HISTORICAL RESUME

The literature reveals that most of the authors in referring to this parasite used the name *Heterakis gallinae* (Gmelin, 1790). The author, actually placed this worm with the genus *Ascaris* and named it, *Ascaris gallinae*. In 1791, Froelich described it again and called it as *Heterakis vesicularis*. The parasite was redescribed by Freeborn (1923) who gave the name *Heterakis gallinae*. Madsen (1949) made a review of the whole literature and brought in some facts regarding the nomenclature of this parasite. The author revealed that Gmelin (1790, p. 3034) based his study of the worm with reference to Goeze's (1782, p. 86) description which later proved to be a species of *Ascaridia*, probably *Ascaridia galli* (Schrank, 1788). Goeze, separately described a worm (Plate 1, Fig. 4) which appeared to be the common *Heterakis* worm of poultry. Schrank (1788, p. 9), with correct reference of description and figures of Goeze, redescribed it under the name *Heterakis gallinarum*. Hence, on priority basis the proper name for the *Heterakis* of fowl is now mentioned as *Heterakis gallinarum* (Schrank, 1788) Madsen, 1949.
The parasite has a wide distribution. Clapham (1933) recorded a host list comprised of representatives from 20 genera and 33 species. The intensity of infestation under natural conditions vary in different parts of the world. A number of workers recorded fairly heavy percentage of infected forms. Dujardin (1845) examined 190 chicken and found 56.8% infested. Ackert (1917) working at Manhattan, Kansas examined 395 chickens and found an incidence of 74.1%. Riley and James (1921) in two separate counts in Minnesota recorded percentage infection by 78.1% and 62.9% respectively. Dorman (1928) examined in two separate groups of 76 and 19 chickens, the first group was found to have a percentage of 68.40. The other group also presented the same percentage of infection. This record is strikingly similar to those of Ackert and of Riley and James. The first group of material came from two possibly different types of environments, the University of Illinois poultry farm and a commercial poultry house, and was collected from 23rd February, 1923 to 10th April, 1926. The second group came from poultry dealers in Rochester, Minnesota and was collected from 4th October, 1926 to 11th November, 1926. It is significant that the data obtained in the two localities were similar and fall between the results obtained by Ackert, Riley and James. Clapham (1933) reported 75.2% infection in chickens and recovered from a single to nearly 700 worms from individual host.
Savchenko (1959), while working in Krinonozoh in U.S.S.R., studied the seasonal dynamics of *Heterakis* infestation in domestic fowls. He made a monthly examination of ten chickens which showed that in adult birds the lowest infestation occurred in January to March and the highest in July to August, and again it falls in December. In the case of young birds the condition was different, the heterakids were first found in June and highest infestation occurred in August to September, falling again by November.

Norton (1964) who worked at the central laboratory, England, reported 77% of the domestic fowls infected with *Heterakis gallinarum*, with an average number of worms per infested bird was 174, and worm burden ranged from 1 to 3760, the last figure, however, included many juveniles. He also expressed doubt about the occurrence of any seasonal variation.

However, there are only two exceptional reports which give low percentage in the incidence of infestation of this parasite. One is given by Roth (1903) who, while working at Bresban, Germany, examined a total of 230 chickens and reported 13 of it infested with this parasite i.e., an incidence of only 5.6%. Then Hodasi (1969) reported an incidence of only 10.2% and low intensity of infection in the native population of fowls in Legon, Ghana.
Morphology of Heterakis gallinarum has been studied by Chitwood (1931), Clapham (1933) and Baker (1936); and except the last named author, rest have given brief descriptions of the worm. The study made by Baker is the only available literature on the anatomy of this worm.

Considerable difference of opinion has been found regarding the development and life cycle of Heterakis gallinarum. First and most profound observation on the development of ova, under natural conditions, and using both solid and liquid media, was made by Graybill (1921). He observed, that the critical range of temperature for the development of egg in culture of salt solution and sugar was 8 to 11°C. Eggs at room temperature i.e. 19 to 21°C developed into complete embryos within 8 days, while other cultures at 18-26°C produced complete embryos between 8-12 days. His list on the resistance of undeveloped eggs to cold, indicated that development of egg continues once they are removed from freezing conditions to room temperature. Embryos kept in salt solution at room temperature survived 12 months, while fully developed ova kept in soil under natural condition retained living embryos even after a period of 8 months. Uribe (1922) made comparable observations on the temperature requirements for the experimental incubation of the eggs of Heterakis papillosa and expressed complete agreement.
with those of Graybill. He also added valuable information that the ova developed uninjured in 1.5% nitric acid and the media kept the ova bacteriologically sterile thereby preventing entry of *Histomonas* pathogen. Dorman (1928) made a detailed study on the cleavage and segmentation of ova of this worm. According to his observations the cleavage is equal, 32-cell stage is completed within 4 or 5 days at 19-21°C. Blastula is formed in 16-cell stage, invagination is initiated in 32-cell stage with the formation of ectoderm, endoderm and blastopore. The most complete study on the development of ova of *Heterakis gallinarum* was made by Clapham (1933), who reported that development is completed in 14-17 days under favourable conditions. A fairly wide range of temperature from 20 to 30°C is tolerant. The development is also normal in various dilute solutions of acid and disinfectant and suggested the use of 1% formalin which kept down the bacterial growth. Eggs remain viable in such solution even for 7 months. Roberts (1937) reported that the development to the infective stage is reached in 5 days if incubated at 33°C. Wickware (1940) examined the effects of freezing temperature on the embryonation and found ova retaining the infectivity even upto 172 days in such conditions. Osipov (1957) reported the ova reaching the infective stage in 78 days when kept at 10-15°C under laboratory conditions; and the period was
reduced to 6 days at 35°C. Lund et al. (1958) studied the effects of media, viz., physiological saline, 1.5% nitric acid, 1% formalin and 2% potassium dichromate on the embryonation of *Heterakis gallinarum* ova and its subsequent development in the chickens. All permitted satisfactory embryonation, but the number of worms recovered from chickens fed to eggs from the dichromate solution was less than 1% of the number of eggs administered from the 3 other media. The percentage of eggs which embryonated was highest in 1% formalin.

Considerable variation exists regarding the course of development of *Heterakis gallinarum* within the host and completion of its life cycle. Generally it is believed that the life cycle is direct, development of the juveniles taking place in the lumen of the caeca. Few have suggested complication in the development processes and there are authors who believe the definite involvement of some vectors in the completion of its life cycle. Leuckart (1876) was the first to initiate the investigation on the life cycle of this worm. He fed eggs which had incubated about 120 days to a chicken and on autopsy after 31 days, about 15 specimens were recovered. Galli-Valerio (1898) and Leutulle and Marotel (1909) reported about the possible formation of cyst in the caecal wall. Riley and James (1921) and Graybill (1921) found that the embryos hatch out in the small intestine and development is
completed by the 24th day. Uribe (1922) expