described the nodules as lymphoid in

character. Dissolution of the tracheal cartilage, infiltration of inflammatory cells around the zone of necrosis surrounding the parasite, proliferation of fibrous tissue and desquamation of the epithelial lining were some of the histo-pathological findings noted by the author.

Clapham (1939a), demonstrated that the larvae of S. trachea were responsible for the typical lobar pneumonia in young chicken. He described the affected lung tissue as consolidated, oedematous and echymotic with the respiratory passages filled with an exudate consisting of erythrocytes, leukocytes, some epithelial cells and fibrin. He referred to, this condition, as 'Syngamus pneumonia' and state that the mortality among birds suffering from syngamiasis could also be due to the pulmonary migration of the different stages of larvae.

Zarus and Blasek (1965), suggested that the presence of the worms in the lungs caused haemorrhage, broncho pneumonia and hyperplasia of the pulmonary lymphatic tissue. In the trachea, the worms caused a catarrhal, haemorrhagic tracheitis resulting in a histiocytic granuloma with necrosis and fibrosis around the point of attachment of the worms.

According to Guilford and Herrick (1954), the lungs of most of the affected birds carried pneumonic changes from 6 to 14 days post-infection. The dorsal side of the lungs had dark brown haemorrhagic areas which during the later

stages became cloudy white. The male worms penetrated the tracheal cartilage and were partially embedded in the nodules on the wall of the trachea. Enigk and Dey-Hazra (1971) proved that the parasite caused interstitial emphysema, pneumonia and then hypochromic anaemia during their migration.

The early pulmonary lesions observed were an increase in the number of lymphocytes between the interlobular connective tissue of the parabronchi, cuffing of the larger vessels by lymphocytes, disappearance of the normal structure of the lung capillaries and consolidation of the bronchioles, infiltration of the lamina propria of the secondary and primary bronchi, lysis of the tracheal cartilage and perforation of the tracheal rings by the attachment of the heads of the male worms (Fernando et al., 1971).

Valenza (1975) detected nodular lesions and worms in the trachea of certain birds which were showing respiratory symptoms.

Treatment

Medication trials against the parasite Syngamus trachea, have been conducted by many scientists with different types of drugs. Research is still going on to evolve the most effective treatment measure against syngamiasis.

Mebendazole.

According to Varga (1973) a single oral dose of 100 mg per kg body weight of mebendazole was almost 100 per cent

effective against both migratory larvae and adult parasites in the trachea of the experimentally infected chickens. The expulsion of worms started from the third day after medication. Thienpont et al. (1973) administered the drug to turkeys at the rate of 0.0125 per cent in food for three days, resulting in the removal of all migrating immatures and adult parasites from the host. He gave medicated mash to the infected birds for 14 days as prophylaxis, which also produced significant results. Schricke et al. (1973) showed that 500 ppm of mebendazole in food given for three days followed by 125 ppm for 15 to 21 days in rock pheasants eliminated the infection and improved the condition of the convalescent groups. They recorded no hindrance to the fertility or brooding ability of these birds. Mitterpak and Vasil (1976) controlled the infections of S. trachea in 10 to 12 week old pheasants by giving mebendazole at 120 mg per kg of body weight in food for three days. This medication which was continued for 13 days eliminated all the worms from the trachea within five days after treatment. Natural cases of syngamiasis in farm bred pheasants in Bulgaria were treated using 10 per cent granules of mebendazole at 2 g per kg for three days in feed (Gurliel, 1983).

Thiabendazole.

Leibovitz (1962) reported marked gain in weight of 440 pheasants given 0.05 per cent thiabendazole in feed. According to Norton-Smith et al. (1963), single doses of 0.3 to

1.5 g per kg body weight of thiabendazole removed the fourth stage and immature worms in the lungs and adult worms in the trachea. He showed that the drug at a concentration of 0.1 per cent in the diet was also effective. Euzeby and Gevrey (1963) were not able to produce positive results with thiabendazole. In the treatment trial carried on by McGregor (1963), he established that thiabendazole given at the rate of 2 g per gallon of drinking water for four days and at the rate of 3 g per gallon for 14 days was ineffective, but the same when given at 0.05 per cent in feed for 10 to 16 days produced parasite-free pheasants within four days. Fardell (1964) treated a pet-raven infected with S. trachea with 1 g of thiabendazole for 10 days. A detailed trial was done by Wehr (1964) in turkeys with the drug. He gave 0.1 per cent of the drug in the mash to one group of birds on the same day in which they were infected and to the other groups on the 2nd, 3rd, 6th, 9th, 12th and 15th day post-infection. Unmedicated control birds were maintained in all these tests. An overall efficacy of 98.17 per cent for thiabendazole against S. trachea, was demonstrated after necropsy and recovery of worms. The same author in 1967, treated pheasants with thiabendazole in mash and obtained a high percentage of efficacy. Wehr and Hwang (1967), found that this drug was effective when it was administered on day 1 or on day 30 post-infection. Administering 5 ml of 0.05 per cent thiabendazole suspension orally and 0.05 per cent in feed to

four-week old infected chicken, Grafner (1967) failed to reduce the infection. Ward et al. (1960) studied the efficacy of thiabendazole at different doses in pheasants. Doses of 0.05, 0.025, 0.005 and 0.0005 per cent were added to feed. It was concluded that the drug at 0.05 per cent would suppress the egg laying capacity of the female parasites. Death of a few birds occurred due to occlusion of the trachea by the parasites. Blanchard and St. Jacques (1979) successfully treated 3000 pheasants with 1 per cent thiabendazole in feed. Fabiyi and Offiong (1979) reported an outbreak of syngamiasis in 240 guinea-fowls in Nigeria and ascribed it to increased earthworm activity after heavy rainfalls. The same authors could reduce the infection using 0.1 per cent thiabendazole in feed for five consecutive days.

Albendazole.

The efficacy of albendazole against nematodes, trematodes and cestodes has been widely studied by several scientists. So far none appears to have studied its efficacy against *S. trachea*. But the drug is known to be very effective against lungworms of cattle, sheep and goats and dogs and lung flukes of dogs and cats.

Theodorides et al. (1976) recommended a dose rate of 10 mg per kg body weight of the drug for the complete removal of *Dictyocaulus filaria* in sheep.

In 1978, Bone and Ernest obtained an efficacy of

96.4 per cent in calves experimentally infected with 4,000 third stage infective larvae of D. viviparus and then treated with 7.5 mg per kg body weight of albendazole paste-formulation orally. Downey (1978) concluded that 7.5 mg per kg body weight of albendazole was effective against Ostertagia sp. and Dictyocaulus sp. in naturally infected calves. Georgi et al. (1978) found out that lungworm Filaroides hirthi in dogs could be killed by an oral dosing of 25 to 50 mg per kg body weight of albendazole given twice daily for five days. Todd et al. (1978) was able to eliminate the cysts of Paragonimus sp. in the lungs of dogs 30 days after treatment with albendazole at the rate of 30 mg per kg body weight. Paragonimus kellicotti ova were not to be seen in the faeces 23 days later.

Schalkwyk et al. (1979) stated that albendazole at 2.5 mg per kg body weight was 99 per cent effective against adult stages of Dictyocaulus sp. and at 3.8 mg per kg, 99.3 per cent effective against its immature stages in sheep.

Cordero-del-Campillo et al. (1980) reported that albendazole at 5 mg per kg body weight reduced the number of protostrongylid parasites in the lungs by 89 per cent after 35 to 49 days and considerably reduced the egg output in the faeces after 20 days in sheep.

Hoskins et al. (1981) studied the clinical effectiveness of albendazole at 50 mg per kg body weight against pulmonary

paragonimiasis in cats. The ova disappeared from the faeces in 11 to 20 days after the treatment.

In 1982, Erb and Georgi recommended a dose of 25 mg per kg body weight twice daily for five days for puppies suffering from Filaroides hirthi infections. Romaniuk and Lipinski (1982) reported that albendazole at 5 mg per kg body weight was effective against D. filaria in cattle by 92 to 100 per cent after 30 to 60 days of treatment.

Foreyt et al. (1983) incorporated the drug in feed pellets at the concentration of 0.029 per cent (4 mg per kg body weight daily) for four consecutive days to sheep. Considerable reduction was obtained in the number of protostrongylus larvae in the dung one to two months after the medication. Reitsma (1983) treated four ponies which had coughing symptoms due to Dictyocaulus arnfieldi infection with 25 mg per kg body weight of albendazole twice daily for five days. One of these ponies had not responded to cambendazole treatment. Satisfactory results were obtained after albendazole treatment.

Romaniuk (1984) reported that Valbazen (albendazole) given as a 5 mg per kg body weight orally to sheep effectively reduced Moniezia, coccidia, intestinal and pulmonary nematodes within 60 to 120 days after the administration of the drug.

Dorchies et al. (1986) supplemented 0.16 g of albendazole in 20 kg feed blocks to be fed to sheep. The animals consumed

42 to 46 g of block daily, equivalent to 0.66 to 0.73 mg of albendazole per kg body weight over 10 to 15 days. They concluded that this medication suppressed protostrongylus infection for two months. Helle (1986) reported that daily administration of albendazole for two weeks at the rate of 1 mg per kg was effective against Muellerius capillaris in goats.

Albendazole has also been used in fowls. Han et al. (1982) reported that a dose of 5 to 10 mg per kg body weight in feed was 100 per cent effective against the gastrointestinal parasites of poultry. Manuel and Gale (1983) were able to eliminate Oxyspirura mansoni, Raillietina, Ascaridia and Heterakis only by increasing the dose of albendazole upto 45 mg per kg.

Ivermectin.

Avermectins are a new family of antiparasitic drugs produced as a fermentation metabolite of the recently discovered actinomycete, Streptomyces avermitilis. This drug is a chemically modified derivative known as 22,23-dihydro avermectin B_1 and has been found to be very efficacious in treating gastro-intestinal and pulmonary nematodes and ectoparasites.

In 1980, Armour et al. carried trials on 24 cross-bred calves and found out that ivermectin was 100 per cent effective against gastro-intestinal nematodes at the dose rate of

100 micrograms per kg body weight orally and 200 micrograms per kg body weight subcutaneously.

Egerton *et al.* (1981) evaluated the efficacy of ivermectin in cattle against gastro-intestinal and lung worms. They found out that there was a 95 to 99 per cent efficacy both by oral and parenteral routes at the rate of 0.1 to 0.2 mg per kg body weight. Lyons *et al.* (1981) injected a single dose of 200 micrograms per kg ivermectin subcutaneously to 12 dairy calves. At post-mortem, seven days later none of the lung worms were recovered from these treated calves.

According to Leaning (1984), ivermectin given subcutaneously was very effective against adult and immature gastro-intestinal nematodes and 100 per cent effective against *D. viviparus* at 200 micrograms per kg body weight. It also removed lice and mites within two weeks after the treatment.

Armour *et al.* (1985) studied about the persistent and stronger activity of ivermectin against lung worms than against the stomach worms. The drug was administered at 200 micrograms per kg body weight subcutaneously. The authors established that the lung worms were the most sensitive, followed by *Ostertagia ostertagi* and then *Cooperia oncophora* to ivermectin. Evinger *et al.* (1985) successfully treated a dog suffering from nasal capillariasis with ivermectin at the dose rate of 0.2 mg per kg body weight. Gregory *et al.* (1985) evaluated the efficacy of the drug along with fenbendazole

against *H. capillaris* in goats. Fenbendazole at 30 mg per kg body weight and ivermectin at 0.2 mg per kg body weight orally produced a reduction of 97 per cent and 98 per cent respectively of the worm. Lyons *et al.* (1985) succeeded in eliminating *Dictyocaulus arnfieldi* and *Trichostrongylus axei* in equines by administering ivermectin at 200 micrograms per kg body weight intramuscularly and orally. Taylor *et al.* (1985) came out with the result that ivermectin could suppress the development of *Ostertagia* sp. for 103 days and that of *Dictyocaulus viviparus* for 119 days. It caused a reduction of 98.7 per cent in the former case and 97.4 per cent in the latter case. These results showed that a few years of continuous suppression with ivermectin would help to remove lung worm infections from fields. Wescott *et al.* (1985) established that ivermectin injectable at 200 micrograms per kg and ivermectin paste at 0.2 mg per kg body weight was 100 per cent effective against the cyathostomes in equines. The production of ova was suppressed by the drug for atleast eight weeks.

In 1986, Borgsteede and Hendriks studied the residual effect of the drug against experimental re-infection with nematodes in calves. Based on post-mortem worm counts, he concluded that the efficacy of ivermectin after the primary infection was 99.7 per cent against *Ostertagia* sp. and 95.1 per cent against *Cooperia* sp. and 100 per cent against *Dictyocaulus* sp. The residual effect remained for one week.

Mousa *et al.* (1986) used ivermectin against ascaridiasis in chicken at 100, 200 and 400 micrograms per kg body weight as a single dose. He found out that the drug was ineffective against the larval stages in the tissues and effective against mature worms (95-100 per cent). Poupland *et al.* (1986) recommended ivermectin at the dose rate of 200 micrograms per kg body weight against immature *D. viviparus* in cattle as he found it more effective than levamisole given at 30 mg per kg. Santiago *et al.* (1986) found out that both oral and injectable formulation of ivermectin at 200 micrograms per kg body weight were 100 per cent effective against the benzimidazole resistant *Haemonchus contortus* in goats. Taylor *et al.* (1986) compared vaccination with treatment against Dictyocauliasis in cattle and concluded that ivermectin if injected thrice subcutaneously produced cent per cent recovery from lung worms and was far superior than vaccination.

Effect of irradiation on the development of *Syngamus trachea*

Shikhobalova (1956) reported that a partial immunity developed in chicks following repeated infections with *Syngamus trachea*, indicated by the smaller size and lesser number of worms developing out of the subsequent infection and also by the passing out of immature worms.

Varga (1964) studied the parasitic development of *S. trachea* larvae irradiated at different doses ranging from 1 to 8 kR and found that when the dose of irradiation was low,

they developed to the adult stage but produced only very few fertile eggs. When the dose of irradiation was high, they neither produced eggs nor copulated at all. According to him a dose of 4 to 5 kR was the suitable level of irradiation for immunization purposes.

Varga (1965) got a reduction of 72 to 100 per cent of worms developing in chicks, immunized with larvae irradiated at 5 kR and then challenged with non-irradiated larvae, in comparison with those recovered from controls. Varga (1966) reported that chicks could be effectively immunized when they were very young, preferably 1 to 4 days old.

According to Ziegler (1966) 20 kR of X'rays was needed to produce the most effective challenge in chicken. Ziegler et al. in 1973/74 concluded that double vaccination was more effective than single vaccination. In four of his experiments, single doses were given orally by tube and in the fifth, two doses, 12 days apart were given in feed to the birds. They were challenged 10 to 13 days later. The results proved that double vaccination was 99 per cent effective and single vaccination was only 70 per cent effective.

Materials and Methods

MATERIALS AND METHODS

Collection of data on the prevalence of *Syngamus trachea* in chicken

Data on the prevalence of *Syngamus trachea* in chicken of different breeds and age-groups were collected from the birds brought to various Veterinary Hospitals in Trichur and Ernakulam for treatment and vaccination. Such data were also collected from birds brought for slaughter to the slaughter house at Kaloor and from birds purchased locally from the owners. The study extended over a period of 12 months from October, 1985 to September, 1986 during when 1351 birds were examined. Details such as breed, age and locality from where the birds had been brought were noted wherever possible. Seasonal occurrence and the intensity of the infection were also noted.

Examination of infected birds

Infected birds brought to hospitals were examined with care and attention for the presence of worm infection and to observe the symptoms. The infection was diagnosed either by finding the worms on direct examination of the trachea or by finding the ova on microscopical examination of the droppings and from the symptoms manifested by the birds. Birds showing respiratory distress and the characteristic symptoms of gape were picked up from the flock for closer examination of the trachea. The bird was held firmly in one

hand and the beak was opened wide with two fingers. The head was held up, keeping the neck extended and the mouth was directed against sunlight.

The droppings of the birds were examined for ova of *S. trachea* by centrifugal sedimentation method.

Collection of worms

Infected birds were allowed to die naturally or destroyed by severing the jugular vein. The trachea was dissected out and incised taking care not to damage the worms. After exposing the trachea, the head of the male worm anchored to the wall of the trachea was gently dislodged. The worms were transferred by means of a fine brush to a Petri-dish containing normal saline.

Harvesting of eggs for making cultures

Ova were obtained from the uteri of gravid females after dissection of the worm on a glass slide under a binocular dissection microscope. The ova released were then washed into Petri-dishes avoiding debris and blood.

Maintenance of egg cultures

Filtered aquarium water or well water was used as the medium for egg cultures. Eggs harvested from gravid females were transferred into a medium sized Petri-dish filled to one-fourth of its capacity with filtered water. The container was then covered by a larger Petri-dish, keeping inverted

over it. The cultures were cleaned regularly by carefully pipetting out the supernatant fluid and adding fresh media. Aeration of the cultures was done by pumping air into the cultures using a pipette. Cultures were maintained at room temperature.

Study of cultures

Cultures were examined under a binocular dissection microscope once daily in the morning hours for the first five days and then in the morning and evening hours until the first larva hatched out. The hatching time was noted. The larva was pipetted out and examined under a light microscope to study its characters.

Experimental infection

Day-old White Leghorn chicks obtained from the University Poultry Farm, Mannuthy constituted the experimental birds for infection experiments. Whenever chicks were not available in the farms, day-old Samrat Broiler chicks purchased from M/s. Tons Hatcheries, Vellanikkara were made use of. Day-old desi chicks purchased locally were also used. A total of 102 birds were used for the entire infection experiments.

These chicks were housed in wooden boxes provided with necessary light and litter for the first two months. Later they were transferred to experimental cages specially fabricated for the purpose. The chicks were fed in the beginning

with chick starter mash and later with grower mash. Clean water was provided ad libitum.

Cultures of 12 to 30 days old were found to be infective. By repeated experiments using different doses of eggs or larvae ranging from 300 to 10,000, 3000 eggs or larvae was found to be the optimum dose required to set up infection in chicks without causing early mortality. On the day of infection, all the viable cultures were pooled together and the volume of the pooled culture was measured in a measuring cylinder. To determine the total number of infective ova or larvae present in the pooled material, 0.1 cc of the material was pipetted out after thorough agitation and the number of the infective ova or larvae present in that aliquote was counted under a microscope. This process was repeated thrice. From these counts, the average was taken and then the total number of ova or larvae in the pooled sample was calculated. Then the volume of the material required to contain 3000 ova or larvae was determined and the same was pipetted out after proper agitation into separate test-tubes. The tubes were centrifuged at 1000 rpm for one minute. The supernatant fluid was decanted leaving behind only a small quantity of the fluid and the sediment at the bottom. The entire fluid with the sediment was then administered to each chick directly into the crop by means of a fine and long pipette. To ensure that all the ova or larvae had been administered, the test-tube was rinsed with a small quantity of water, which was also administered.

Study of worms

The birds given experimental infection were sacrificed at regular weekly intervals to study the stage to stage development of the parasite. The entire viscera was thoroughly examined for any worm or lesion giving more attention to the lungs, bronchi and trachea. These tissues were placed in warm normal saline. The lung tissue was teased with a mounted needle while the bronchi and trachea were cut open with small fine scissors. Worms, both mature and immature, if present, were picked up and transferred into a Petri-dish containing normal saline, to remove the mucus and debris. They were subjected to microscopical examination for a detailed study. The immature worms were studied either live after mounting in normal saline solution or, after killing and clearing in lactophenol. The mature worms were studied after making either temporary mounts in carbolic acid or permanent mounts in Canada balsam.

Measurements.

The eggs, larvae and adult worms were measured using a calibrated microscope. In all cases, not less than 25 specimens were measured and the mean was calculated.

Drawings.

All diagrams were drawn using a Camera lucida.

Photomicrographs.

Photomicrographs of fresh larvae and worms were taken.

Preservation.

For further studies, the larvae obtained were preserved in 2 per cent warm formalin and the adult worms in 10 per cent formalin.

Determination of prepatent period

The prepatent period of the parasite was determined by conducting faecal examination daily from the 14th day of infection till the first eggs were seen in the faeces.

Study of clinical signs and pathogenesis

Clinical signs were studied by closely observing the symptoms exhibited by the birds which were suffering from the infection.

The gross pathology of the affected trachea and lungs was recorded during the post-mortem examination. Tissues carrying suitable lesions were cut and washed in tap water. Some of them were fixed in 10 per cent formalin for a deeper examination. They were processed in the usual manner and sections ranging from five to eight microns were prepared. The sections were stained with Haematoxylin and Eosin and examined to find out the various pathological changes.

Assessment of the efficacy of anthelmintics

The comparative efficacy of three anthelmintics viz., mebendazole, thiabendazole and albendazole given at the rate of 40 mg per kg body weight, 500 mg per kg body weight and

15 mg per kg body weight respectively against syngamiasis in chicken was assessed in the following way.

Forty birds experimentally infected with _S. trachea_ formed the experimental birds for the trial. These birds were divided into four groups of ten each, out of which three groups were medicated with anthelmintics and they formed the medicated test groups while the remaining one group formed the non-medicated positive control group. The intensity of infection was determined by taking faecal egg counts. The arrangement of groups was carried out in such a way that the average egg per gram of all groups was almost identical. The anthelmintics were administered to each bird individually per os by means of a long and fine pipette, after diluting with water in appropriate doses computed on the basis of body weight of each bird. The test groups and control group were maintained separately under identical conditions. The efficacy of the drug was assessed based on the following three parameters.

Egg per gram counts.

The individual faecal egg counts of all the birds were determined for five days before and five days after medication. Then the group average was calculated. The reduction in the egg counts in the test groups was arrived at by substracting the mean post-medication count of the group from the mean pre-medication count of the same group. Then the reduction percentage was worked out. The value thus obtained

was compared with that obtained for the control group and thus the comparative efficacy of each anthelmintic was determined.

<u>Worm counts.</u>

Seven days after medication all the birds in the test groups and control group were sacrificed and a thorough post-mortem recovery of worms was carried out. By substracting the average number of worms present in a test group from that of the control group, the number of worms eliminated by medication from that group was determined. The percentage of elimination was calculated and that represented the percentage of efficacy of the anthelmintic.

<u>Weight gain.</u>

The mean weight gain of a test group for the period of experiment was calculated by reducing the mean pre-medication weight of the group from the mean post-medication weight of the same group. This figure was then compared with the similarly calculated mean weight gain of the control group. Thus the influence of the drug on the body weight gain of the chicks was assessed.

Experimental trials with the drug, Ivermectin were conducted in another flock of chicks consisting of 12 birds. Its efficacy was also assessed on the above lines.

Effect of irradiation on the development of *S. trachea*

Day-old White Leghorn chicks, 24 in number were made use

of as experimental birds for this study. The experiment was conducted twice. During each time, the birds were divided into a test group and a control group, each having equal number of chicks. The chicks in the test group were administered 3000 infective ova or larvae irradiated at 5 kR in a cobalt chamber while those in the control group were given the same dose of non-irradiated material. Both groups were maintained under identical conditions. Whenever there were casualties, post-mortem was conducted and a thorough search was made for the developmental stages of the worm. After completion of the prepatent period of the worm, all the birds were sacrificed and a detailed search for the worms was done. From the results obtained, the effect of irradiation was determined.

Results

RESULTS

Prevalence of Syngamus trachea in chicken

The prevalence of Syngamus trachea had a direct bearing on the season, age of the bird and the type of management under which they were reared.

Season: There are two seasons in Kerala - summer or dry season from December to May and rainy season from June to November. During summer the atmospheric temperature may go upto 36°C in certain districts of the State. The average annual rainfall from the South-west and North-east monsoons has been recorded to be 150-170 cm. Out of 1351 chickens examined, over a period of 12 months from October 1985 to September 1986, for the presence of S. trachea infection, 73 birds were found to be positive with an average of 5.4 per cent. Regarding the season-war incidence, it was less in summer (0 to 4 per cent) and more in rainy season (2 to 14.7 per cent) (Table 1).

Age: The infection was found to be more prevalent among young birds of 1 to 2 months of age, their percentage being 76.71 (Table 2).

Management: The infection was observed to be more among birds under back-yard system of management than those under deep litter system of management. A percentage of 6.59 (Table 3) of the infected birds were reared under the back-yard system.

Table 1. Month-war occurrence of S. trachea infection in chicken

Month	Number of birds examined	Number of birds infected	Number of worms obtained from the trachea (pairs)	Percentage of infection
1985 October	80	2	3 each	2.5
November	50	1	10	2
December	50	2	2 and 4	4
1986 January	50	2	4 and 36	4
February	50	0	0	0
March	250	6	2-3	2.4
April	105	2	3 and 7	1.9
May	75	3	2-4	4
June	200	4	2-6	2
July	136	20	2-94	14.7
August	205	18	2-58	8.78
September	100	13	2-26	13
Total	1351	73	2-94	5.4

Table 2. Percentage of infected birds below 1-2 months of age

Number of birds found infected	Number of infected birds below 1-2 months of age	Percentage
73	56	76.71

Table 3. Percentage of infected birds reared under the back-yard and deep litter system of rearing

	Back-yard system	Deep litter system	Total
Number of birds examined	940	411	1,351
Number of birds found infected	62	11	73
Percentage	6.59	2.67	5.4

Site of attachment of worms

The birds when examined for the presence of worms, the latter were found attached to anywhere in the trachea. Some were seen at the anterior part while majority of the worms were found deep inside the trachea.

Description of eggs

The eggs were round to oval, thin-shelled, medium-sized with segmenting embryo, operculate at both poles, one of the opercula being indistinct. They measured 0.070 mm to 0.084 mm with an average of 0.077 mm in length and 0.042 mm to 0.046 mm with an average of 0.044 mm in breadth (Plate I, Figs. 1 and 2 and Plate II, Fig. 1).

Development of eggs

Cultures with mature eggs kept in aquarium water at room temperature (27 to 28°C) alone developed. Immature eggs, medium other than the aquarium water and high temperatures, did not give good cultures. Cultures kept in certain months viz., March, April and May showed disintegration and degeneration of eggs. Normally the eggs undergo a series of changes during culturing. These changes are noted in Table 4.

The developing ova measured 0.070 to 0.083 mm with an average of 0.077 mm in length and 0.028 to 0.056 mm with an average of 0.042 mm in breadth (Plate I, Fig.3 and Plate II, Fig.2). The ova with well developed larvae inside, also measured similarly (Plate I, Fig.4 and Plate II, Fig.3).

Table 4. Cultural changes of ova of *S. trachea*

Day	Changes taking place
0	No change
1	Embryonic segmentations became distinct
2	Segmentation gradually disappeared and a dark tinge appeared
2-3	Embryonic cells organised to form a hazy larva. A diffuse dark material was also present
4-6	Larva became more and more distinct
7	Larva was fully formed and started hatching

The ova in cultures kept at room temperature in the present laboratory conditions started hatching from the seventh day onwards. Exceptionally certain cultures showed hatching even on the third day. Hatching of the ova took place by gradual dissolution of the cap at one of the poles and the larvae emerged out with its tail first (Plate III, Fig. 1).

The newly hatched out larvae were ensheathed, the sheath being clear at the tail end. Some of them would be seen lying simply coiled while some would be moving sluggishly at the bottom of the Petri-dishes. The dead ones floated on top of the medium. The larvae were found to remain viable as long as one month from the day of setting up cultures.

Experimental infection

To find out a satisfactory dose of infective material to set up infection without causing early death of the chicks, the latter were administered with different doses of infective material starting from 300 to 10,000 infective ova or larvae. A dose of 3,000 ova or larvae was found to be satisfactory. Higher doses caused mortality in chicks one week after infection. Laboured breathing, off-feed, isolation, prostration with one leg extended were some of the clinical manifestations observed before death.

The number of larvae established after the experimental infection was more or less directly proportional to the dose

of the infective material. When the dose of the infective material was 10,000 the number of larvae obtained from the lungs and trachea was 100 to 300. For a dose of 8,000 it was 100 to 200, for 5,000 it was 7 to 120 and for 3,000 it was 0 to 40.

With a standard dose of 3,000 ova or larvae, it was possible to sacrifice the chicks at weekly intervals to study the developmental stages. The development was not uniform for all the larvae. Some of them developed fast while some were very slow to develop. Hence different developmental stages of the larvae were recovered from the same situations at the same time. To cite an example, on the sixth day of infection, third stage, fourth stage, fifth stage and young copulating forms were noticed simultaneously in the lungs. For more details, refer table 8.

Description of larvae and adults

<u>Third stage larva</u> (Plate IV, Figs.1 and 2 and Plate V, Fig.1).

The third stage larvae were eel-like organisms, ensheathed, the sheath being distinct at the tail end and wrinkled at certain other points. They remained at the bottom of the Petri-dish and moved very sluggishly.

The larva had an average length of 435.75 microns and an average width of 17.5 microns. Buccal capsule was small and indistinct with an average depth and width of 5.25 microns. Pharynx was also indistinct and 10.5 microns long. Oesophagus

Table 5. Various developmental stages of *S. trachea* obtained from lungs and trachea on different days of infection

Day	Stages of development of larvae obtained	
	Lungs	Trachea
1	Nil	Nil
2	Third stage	"
3	Third stage	"
4	Third stage	"
5	Third stage and moulting forms	"
6	Third and fourth stages and moulting forms	"
7	Third, fourth and fifth stages and young worms in copulation	"
8	Fourth and fifth stages and young copulating forms	Immature worms as single and in pairs
9	Juveniles as single and in pairs	"
13-15	Juveniles (few)	Juveniles in copulo only

was tubular and had an average length of 108.5 microns carrying a small slight bulb posteriorly. It measured nearly one-fourth of the total length of the body. The brain was well demarcated, encircling the oesophagus at an average distance of 64.75 microns from the anterior end. The genital primordium appeared spindle or lens shaped with two or three cells at an average distance of 175.0 microns from the anterior end (Plate IV, Fig.3 and Plate V, Fig. 2). The intestine measuring an average length of 203.5 microns was filled with blood and refractile globules. Rectal tube, being 38.5 microns long ended in the anal opening. Tail had an average length of 31.5 microns and its tip was pointed in females and blunt in males (Table 6).

Fourth stage larva.

Male: (Plate VI, Figs.1 and 2 and Plate VII, Figs.1 and 2): These larvae obtained from the lungs from day 5 post-infection were slender with vigorous movements. It had a maximum length of 1098.1 microns and a minimum of 903.5 microns with an average width of 55.6 microns. The buccal capsule was thick walled, the shape being oval to conical. It was 105 to 17.5 microns deep and 10.5 to 21 microns wide. Oesophagus was slightly bulbous with an average length of 197.75 microns. The brain was very distinct and it was situated in the middle of the oesophagus at an average distance of 96.25 microns from the oral end. Intestine had a maximum length of 820.1 microns and a minimum of 681.1 microns. It measured almost

three-quarters of the total length and was filled with food and refractile globules. It ended in the anus before which it formed a spike-like canal which was the rectal tube measuring a length of 64.75 microns. Bursal rays were found posteriorly but not quite prominent. Tail was blunt or truncated with a short pointed tip and was 59.5 to 63.0 microns long.

Female (Plate VIII, Figs.1, 2 and 3 and Plate IX, Figs. 1, 2 and 3): The female larvae were similar to the males except for the long and slender posterior extremity. These larvae measured a length of 863.50 microns and a width of 55.6 microns in average. Buccal capsule was thick walled and cylindrical in shape possessing an average depth of 10.3 microns and an average width of 12.4 microns. Oesophagus with a slight swelling at the posterior end measured a length ranging from 192.4 to 199.5 microns. The brain was situated at a distance of 92.5 to 122.5 microns from the anterior end and was distinct. Intestine measuring an average of 600.23 microns in length was filled with blood. Vulva appeared as a prominence at the end of the first third of the body. It was situated at an average distance of 526.33 microns from the oral end. The intestine ended in the rectum which opened out through the anus. The tail was 77.0 to 85.1 microns long with a pointed tip (Table 6).

Fifth stage larva (Juvenile).

The fifth stage larvae developed in the lungs on the

seventh day after the administration of the infective material.

Male (Plate X, Figs.1 and 2 and Plate XI, Figs.1 and 2): The males measured a length ranging from 0.84 mm to 1.1 mm with an average of 0.98 mm. The body thickness was 41.7 microns in average. The buccal capsule, being quite large, thick walled and conical in shape measured 17.5 to 22 microns in depth and 14 to 18.5 microns in width. The oesophagus had a posterior swelling and was 157.5 to 210 microns long. The brain was well-defined and was situated 92 to 112 microns away from the anterior end. Intestine filled with dark granules was 525 to 764.5 microns long. Spicules could be seen clearly. They were broad and divergent anteriorly but fused posteriorly and were more or less equal in size. They measured an average length of 56 microns. Bursal rays could be seen clearly and were 28 to 31.5 microns in length engulfing the vulval projection of the female with which it was in copulation.

Female (Plate X, Figs.3 and 4 and Plate XII, Figs.1 and 2): The female worms were much stouter and larger than the males. They measured a length of 1.81 to 1.96 mm which was almost twice the length of the males. The width of the body was in the range of 55.6 to 69.5 microns. The buccal capsule was 31.5 to 41.7 microns deep and 31.5 to 55.6 microns broad with three pairs of teeth at its base. The oesophagus had a posterior bulb and was 0.25 to 0.26 mm long. The brain was

Table 6. Measurements of the different stages of larvae of *S. trachea* (in microns)

Particulars		Third stage larva			Fourth stage larva (male)			Fourth stage larva (female)			Fifth stage larva (male)			Fifth stage larva (female)		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Body	Length	206.5	665.0	435.75	903.5	1098.1	1000.8	620.6	1107.1	863.58	840.0	1112.0	976.0	1807.0	1959.9	1883.45
	Breadth	10.5	24.5	17.5	55.6	55.6	55.6	24.5	31.5	28.0	42.0	87 5	64.75	55 6	69 5	62.55
Buccal capsule	Width	3.5	7.0	5.25	10.5	21.0	15.75	10 1	14.8	12.4	14.0	18.5	16.2	31.5	55 6	43.55
	Depth	3.5	7.0	5.25	10 5	17.5	14.0	10.1	10.5	10.3	17.5	22.2	19.85	31.5	41.7	36.6
Pharynx (length)		10.5	10.5	10.5	-	-	-	-	-	-	-	-	-	-	-	-
Oesophagus (length)		77.0	140.0	108.5	192.5	203.0	197.75	192.4	199.5	195.95	157.5	210.0	183.75	250.20	264.1	257.15
Brain (from the anterior end)		42.0	87.5	64.75	87.5	105.0	96.25	92.5	122.5	107.5	92.0	112.0	102.0	180.7	556.0	368.35
Genital primordium (from the anterior end)		140.0	210.0	175.0	-	-	-	-	-	-	-	-	-	-	-	-
Vulva (from the anterior end)		-	-	-	-	-	-	432.6	620 06	526.33	-	-	-	708.9	834.0	771.45
Intestine (length)		112.0	455.0	283.5	681.1	820.0	750 55	540.36	820 1	680.23	525.0	764.5	644.75	1453.4	1584.6	1519.0
Rectal tube (length)		35.0	42.0	38.5	49.0	80.5	64.75	37.8	37.8	37.8	59.5	63.0	61.25	59.5	69.5	64.5
Anus (from the anterior end)		199.5	609.0	404.25	844.0	1035.1	939.55	543.06	1022.0	782.53	770.0	1042.0	906 0	1709.7	1862.6	1786.15
Tail (length)		7.0	56.0	31.5	59.5	63.0	61.25	77.0	85.1	81.05	70.0	70.0	70.0	97.3	97.3	97 3
Spicules (length)		-	-	-	-	-	-	-	-	-	42.0	70.0	56.0	-	-	-
Bursal rays (length)		-	-	-	-	-	-	-	-	-	28.0	31.5	29.5	-	-	-

situated at an average distance of 0.37 mm from the oral end at about the middle of the oesophagus. The intestine was long and tortuous, measuring 1.45 to 1.58 mm long which would come to three-quarters of the total length. The vulva, visible as a clear prominence was located at a little below the middle of the body 0.71 to 0.83 mm away from the anterior extremity. From this, it was concluded that the males were attached to the females just below the middle of the females. The rectal canal was spike-like and measured a length of 35 microns. The tail was short and pointed and 97.3 microns long (Table 6).

Pairing of worms (Plate XIII, Fig.1).

It has been observed that copulation occurred in the lungs itself after the seventh day of infection. The worms in pairs, when separated similated in measurements and descriptions of the fifth stage male and female. Non-copulating forms were recovered from the lungs as well as from the trachea after the seventh day. This suggested that copulation of worms could occur in the lungs and also after reaching the trachea. By the nineth day of infection, copulation of worms would be over and only a very few non-pairing forms were obtained from the lungs thereafter.

The copulated pairs obtained from the lungs and trachea were more or less of the same size and characters. The male-female length was in the ratio of 1:1.51 to 1:1.66.

That means the males were nearly two-third of the length of the females. The buccal capsule was deep and voluminous like a semicircular container, the wall being thick and with three pairs of teeth inside. The oesophagus had a small swelling posteriorly, and was of one-tenth of the body length in females and one-fifth in males. The intestine was very long and its cells were filled with dark granules. It occupied 80 per cent of the total length of the female worm and 70 per cent of that of the male worm. Vulva was situated just above the middle of the body. The bursa of the males had well developed bursal rays fixed into the vulval flap in the form of a cone. The uterine coils were seen twisted around the intestine. The tail was long and pointed. The male-female attachment occurred at two-fifth of the total body length of the female.

Immature worms (13 days old).

These were obtained from the trachea and were different from those obtained earlier.

Male: The males were 1.5 mm long with an anterior sheath of 13.9 microns. The buccal capsule was large and semicircular, 55.6 microns deep and 97.3 microns wide. The oesophagus was very prominent with a well defined posterior swelling and was 347.5 microns long. It reached upto nearly one-fifth of the total length. Brain was 250.2 microns away from the anterior end and at about the middle of the

oesophagus. The intestine was 973 microns long and filled with blood. The bursa was fixed into the vulval flap. It was 69.5 microns long. Rays were clearly visible but difficult to identify.

Female: They were large and stout and measured an average length of 3.06 mm possessing cuticular projections both at the anterior and posterior extremities. The anterior cuticle was 41.7 microns long. The buccal capsule was thick walled voluminous and semicircular in shape with a depth of 83.4 microns and a width of 125.1 microns. The oesophagus was 0.38 mm long and was only one-tenth of the total body length. It was bulbous distally. The brain was at 305.8 microns away from the anterior end encircling the oesophagus. The intestine being 2.1 mm long extending to more than half the length of the worm, was filled with blood. The vulva was at a distance of 695 microns from the oral end and this distance was one-fifth of the total body length. The tail was 139 microns long with a spike-like pointed tip. The tail sheath was 111.2 microns long (Table 7).

The length ratio of the male and female was 1:2.1. The male was attached to the female at about one-fifth of the body of the latter.

Immature worms (15 days old) (Plate XIV, Figs. 1,2,3,4 and 5).

Male: The males measured about 2.5 to 2.52 mm in length and was with an anterior cuticle of 41.7 microns. The buccal

Table 7. Measurements of the immature worms (in microns)

Particulars	13 days old worm						15 days old worm					
	Male			Female			Male			Female		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Length	1.4 mm	1.6 mm	1.5 mm	3.06 mm	3.06 mm	3.06 mm	2.5 mm	2.52 mm	2.51 mm	4.1 mm	7.3 mm	5.7 mm
Breadth	220.0	220.0	220.0	305.0	305.0	305.0	275.0	275.0	275.0	475.0	475.0	475.0
Buccal capsule – Width	97.3	97.3	97.3	125.1	125.1	125.1	194.6	194.6	194.6	208.5	208.5	208.5
Buccal capsule – Depth	55.6	55.6	55.6	83.4	83.4	83.4	83.4	208.5	145.95	152.9	222.4	187.7
Oesophagus	347.5	347.5	347.5	375.3	375.3	375.3	417.0	472.6	444.8	417.0	444.8	430.9
Brain (from the anterior end)	250.2	250.2	250.2	305.8	305.8	305.8	305.8	347.5	326.65	278	417	347.5
Intestine (Length)	973.0	973.0	973.0	2.09 mm	2.09 mm	2.09 mm	1.81 mm	1.96 mm	1.89 mm	3.1 mm	5.5 mm	4.3 mm
Rectal tube	-	-	-	-	-	-	166.8	166.8	166.8	139.0	208.5	173.5
Bursal rays	69.5	69.5	69.5	-	-	-	139.0	139.0	139.0	-	-	-
Vulva (from the anterior end)	-	-	-	695.0	695.0	695.0	-	-	-	1.1 mm	1.4 mm	1.25 mm
Tail (length)	-	-	-	139.0	139.0	139.0	-	-	-	236.3	333.6	284.95

capsule as described above had a length of 83.4 to 208.5 microns and a width of 194.6 microns. The oesophagus was 417 to 472.6 microns long and it constituted nearly one-fifth of the body. The brain was 305.8 to 347.5 microns away from the anterior end. The intestine was of about three-fourths of the total length and was 1.81 to 1.96 mm long. Rectal tube was 166.8 microns long and the bursal rays were 139 microns long.

Female: Female worms were much stouter and thicker than the males. They measured a length of 4.1 to 7.3 mm and a thickness of 235 microns. They possessed an anterior cuticle of 41.7 to 69.5 microns long. The buccal capsule was deep, thick walled and semicircular with three pairs of teeth at its base. It was 152.9 to 222.4 microns long and 208.5 microns, wide. The oesophagus was 417 to 444.8 microns long with a posterior bulb. It was of about 1/13th of the total body length. The brain was located 278 to 417 microns away from the anterior end. Vulva appeared prominent and large, located at a distance of 1.1 to 1.4 mm from the anterior end and was at about one-fifth of the body. Uterine coils measuring 3.1 to 6.0 mm in length were entwining the intestine which was filled with blood and food particles. The intestine was more than three-quarters of the whole body length. Rectal tube ended in a spike-like fashion and was 139 to 208.5 microns long. The tail was pointed without any tail sheath and was 236.3 to 333.6 microns long (Table 7).

The ratio between the length of the male and female was 1:2.26. The males were attached to the female at one-fifth of the latter's body.

<u>Adult worms</u> (Plate XIII, Fig.2 and Plate XV, Fig.1).(Table 8).

The adult worms were found in the most peculiar fashion, with the result they have acquired several names, viz., red worms by its bright red colour, forked worms since both the male and female are in permanent copula, thus resembling the alphabet 'Y', and gape worm as gape is supposed to be the most characteristic symptom of the disease caused by the worm.

Male: The males were strikingly smaller in size than the females. They were white to cream in colour, the head being embedded in the mucosa of the trachea while *in situ*.

The male was 2.43 to 3.14 mm long (average of 2.79 mm). The mouth on enface view, revealed three pairs of festoons or teeth opposite to each other (Plate XVI, Fig.1). The buccal capsule was strongly semicircular having a depth of 0.14 to 0.35 mm and a width of 0.18 to 0.4 mm. The wall of the buccal capsule appeared chitinous. The sides had an average thickness of 62.5 microns while the bottom was 41.7 microns thick.

The oesophagus ranged from 0.32 to 0.6 mm in length. Its width at the anterior region was 41.7 microns and at the posterior region 62.5 microns the latter region being bulbous in appearance. The intestine was 1.71 to 2.36 mm long,

twisted and filled with food materials and blood. It occupied almost three-quarters of the total body length. The bursa was obliquely truncated and cemented onto the vulval flap of the female permanently. It was 0.17 mm long.

Female: The females were large, bright red in colour and moving freely and actively in the lumen. They were 10.43 to 12.02 mm long. The thickness of the body varied at different regions. It was 0.36 mm at the anterior end, 0.32 mm at the middle and 0.35 mm at the posterior end. Enface view of the mouth showed that the inner diameter of the oral cavity was 0.39 mm and the outer diameter was 0.5 mm. Three pairs of teeth with fine processes were arranged in a circular fashion at the base. The length of the teeth was 69.5 to 83.4 microns while the breadth at the tip was 13.9 microns and at the base 20.85 microns (Plate XII, Fig.3 and Plate XVI, Fig.2).

The buccal capsule was deep, voluminous and thick walled. Its depth was 0.29 mm and the width was 0.33 mm with a wall thickness of 55.6 microns at the sides and 13.6 microns at the base.

The oesophagus was 0.66 mm long with a posterior bulb. The width at the anterior and posterior extremities was 62.55 microns and 0.17 mm respectively. The vulval prominence was at nearly one-fifth of the total body length and at a distance of 1.74 to 2.92 mm from the oral end. The intestine was

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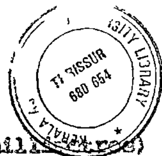

Table 8. Measurements of the adult worms (in millimetres)

Particulars	Male			Female		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Length	2.43	3.14	2.79	10.43	12.02	11.23
Breadth:						
Anterior	0.139	0.167	0.153	0.348	0.375	0.361
Middle	0.111	0.167	0.139	0.473	0.570	0.521
Posterior	0.209	0.222	0.216	0.278	0.417	0.348
Mouth:						
Inner diameter	0.195	0.222	0.209	0.361	0.417	0.389
Outer diameter	0.32	0.343	0.334	0.487	0.514	0.5[illegible]
Teeth:						
Length	0.042	0.056	0.049	0.070	0.083	0.076
Breadth	0.014	0.014	0.014	0.014	0.028	0.021
Buccal capsule:						
Depth	0.139	0.348	0.244	0.273	0.3[illegible]6	0.29[illegible]
Width	0.181	0.403	0.292	0.278	0.389	[illegible]3
Thickness of wall:						
Sides	0.056	0.070	0.063	0.042	0.070	0.056
Base	0.028	0.056	0.042	0.042	0.056	0.0[illegible]7
Oesophagus:						
Length	0.320	0.598	0.419	0.556	0.765	0.[illegible]
Width: Anterior	0.042	0.042	0.0[illegible]	0.056	0.070	0.[illegible]63
Width: Posterior	0.056	0.070	0.0[illegible]	0.167	0.167	0.[illegible]67
Intestine (length)	1.71	2.36	2.[illegible]	8.6	10.77	9.6
Vulva (from anterior end)	-	-	-	1.74	2.92	2.[illegible]3
Bursa	0.139	0.209	[illegible]	-	-	-
Anus (from anterior end)	-	-		10.16	11.60	10.[illegible]8
Tail (length)	-	-		0.275	0.417	.346

8.6 to 10.77 mm long, twisted and entwined around the uterine coils. The uterus was full of both mature and immature eggs. The tail was conical with a pointed process and 0.35 mm long.

The length ratio of male and female was 1:4.

Prepatent period

After oral infection, the larvae reached the lungs probably through the blood stream, via oesophagus, intestine or peritoneum within 12 hours. There it moulted to the fourth stage on day 5 after infection. Moulting forms were recovered on day 6 too. On day 7, fifth stage larvae were obtained indicating that moulting from the fourth to the fifth stage occurred on day 6. It has been found out that copulation took place in the lungs itself on day 7 and by day 8 the copulated pairs migrated to the trachea. Since single larvae were obtained from the trachea, it was concluded that copulation could also happen after migrating to the trachea on day 8. The single or copulated pairs of worms remained in the trachea from day 8 onwards. On maturation, every female would be attached to a male and none remained single. By day 13 worms in copulo only were present. The male worm remained in the trachea with its head end embed in the mucosa and holding with its tail and the female fr of any attachment. On maturation, the female started di charging ova, which were coughed up and swallowed by th bird and passed out through its droppings. Ova were o

in the droppings from day 18 post-infection onwards. The prepatent period was determined to be 18 to 22 days.

Clinical signs and pathogenesis

Birds that were naturally infected showed severe gaping movements with a hissing sound or cough, shaking of head, weakness, anaemia followed by loss of appetite and activity. Some of the affected birds showed neither any sympton nor any egg in the droppings. Out of 73 affected birds examined, only 34.24 per cent manifested symptoms (Table 9).

Table 9. Percentage of infected birds that showed symptoms

Number of birds found infected	Number of infected birds that showed symptoms	Percentage
73	25	34.24

Experimentally infected chickens became off-food after six days of infection. The symptoms became intense after 11 days. Weakness, sitting flat on the floor with limbs outstretched, respiratory distress and gasping for air were some of the symptoms shown. Gape was manifested in the later stages of the infection when the birds became restless with ruffled feathers. The younger birds, since the size of the lumen of the trachea was comparatively narrower, a few worms could occlude the trachea and cause suffocation.

Grossly, the lungs were found to be highly congested and very fragile during the early stages of infection. Simultaneous areas of consolidation and cloudy white areas with haemorrhagic spots were seen. The different stages of larvae formed in the lungs were responsible for these kind of lesions.

The trachea showed haemorrhage and inflammation. Haemorrhage was either petechial or diffuse. There were severe necrosis and other changes around the area of attachment of the worms to the mucosa. Discrete, whitish, pea-sized nodules were present at the site of attachment of the male worms on the mucosa. The female worms, bright red in colour, were immersed and entangled in the mucus produced and sometimes found entwined and plugged at the anterior and posterior ends of the trachea. No location specificity was noticed for the worms in the trachea. They were found anywhere in the trachea. The total number of worms recovered from the trachea ranged from 2 pairs to 94 pairs. The tracheal contents consisted of mucus, blood, tissue debris and ova of the worms.

Microscopically, the lung tissues showed numerous necrotic worm tracts in the parenchyma with extensive cellular infiltration. There was massive haemorrhage into the alveoli. The migration and development of the larvae caused desquamation of the bronchial epithelium. Cross sections of the migrating larvae could also be seen (Plate XVII, Fig. 1).

The trachea showed total dystrophy of the mucosa. Fibrosis and organisation of the epithelial lining was detected. Nodular outgrowths were seen as pedunculated masses containing large number of mononuclear cells. There was also infiltration of inflammatory cells like lymphocytes, eosinophils, plasma cells, etc. Sections showed the parasite deeply embedded in the mucosa, submucosa and almost reaching the cartilage. Buccal capsule, oesophagus and teeth of the worms could be clearly seen in the sections (Plate XVII, Fig.2).

Comparative efficacy of anthelmintics against syngamiasis in chicken

In the present investigation, the comparative efficacy of Mebendazole (methyl-5-benzoyl-2-benzimidazolecarbamate), Thiabendazole (2-(4-thiazolyl)-1H-benzimidazole) and Albendazole (Methyl (5-(propylthio)-1H-benzimidazole-2-yl) carbamate) given orally at the dose rate of 40 mg, 300 mg and 15 mg per kg body weight respectively and that of Ivermectin injected subcutaneously at the rate of 200 micrograms per kg body weight was assessed on the basis of the following aspects:

<u>Egg per gram counts.</u>

Out of the first three anthelmintics, Mebendazole was found to have the highest efficacy (96.22 per cent). It was closely followed by Albendazole (95.14 per cent). The lowest efficacy was met with Thiabendazole (89.27 per cent)(Table 10).

Table 10. Comparative anthelmintic efficacy of mebendazole, thiabendazole and albendazole based on E.P.G

Group name	Mebendazole group									
Wing band numbers of birds	7842	7847	7848	7852	7855	7857	7859	7862	7869	7855(b)
Pre-treatment E.P.G.	400	300	1600	1300	4300	600	3000	3500	900	2600
Post-treatment E.P.G.	0	0	0	600	0	100	0	0	0	0
Reduction in E.P.G.	400	300	1600	700	4300	500	3000	3500	900	2600
Efficacy per head in percentage	100	100	100	53.85	100	83.33	100	100	100	100
Efficacy per group in percentage	96.22									

Group name	Thiabendazole group									
Wing band numbers of birds	7849	S	B	7853	7854	7858	7867	7857(b)	7841(b)	7851(
Pre-treatment E.P.G.	450	1000	900	3300	2000	1500	1500	1200	900	300
Post-treatment E.P.G.	300	100	300	200	0	100	0	400	0	0
Reduction in E.P.G.	150	900	600	3100	2000	1400	1500	800	900	300
Efficacy per head in percentage	33.3	90	66.66	93.94	100	93.33	100	66.66	100	100
Efficacy per group in percentage	89.27									

1. Mebendazole - 40 mg/kg body weight
2. Thiabendazole - 500 mg/kg body weight
3. Albendazole - 15 mg/kg body weight

Albendazole group							
4	M	7860	7865	7866	7871	7850(b)	7852(b)
0	950	1600	800	2500	2500	1200	9000
0	300	0	0	0	0	0	0
0	650	1600	800	2500	2500	1200	9000
0	68.42	100	100	100	100	100	100
					95.14		

Albendazole group										Control (Non-medicated) group									
4	M	7860	7865	7866	7871	7850(b)	7852(b)	7853(b)	7858(b)	7841	7843	7850	7863	7864	7870	7872	7842(b)	7859(b)	7856(b)
0	950	1600	800	2500	2500	1200	900	300	800	200	3400	250	900	600	400	600	1100	1000	500
0	300	0	0	0	0	0	0	0	100	600	2200	300	3700	1500	400	3000	1300	1000	400
0	650	1600	800	2500	2500	1200	900	300	700	400	+1200	-50	-2800	-900	0	-2400	-200	0	+100
0	68.42	100	100	100	100	100	100	100	87.5	-200	+35.29	-20	-311.1	-150	0	-400	-18.18	0	+20
95.14										-104.399									

Worm counts.

According to the number of worms obtained at necropsy from each group, the efficacy of Mebendazole was 88.10 per cent, and that of Albendazole was 76.19 per cent. Thiabendazole was the least effective (45.24 per cent) vide table 11.

Body weight gain.

On the basis of the influence of each anthelmintic on the body weight gain of the treated chicks, Mebendazole was found to be superior (95.52 per cent), closely followed by Albendazole (95.02 per cent) and then Thiabendazole (94.18 per cent) vide table 12.

Anthelmintic efficacy of Ivermectin.

Depending upon the egg per gram counts, the efficacy of Ivermectin was found to be 94.65 per cent (Table 13). Though the efficacy was only 18.19 per cent based upon the worm counts, the worms obtained at necropsy were dead or almost dying discharging small and round immature eggs and they were dark red in colour. The worms obtained from the control group were bright red and active (Table 14). As shown in table 15, the percentage of gain in weight by the group of birds medicated with Ivermectin was 66.45 per cent while that of the control was 61.04 per cent.

Effect of irradiation on the development of _Syngamus trachea_

In an attempt to study the effect of irradiation on the development of _S. trachea_ in chicken, two groups of

Table 11. Comparative anthelmintic efficacy of mebendazole, thiabendazole and albendazole against _S. trachea_ based on the worm count at autopsy

Group	Total number of worms retained	Average number of worms retained	Percentage of worms retained	Efficacy of drug
Mebendazole group	5	0.5	11.9	88.10
Thiabendazole group	23	2.3	54.76	45.24
Albendazole group	10	1	23.81	76.19
Control (Non-medicated group)	42	4.2	100	-

Table 12. Comparative anthelmintic efficacy of mebendazole, thiabendazole and albendazole against _S. trachea_ based on the body weight gain (kg)

Group	Mean pre-treatment weight	Mean post-treatment weight	Weight gain	Percentage of weight gain
Mebendazole group	128.3	250.85	122.55	95.52
Thiabendazole group	154.6	302.2	145.6	94.18
Albendazole group	126.6	246.9	120.3	95.02
Control (Non-medicated group)	138.6	267.4	118.8	85.71

Table 13. Anthelmintic efficacy of Ivermectin against *S. trachea* based on E.P.G.

Group	Ivermectin group						Control (Non-medicated) group					
Wing band number of birds	7879	7866	7868	7899	7901	7882	7892	7864	7867	7869	7896	7900
Pre-treatment E.P.G.	900	2300	600	400	200	200	700	1500	200	1000	800	300
Post-treatment E.P.G.	100	100	100	0	0	0	700	400	600	1900	1500	1500
Reduction in E.P.G.	800	2200	500	400	200	200	0	1100	-400	-900	-700	-1200
Efficacy of drug per head (%)	88.89	95.65	83.33	100	100	100	0	73.33	-200	-90	-87.5	-400
Efficacy of drug per group (%)	94.65						-117.36					

Dose - Ivermectin: 200 micrograms per kg body weight

Table 14. Anthelmintic efficacy of Ivermectin against *S. trachea* based on the worm counts at autopsy

Group	Total number of worms retained	Average number of worms retained	Percentage of worms retained	Efficacy of the drug (%)
Ivermectin	18	3	81.82	18.19
Control (Non-medicated)	22	3.66	100	-

Table 15. Anthelmintic efficacy of Ivermectin against *S. trachea* based on the body weight gain (kg)

Group	Mean pre-treatment weight	Mean post-treatment weight	Weight gain	Percentage of weight gain
Ivermectin	181.83	302.67	120.83	66.45
Control (Non-medicated)	160.83	259.0	98.17	61.04

experimental chicks were administered with irradiated and non-irradiated infective eggs or larvae. They were sacrificed when the prepatent period was over to recover worms if any. No worm, either mature or immature, could be recovered even from the control birds indicating that the birds remained refractory to infection. Though the experiment was repeated again, the result was the same. So no definite conclusion could be derived out of the experiment. Further studies are required to establish the effect of irradiation on the development of _S. trachea_.

Plates

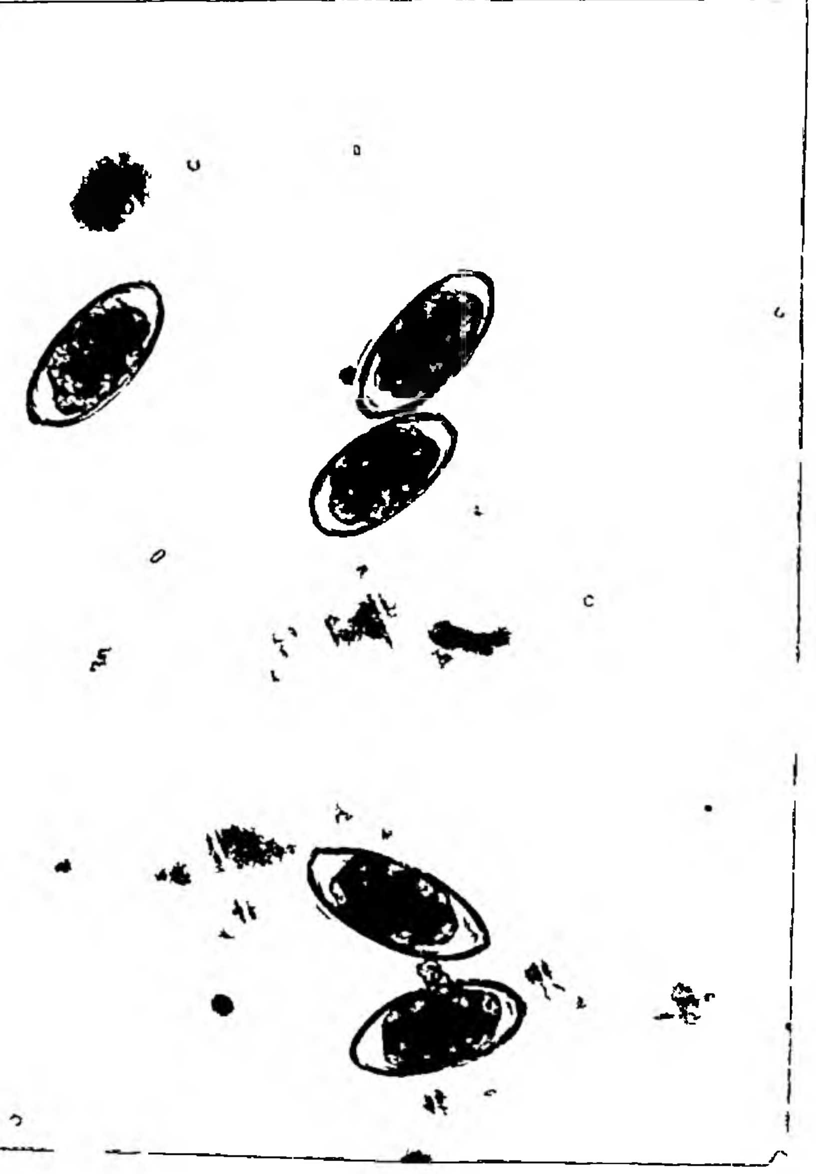

Fig 1

Fig. 2

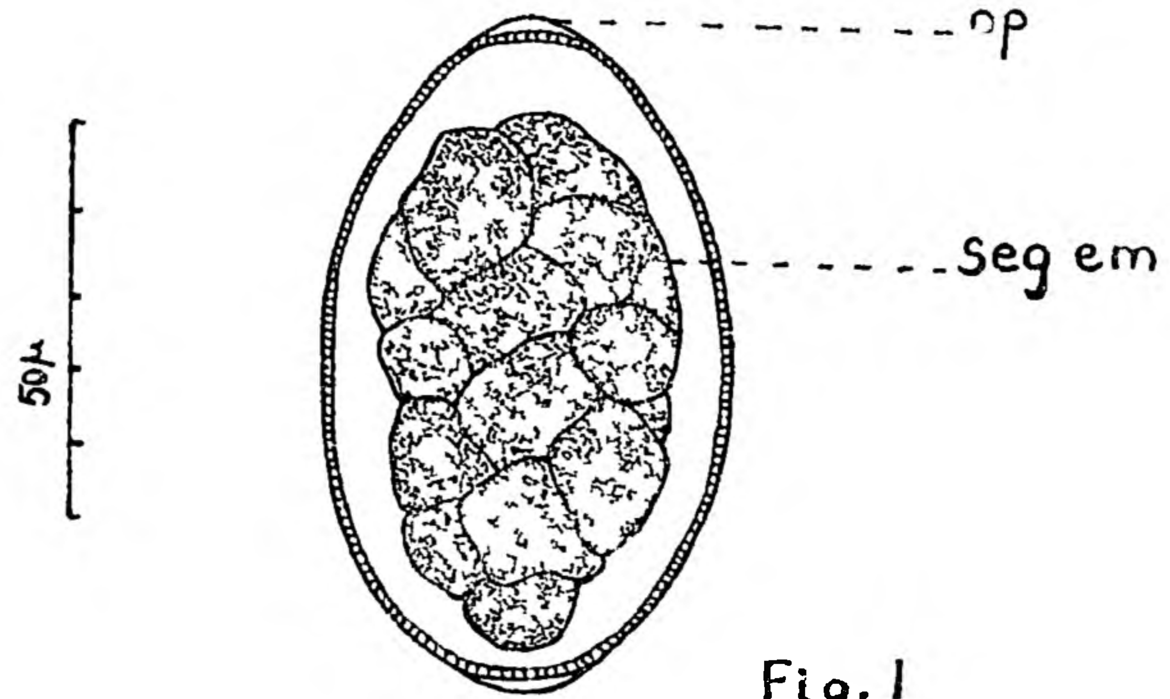

Fig. 1

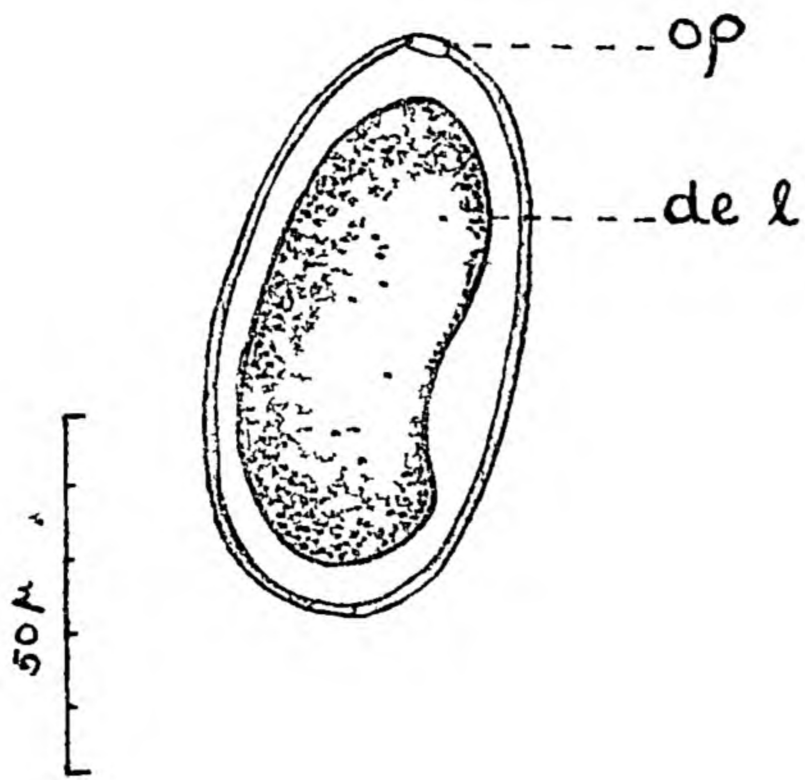

Fig 2

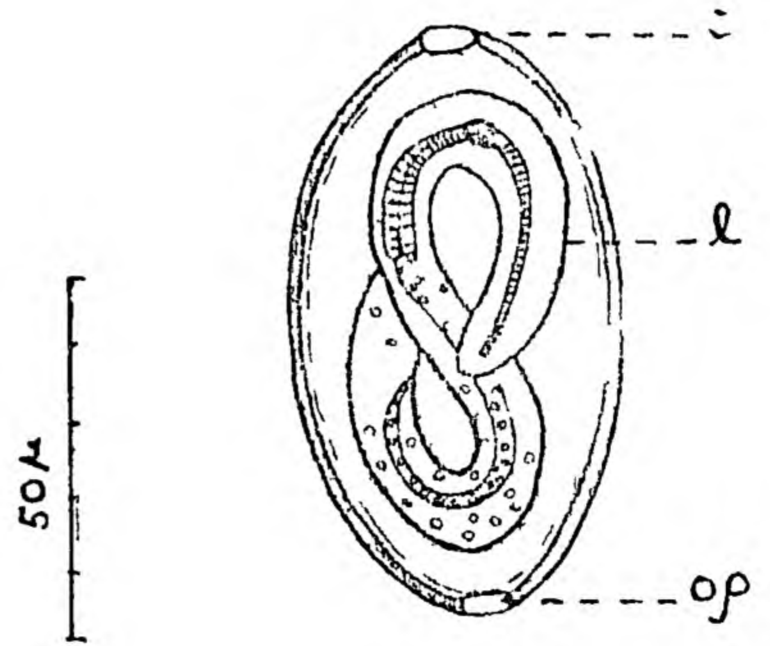

Fig 3

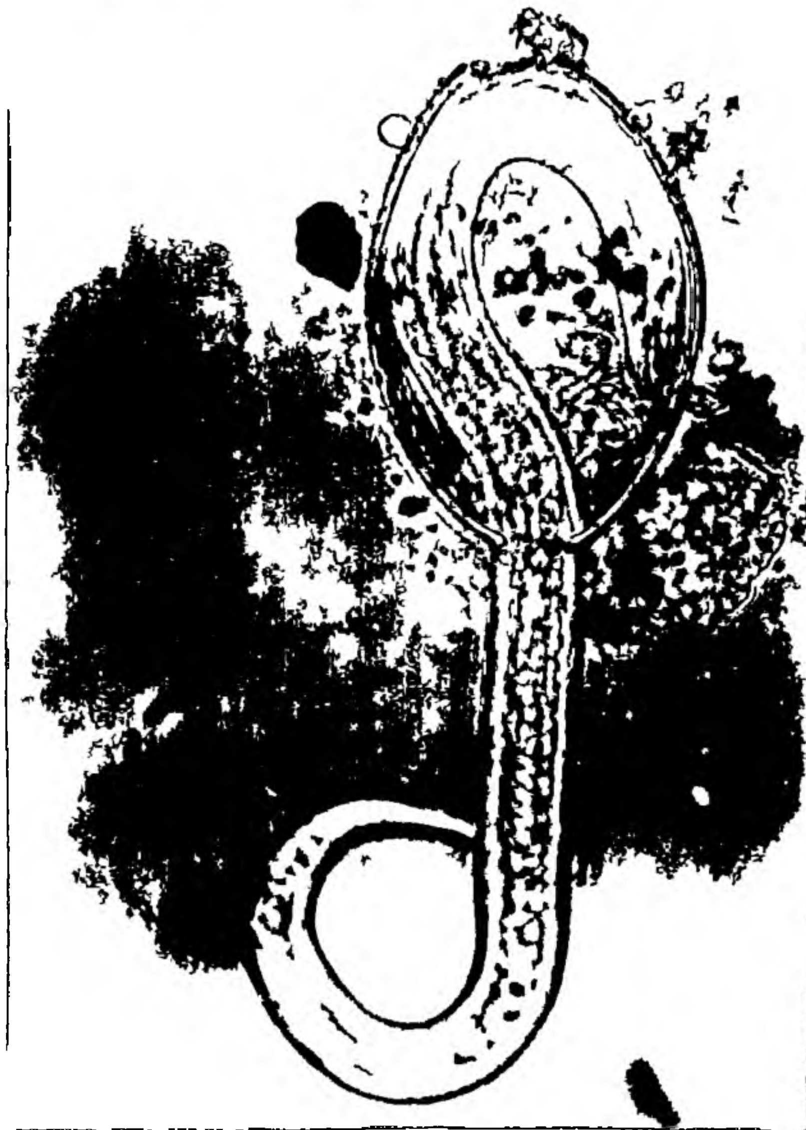

Fig. 1

Fig.1

Fig.2

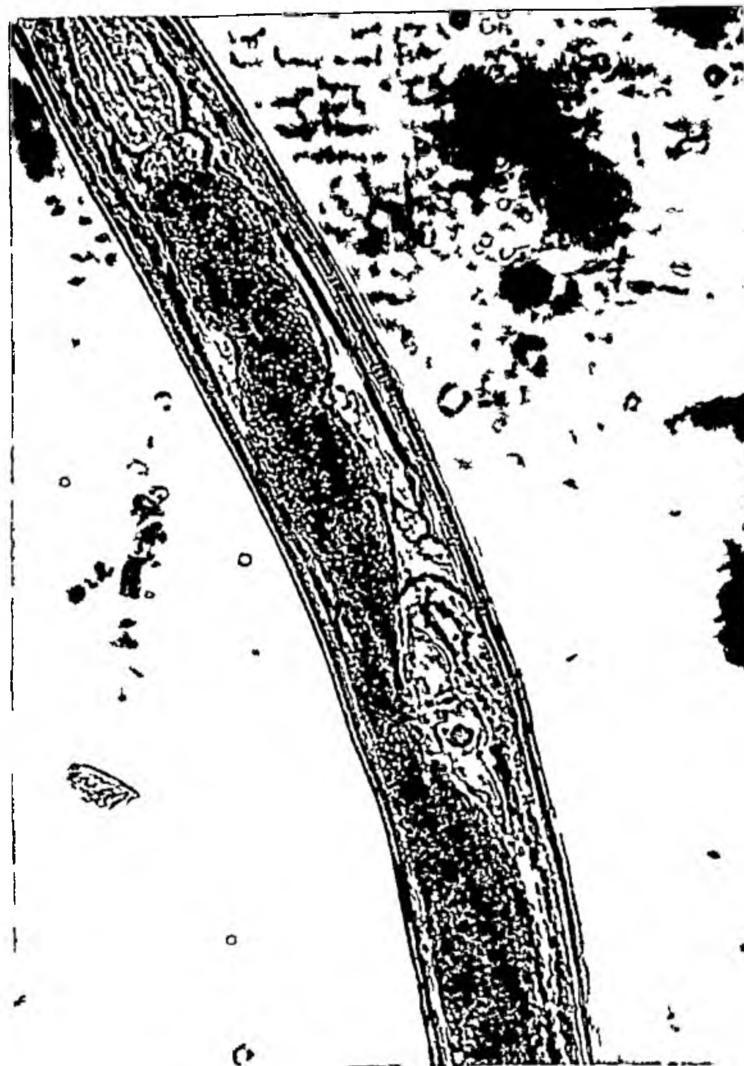

Fig 3.

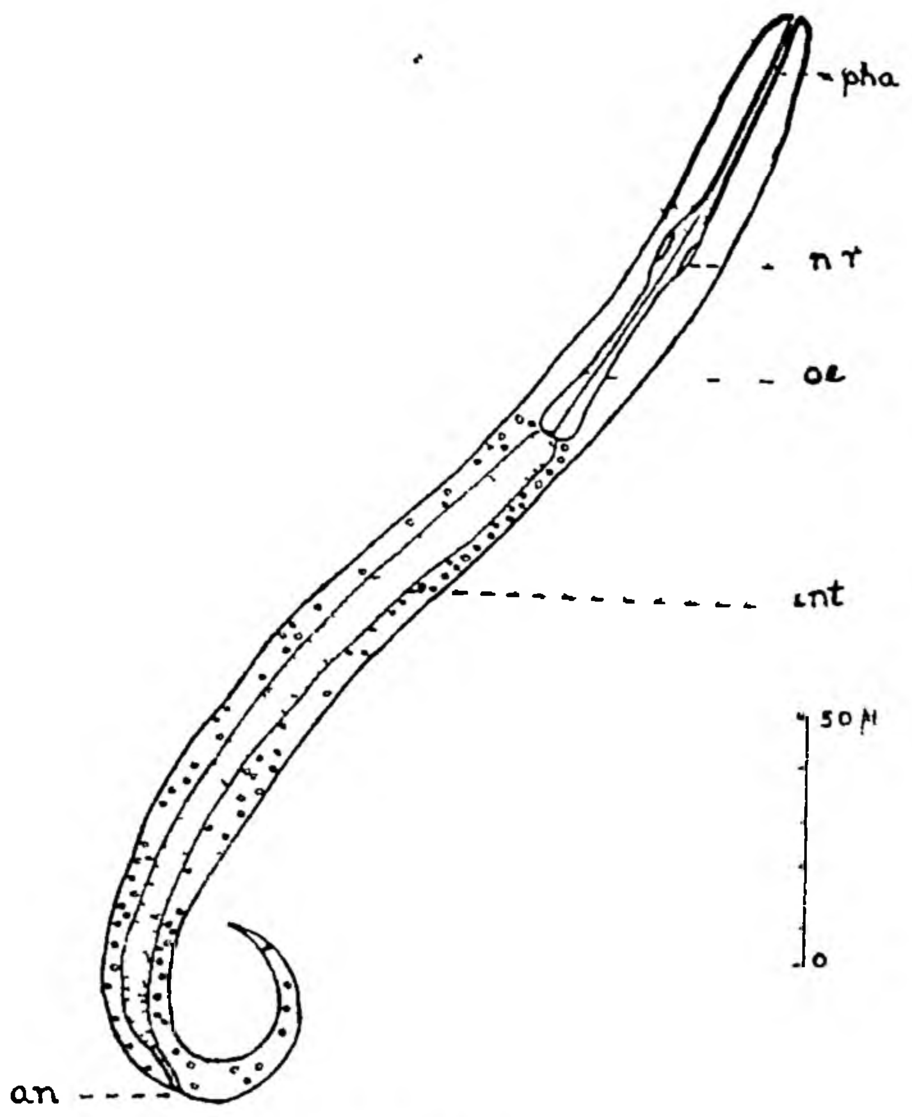

Fig 1

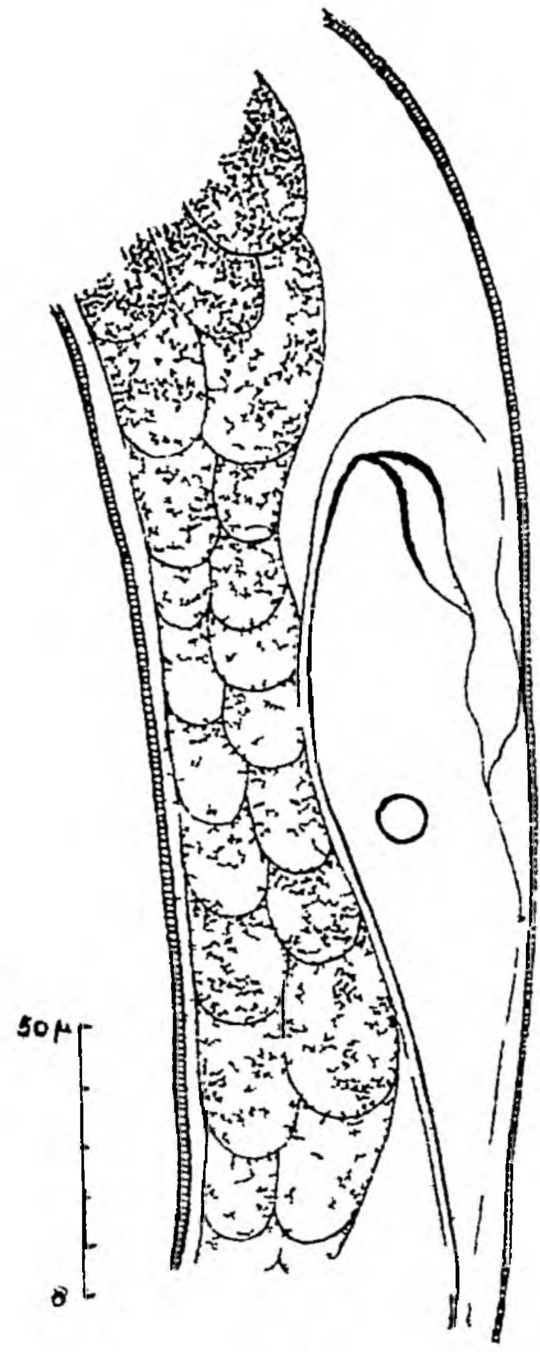

Fig 2

Fig. 1

Fig. 2

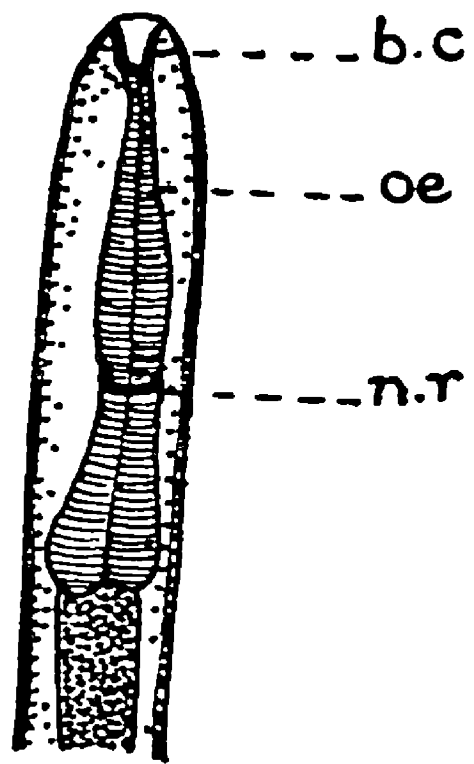

Fig.1

50μ

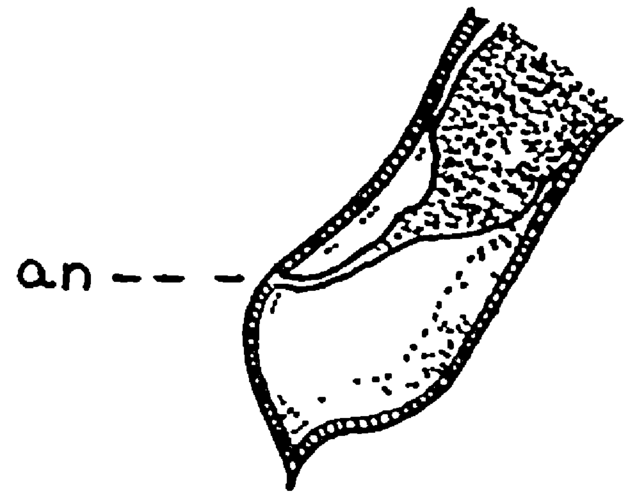

Fig.2

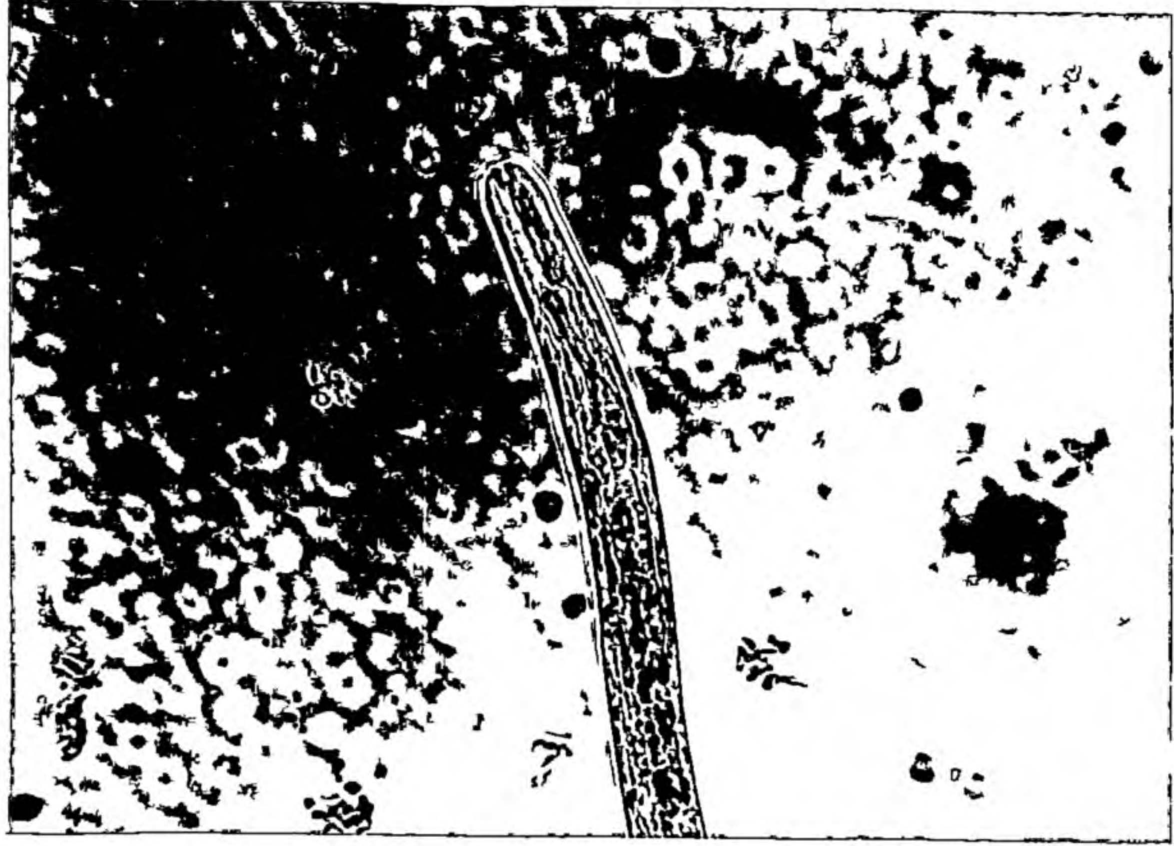

Fig.1

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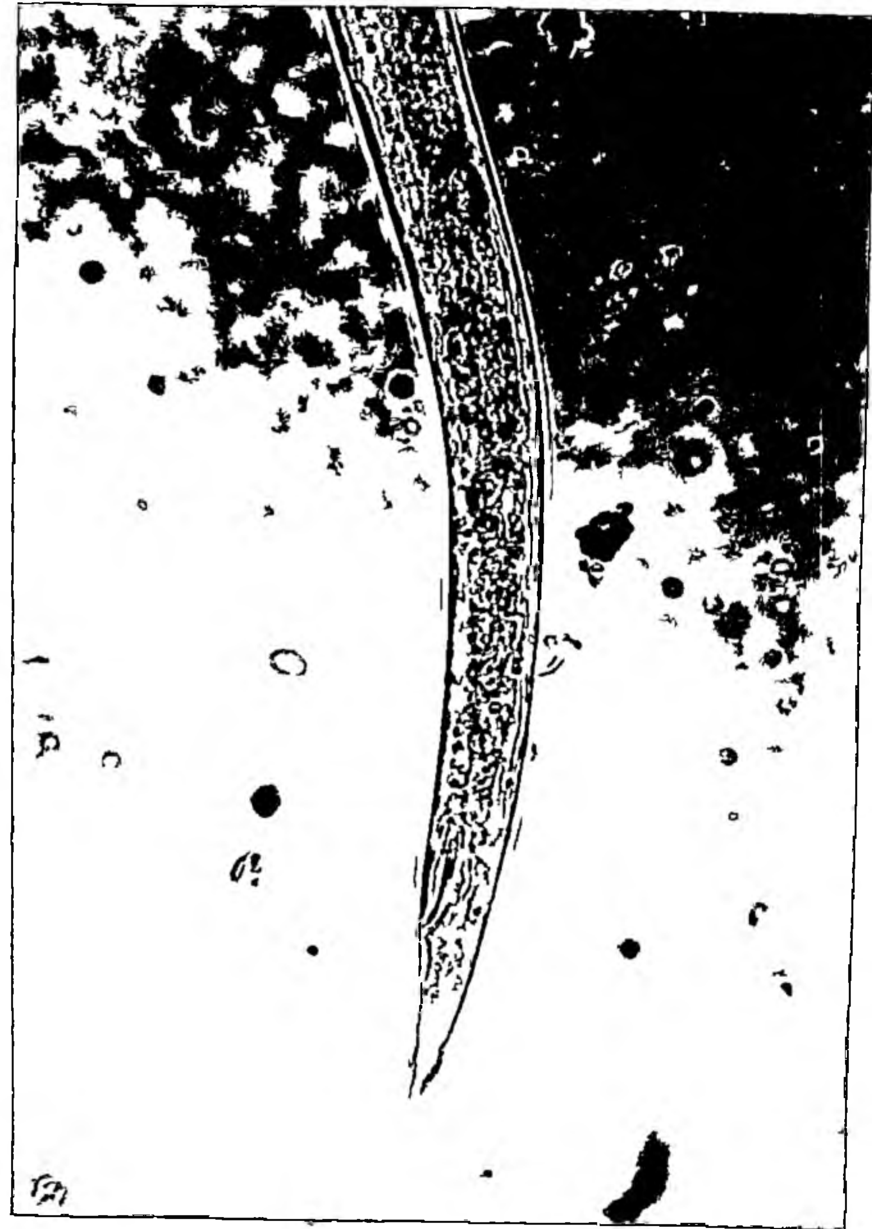
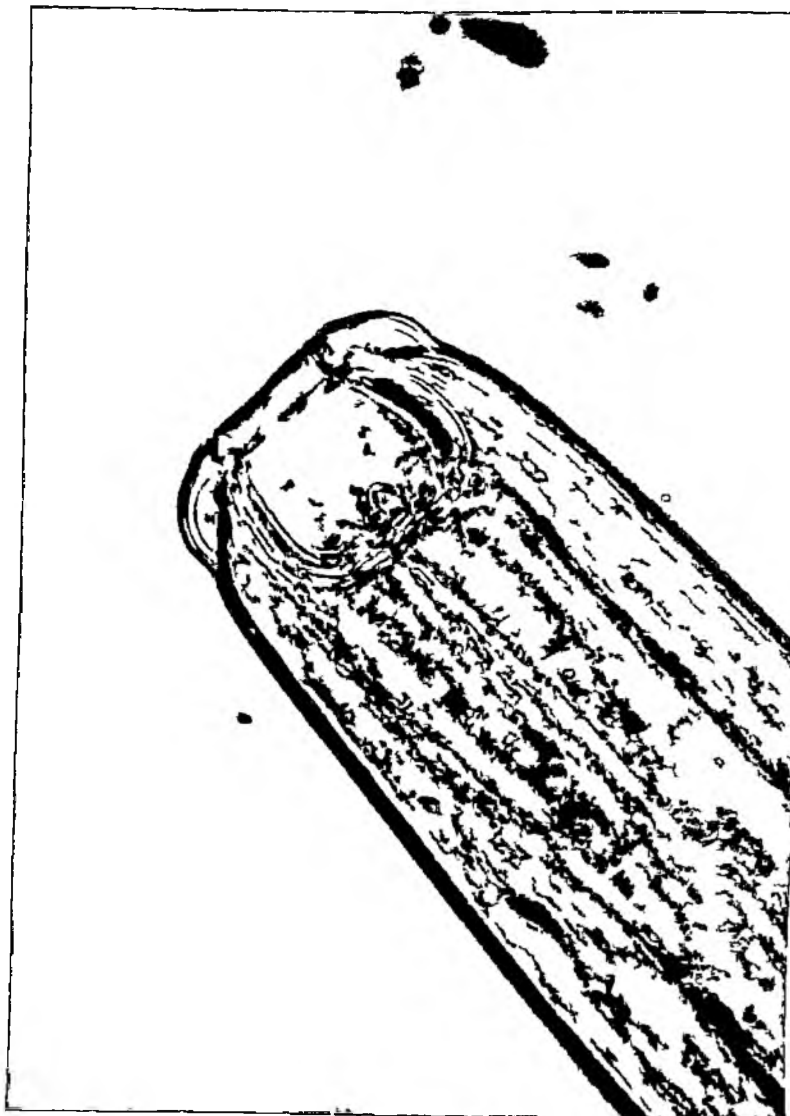


Fig.3

Fig 1

Fig 2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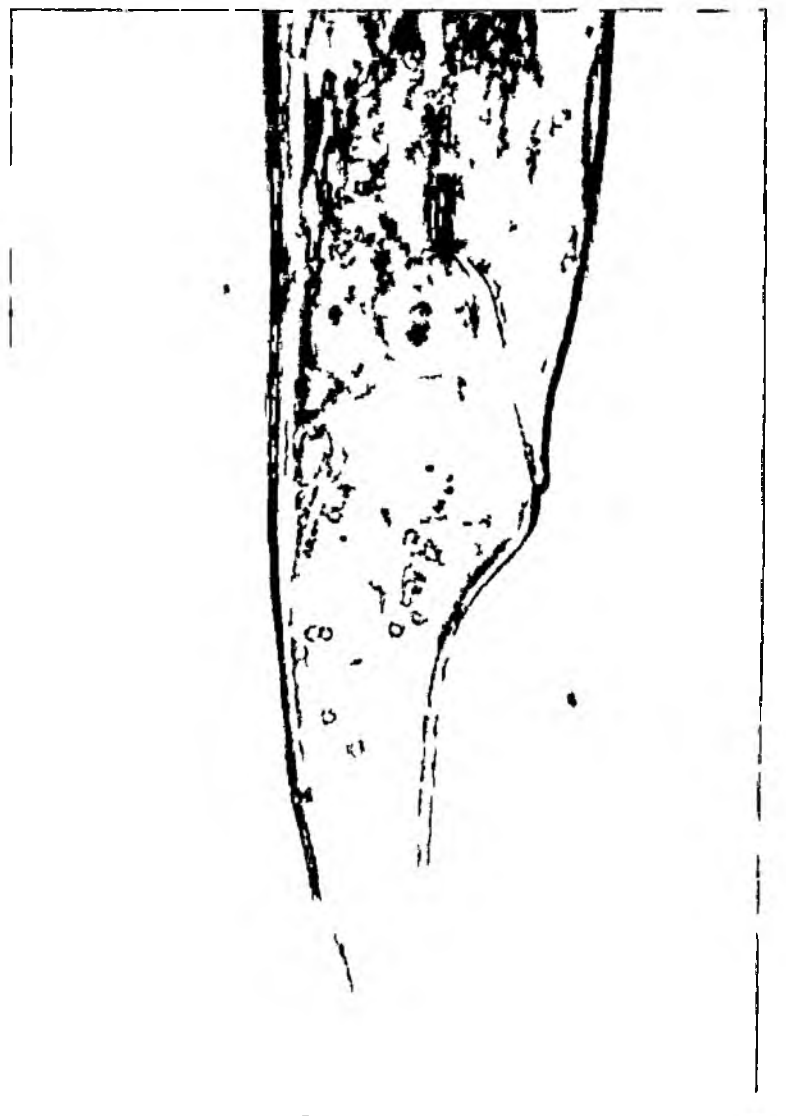
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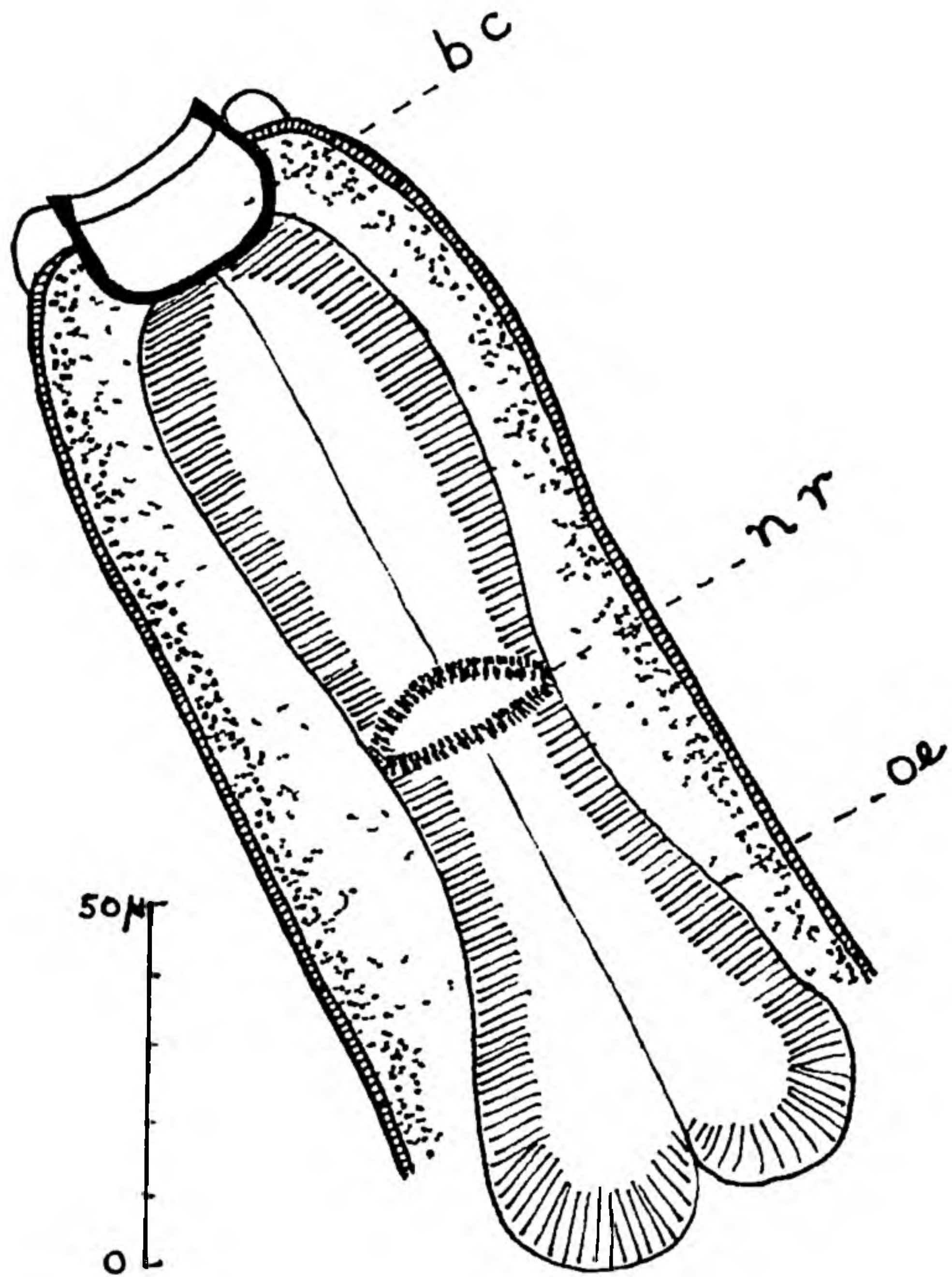

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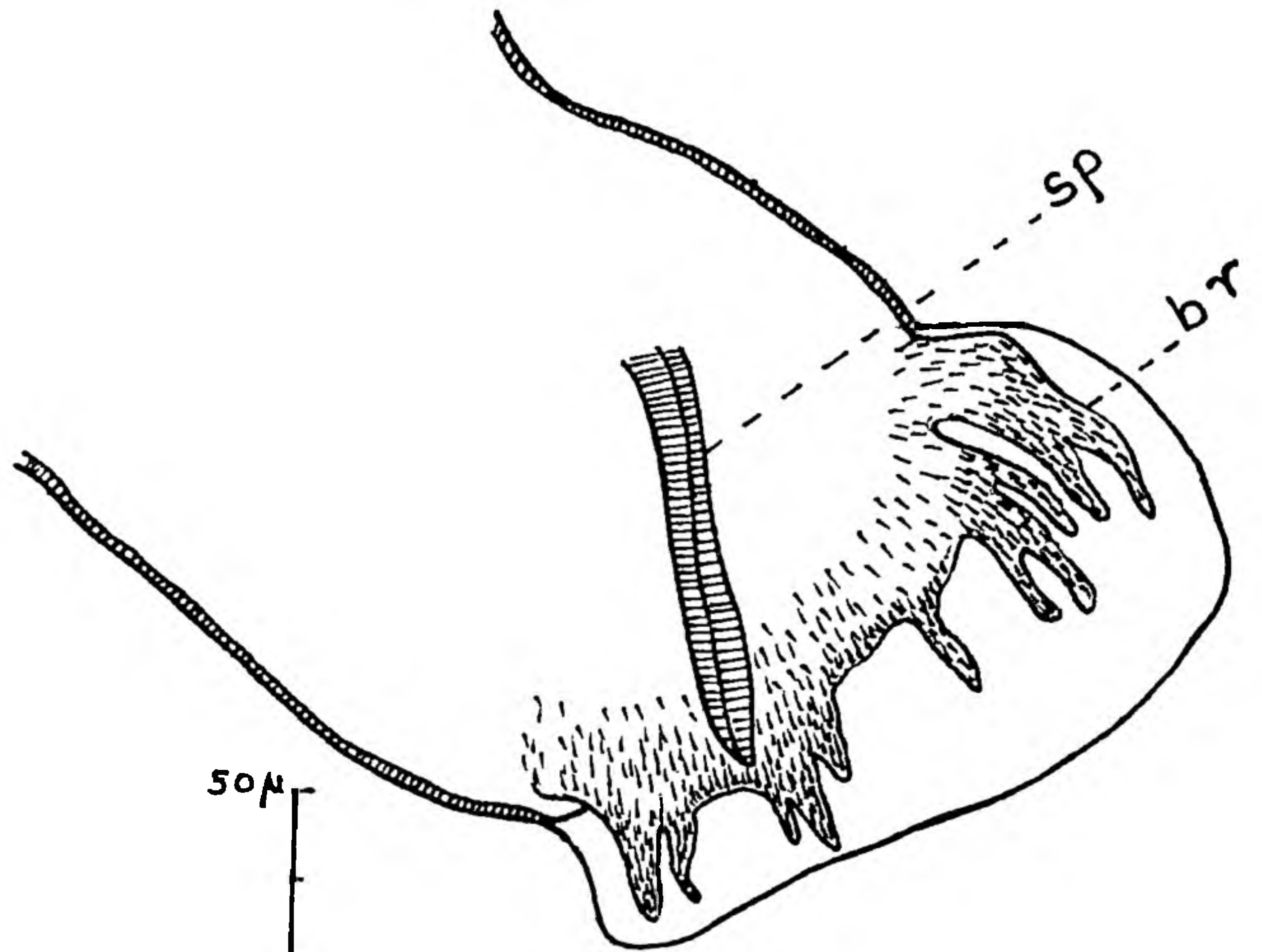

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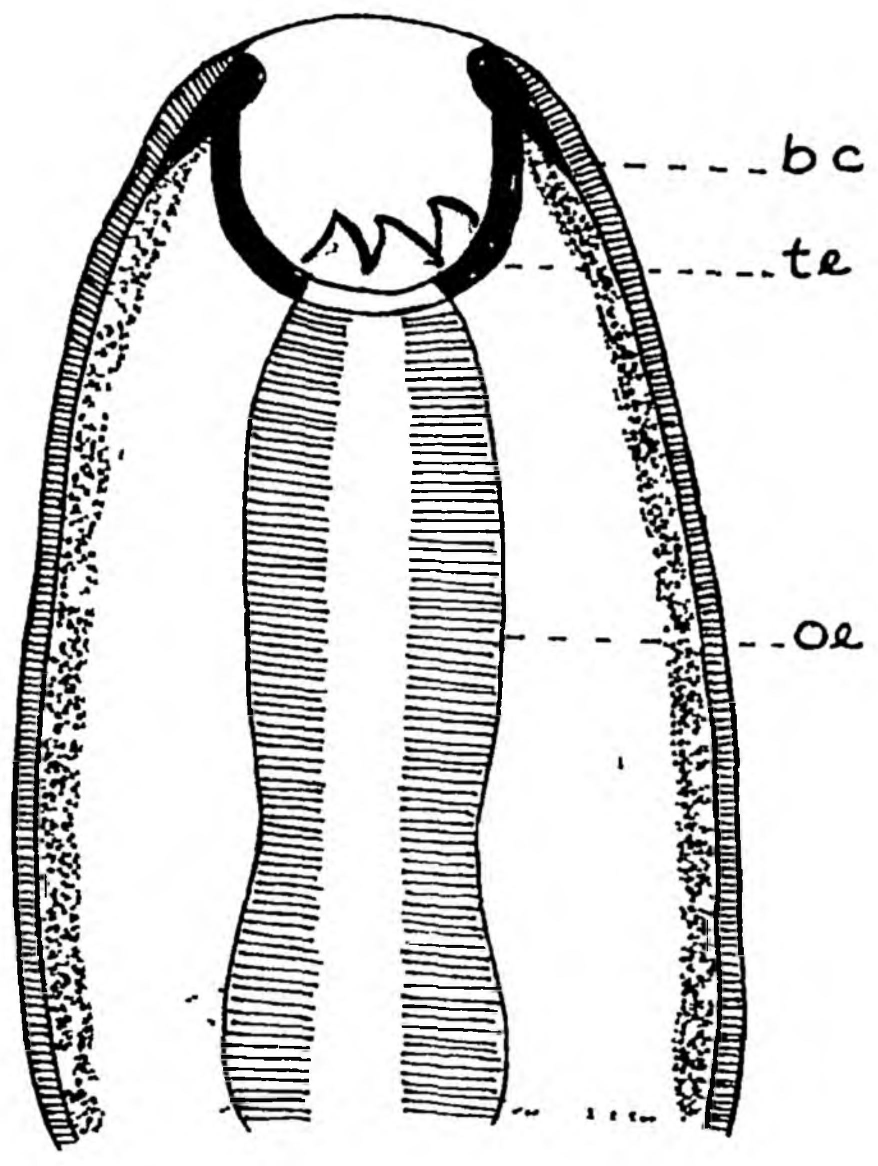

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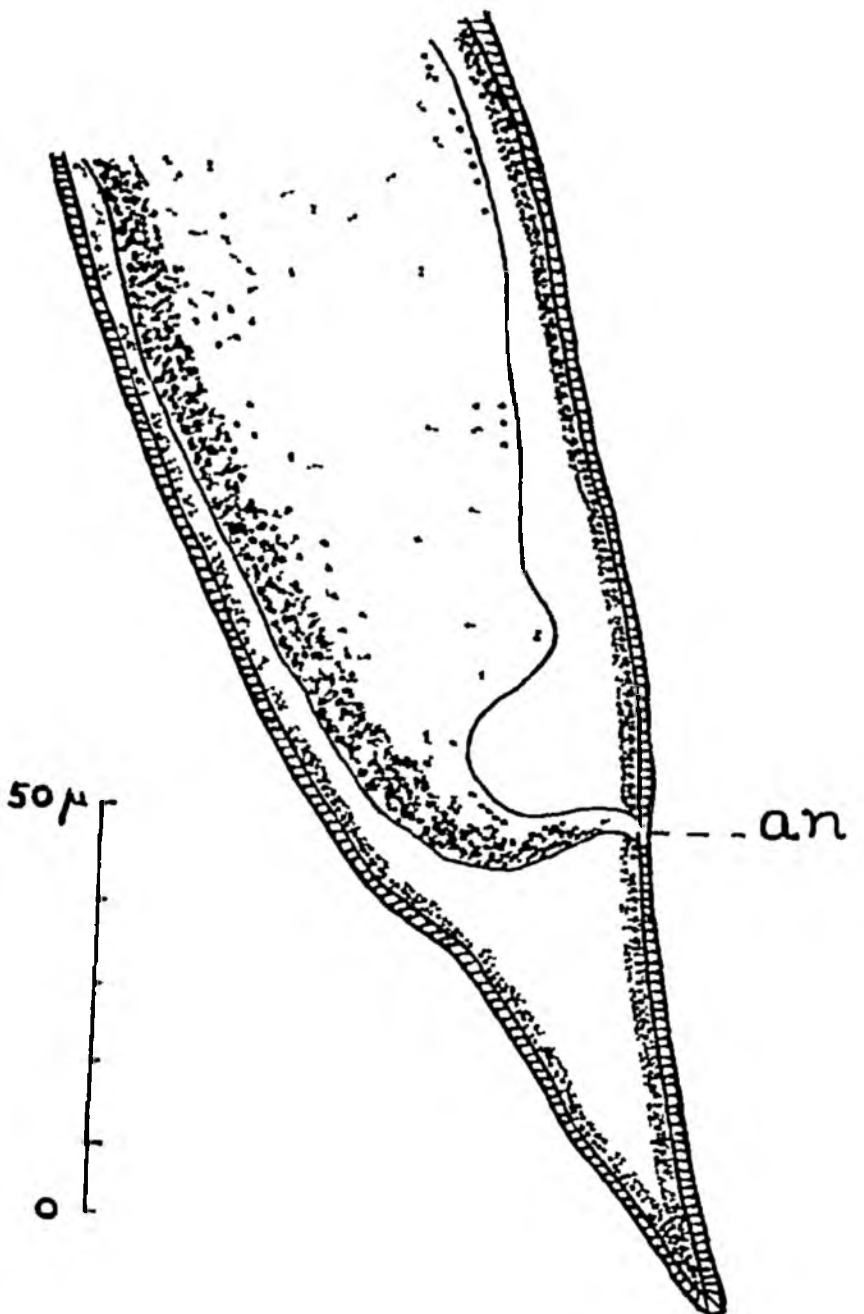

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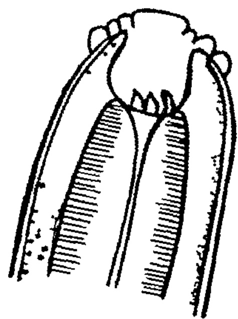

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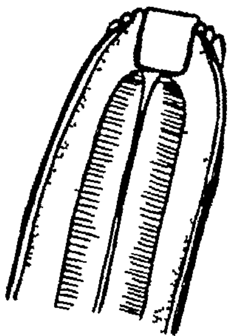

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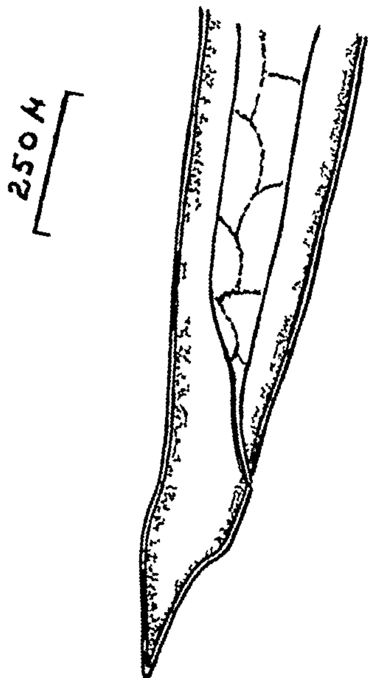

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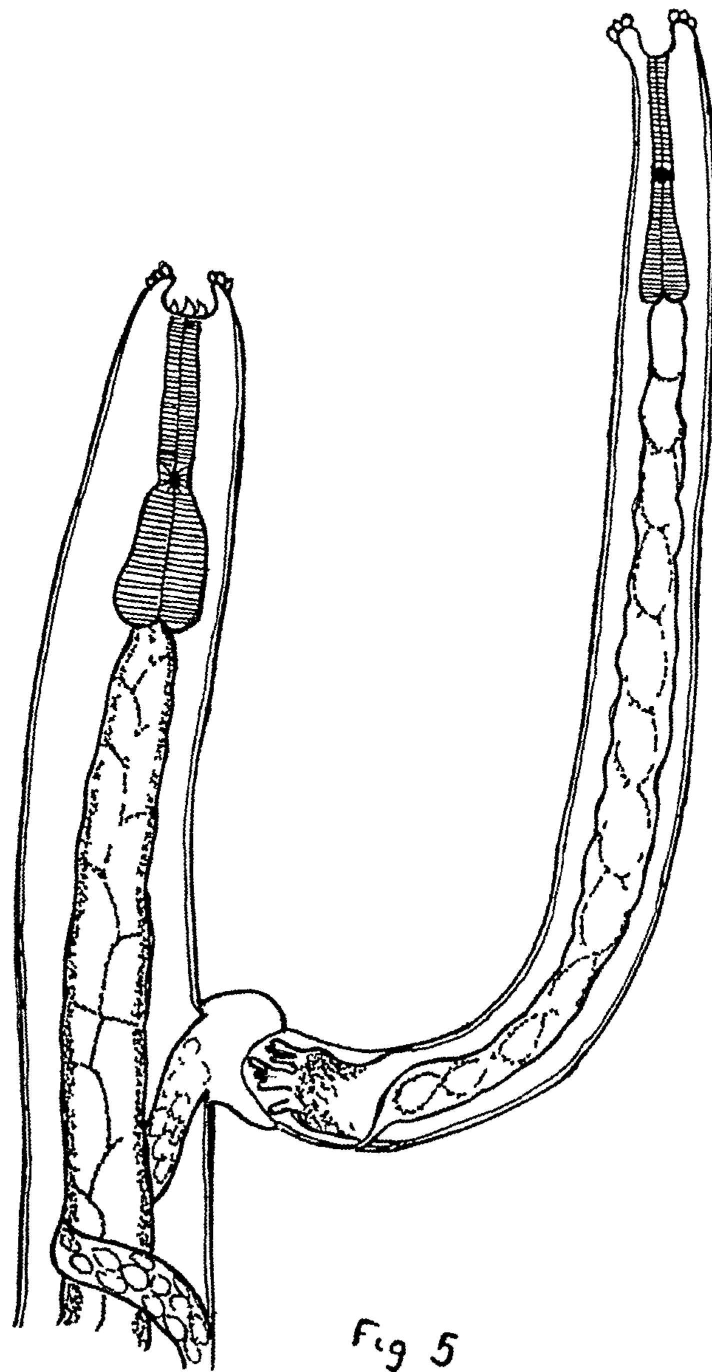

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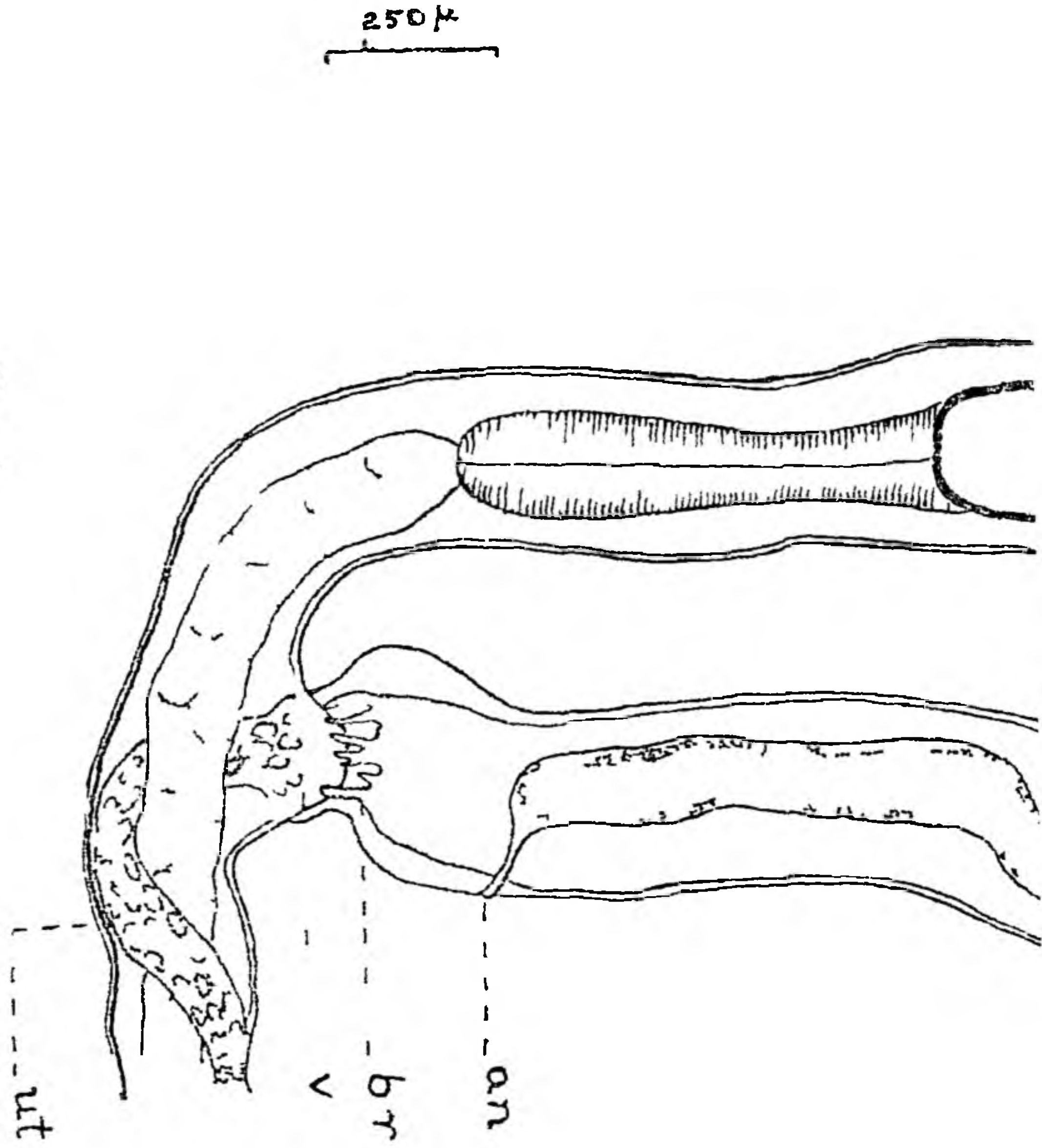

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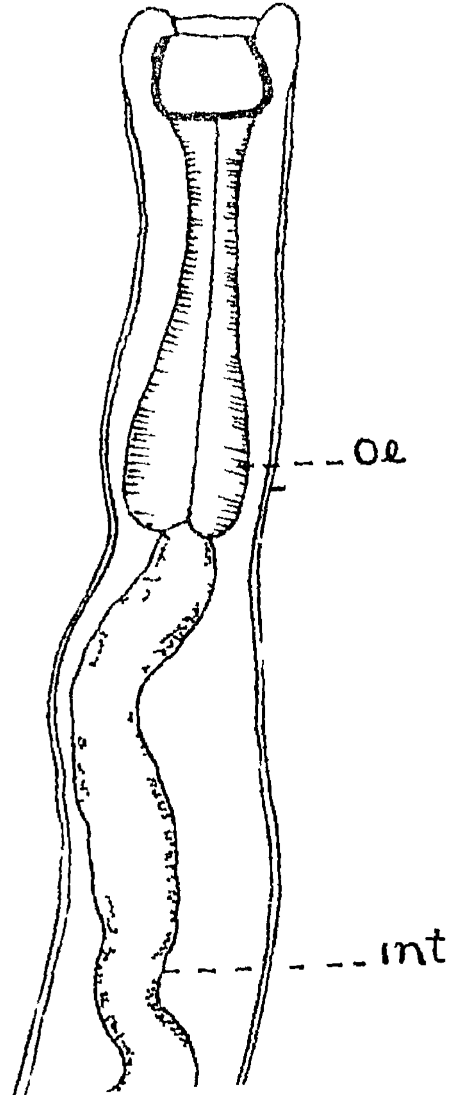
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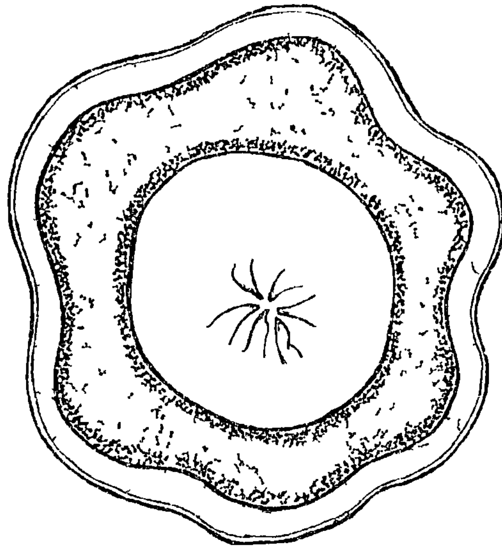

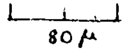

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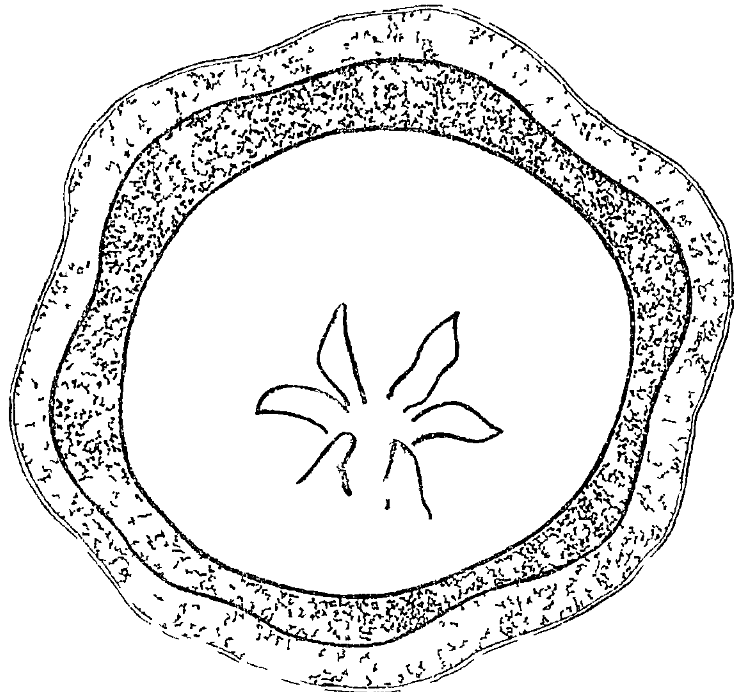

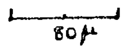

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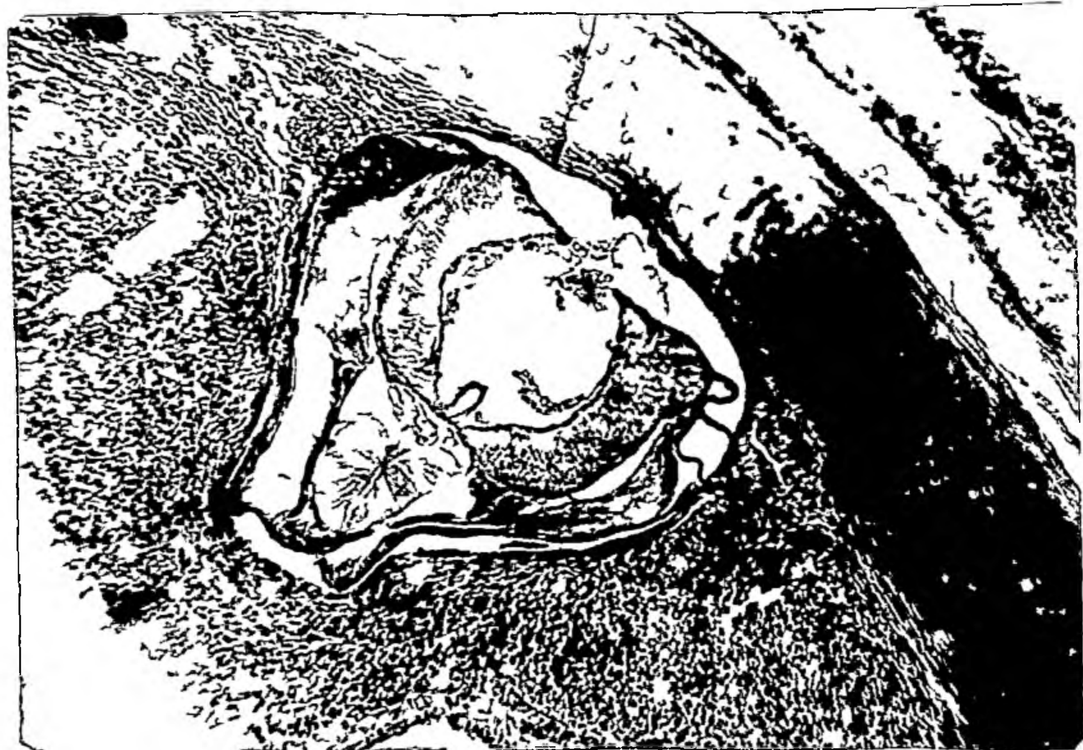

Fig 2

Discussion

DISCUSSION

Prevalence of Syngamus trachea infection in poultry was one of the aspects of study in the present investigation. During the period of research which extended for one year, it was found out that the occurrence of gapeworms was more in the younger birds than in the adults as reported by Ransom (1921). This is in contradiction to the reports of Crawford (1940), Thuraisingham (1940), Olivier (1943) and Fabiyi and Offiong (1979) who noticed the infection more in adults than in young birds.

As revealed in the present study, the prevalence of infection was found to be high after the monsoon rains. This observation is in agreement with that of Fabiyi and Offiong (1979) but contrary to that of Enigk and Dey-Hazra (1971) who found the infection more in summer.

The rate of infection worked out in the present investigation was 5.4 per cent whereas that obtained by Varghese (1966) was as low as 0.9 per cent. As regard to the intensity of infection, Varghese (1966) could recover a maximum of only three pairs from a single bird while in the present investigation a maximum of 94 pairs could be collected from a single bird. Olivier (1943) also collected 94 pairs of worms from an adult hen in Bolivia.

On culturing the eggs, it was observed that the suitable temperature for setting up cultures was room temperature

(22 to 32.5°C) as reported by Ortlepp (1923). But temperatures ranging from 22.1 to 36.2°C recorded during the months of March, April and May were unsuitable for the maintenance of good cultures.

Regarding the time of hatching of eggs, usually it started by the seventh day of setting up cultures. Rarely hatching occurred earlier, as early as the third day but according to Ortlepp (1923) and Wehr (1937a), hatching never occurred earlier than the nineth day. In the present investigation, it was found that many eggs with developed larvae inside did not hatch.

The larvae that hatched out were in the third stage. This observation is in agreement with that of Wehr (1937a) but disagrees with that of Ortlepp (1923), according to whom the hatched out larvae were in the second stage and that they were the infective stage.

It was understood by the present study that transport hosts are not necessary for the transmission of the infection.

In the present experiment, chicks were infected by directly feeding them with infective eggs or larvae without passing them through any transport hosts like earthworms. Ortlepp (1923) and Wehr (1937a) were successful in producing infection in chicks by this method. But Bates Jr. (1972) failed to establish infection in this way.

After the experimental infection, the larvae reached the lungs within 12 hours. According to Ortlepp (1923), the larvae reached the lungs within 24 hours and according to Wehr (1937a) in 17 hours. During the present study, no larvae were recovered from the liver on any occasion during the post-mortem of infected birds, sacrificed to study the stage to stage development of the worm, thus making it impossible either to agree or disagree with Shikhobalova and Rhizhikov (1956), Barus and Blazek (1965) and Enigk and Dey-Hazra (1971) who reported that the parasite has a migratory path through the liver. Though Clapham (1939a) was able to recover larvae from the lungs and heart, he also was unable to collect any larva from the liver.

As per the present findings, copulation of the worms took place in the lungs itself on the seventh day whereas according to the findings of Wehr (1937a) it occurred from the third to the seventh day and the worms migrated to the trachea on the nineth day post-infection. In the present study, migration of the worms to the trachea occurred from the eighth day onwards. Single worms were found in the trachea 9 to 10 days following infection indicating that sexual union could also occur even after migrating to the trachea. In agreement with the conclusions of Fernando (1971), the male worms were found anchored to the tracheal mucosa by the 11th day. The prepatent period was determined as 18 to 22 days in the present study, as against 17 to 20 days noted by Ortlepp (1923).

The measurements and description of the different stages of the parasite obtained in the present study tally more or less with those given by Wehr (1937a) and Varghese (1966). The thick-walled buccal capsule with its chitinous rim and six conical teeth at the base was seen in all specimens of the adult worms examined. Leaf crowns were absent as reported by Varghese (1966). The male-female length ratio was roughly 1:4 as found out by Varghese (1966).

Regarding the pathogenesis and clinical manifestations, it was concluded that the pathogenic effects were more in the younger birds than in the adults as stated by Clapham (1935b). Birds die due to asphyxiation and dyspnoea caused by the pea-sized, whitish nodules on the tracheal mucosa as reported by Clapham (1935b) and Fabiyi and Offiong (1979).

According to Wehr (1937b), the worms attached to anywhere in the trachea in experimental infections, while in the natural conditions, the parasites were usually located in the lower half of the trachea. In the present study, examination of the affected tracheas has shown that the parasites were seen throughout the trachea, majority of them being located posteriorly, both in the natural and experimental infections.

It was found out from the present investigation that the larvae of S. trachea were responsible for the condition known as 'Syngamus pneumonia' and early mortality in young

chicks, as demonstrated by Clapham (1939a). The lungs showed consolidation and cloudy white areas with haemorrhagic spots and infiltration of inflammatory cells as noticed by Guilford and Herrick (1954). Catarrhal haemorrhagic tracheitis, invasion of the male worm into the tracheal cartilage, dissolution of the cartilage, infiltration of lymphocytes, eosinophils and mononuclears around the zone of necrosis surrounding the parasite were some of the histo-pathological findings noted, as observed by Clapham (1933b), Wehr (1937b), Guilford and Herrick (1954), Fernando et al. (1971) and Valenza (1975).

During the present work, efficacy of the following four drugs tried against S. trachea in chicken was assessed.

Mebendazole.

Mebendazole given at the rate of 40 mg per kg body weight orally was found to be effective in removing the adult parasites. The percentage of efficacy was 96.22, 80.10 and 95.52 based on the egg counts, worm counts, and gain in weight respectively. Varga (1973) noticed 100 per cent efficacy for this drug against the worm at a very high dose of 100 mg per kg. Thienpont et al. (1973), Schricke et al. (1973) and Zurliiski (1983) had administered mebendazole in feed to turkeys and pheasants with success in controlling both the adult and migrating stages of the parasite. No adverse reactions were manifested by the treated chickens. This drug was found to be the most effective among the four drugs used.

Thiabendazole.

Thiabendazole given at the rate of 500 mg per kg body weight was 89.27 per cent, 45.24 per cent and 94.18 per cent effective based on the egg counts, worm counts and body weight gain of the treated birds respectively. But according to Euzeby (1963) and Grafner et al. (1967), it failed to show any efficacy against the worm in chicken. Leibovitz (1962), Ward et al. (1968), Wehr (1967), Blanchard and St. Jacques (1979) and Fabiyi and Offiong (1979) had administered the drug in feed at the rate of 0.05 to 1 per cent and obtained an efficacy of 87.1 per cent to 100 per cent. This anthelmintic was less effective when compared to the other four drugs.

Albendazole.

Albendazole at a dose of 15 mg per kg body weight was 95.14 per cent, 76.19 per cent and 95.02 per cent effective on the basis of egg counts, worm counts and gain in weight respectively against syngamiasis in chicken. Though the drug has been used against lung worms of animals and gastro-intestinal parasites of poultry, by many earlier workers, nobody has tried to assess the efficacy of this drug against S. trachea in poultry. In the present study albendazole was found to be the second best among the four anthelmintics tried against the parasite.

Ivermectin.

Ivermectin given at a dose of 200 micrograms per kg body weight subcutaneously had an efficacy of 94.65 per cent on the basis of egg counts. Though the percentage of efficacy appears to be satisfactory, the drug failed to give any clinical cure to the treated birds. As in the case of albendazole, so far no reports have been obtained regarding the use of ivermectin against *S. trachea*. It has been used against a variety of both ecto and endoparasites in birds and animals. So the present study appears to be the first of its kind as far as its use against syngamiasis in poultry is concerned.

Regarding the irradiation experiments, though they were repeated twice, both the test groups and control groups of birds behaved similarly. No worm of any stage was present in any of the birds. This is contrary to the findings of Varga (1965) and Ziegler *et al.* (1973 and 1974), who could establish a satisfactory level of immunity in very young chicks dosed with eggs or larvae irradiated at 4 to 5 kR of X rays. The reason for the non-establishment of worms in the birds of the control group infected with non-irradiated eggs or larvae remains obscure.

Summary

SUMMARY

A detailed study on the prevalence, life-cycle, pathogenesis, treatment and control of Syngamus trachea infection in chicken was carried out during a period of one year and the following observations were made.

1. Season had a direct influence on the occurrence of the infection. The infection was more severe and widespread during the monsoons extending from June to November (2 to 14.7 per cent) and less during the summer extending from December to May (0 to 4 per cent) with an average incidence of 5.4 per cent. A very high percentage of the birds infected were in the age group of 1 to 2 months. Birds under the free-range system of rearing were observed to be more exposed to the infection than those kept under the deep litter system. Infection occurred in all kinds of chicken irrespective of the breed.

2. The eggs became infective seven days after setting up cultures. The larvae, if hatched out were also infective. About three thousand infective eggs or larvae were required to establish infection in day-old chicks. Infection could be established by direct oral administration of the infective eggs or larvae without the necessity of passing them through transport hosts like earthworms, snails, slugs, etc.

3. The infective larvae reached the lungs within 12 hours of infection. Moulting to the fourth and fifth stages

occurred on the fifth and sixth day of infection respectively. Sexual union took place in the lungs on the seventh day and also after migrating to the trachea. The sexually united pairs as well as the single ones migrated to the trachea from the eighth day onwards. The worms matured and started laying eggs after 18 to 22 days under experimental conditions.

4. Extending the neck, opening the beak and gasping for air were the characteristic symptoms exhibited by the infected birds. They were shown from sixth day following infection. Mortality from asphyxia due to obstruction of the trachea was also noticed. Varying numbers of worms in copulo ranging from 2 pairs to 94 pairs were recovered on necropsy of affected birds. Severe haemorrhages, inflammatory changes, accumulation of mucus and discrete white nodules were seen in the trachea. Histologically, dystrophy of the mucosa, fibrosis of the epithelium and infiltration of the inflammatory cells were observed. Lungs and bronchi also showed almost similar changes noticed in the trachea. In addition to this, larvae of different developmental stages were present in the lung tissue.

5. Some infected birds showed neither clinical signs nor eggs in the faeces and some passed eggs in faeces without manifesting any clinical sign. So the direct examination of the trachea for the presence of worms is more reliable for a specific diagnosis.

6. Out of the four anthelmintics, namely, mebendazole (40 mg per kg body weight), thiabendazole (500 mg per kg body weight), albendazole (15 mg per kg body weight) and ivermectin (200 micrograms per kg body weight) tried against *Syngamus trachea* infection in chicken, mebendazole was found to be more effective with 96.22 per cent reduction of eggs in the droppings, 88.10 per cent of disappearance of worms in the trachea and 95.52 per cent of weight gain of the treated birds. This was closely followed by albendazole with an efficacy of 95.14 per cent, 76.19 per cent and 95.02 per cent in the respective three parameters. Thiabendazole showed an efficacy of 89.27 per cent, 45.24 per cent and 94.18 per cent while ivermectin had an efficacy of 94.65 per cent, 18.19 per cent and 66.45 per cent on the reduction of eggs, disappearance of worms from the trachea and gain in weight of the treated birds respectively. Thiabendazole and ivermectin were found to be the least effective.

7. In order to study the effect of irradiation on the development of larvae of *S. trachea*, 3,000 infective eggs or larvae were irradiated at 5 kR and administered orally to 12 day-old chicks. A control group administered with non-irradiated eggs or larvae of the same dose was kept under identical conditions. Both the experimental and control groups behaved in the same way. There was no parasitic development in any one of them as detected at autopsy. Since the experiment did not produce any definite result it was concluded that, this aspect requires further study.

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BIOLOGY, PATHOGENESIS AND CONTROL OF SYNGAMUS TRACHEA INFECTION IN CHICKEN

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ABSTRACT OF A THESIS

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ABSTRACT

In a study conducted for a period of one year on the biology, pathogenesis and control of Syngamus trachea infection in chicken, it has been found that the infection was more in very young birds below 1 to 2 months of age, reared under the free range system and during the monsoons.

The egg cultures became infective on the seventh day of culturing. A dose of 3,000 infective eggs or larvae was found to be suitable for a successful establishment of infection in chicks. Experimental infection could be set up by the direct feeding of the infective eggs or larvae without the necessity of the intervention of any transport hosts like earthworms.

A detailed study on the stage to stage development of the parasite was carried out. They established in the trachea by the eighth day and attained patency 18 to 22 days following infection. Gaping movements, nodular growths on the tracheal mucous membrane, haemorrhage and production of mucus in the trachea, consolidation and ecchymosis of the lungs were the chief clinicopathological symptoms observed.

Anthelmintic efficacy of mebendazole, thiabendazole, albendazole and ivermectin was assessed on the basis of the reduction of ova in the droppings, disappearance of worms from the trachea and gain in body weight of the treated birds. Mebendazole administered at 40 mg per kg body weight was found to be the most effective among the drugs tried closely followed

by albendazole given at 15 mg per kg body weight and then thiabendazole at 500 mg per kg body weight. Ivermectin dosed at 200 micrograms per kg body weight subcutaneously was found to be the least effective.

Assessment of the effect of irradiation at 5 kR on the development of _S. trachea_ in chicken was attempted twice with no conclusive results.

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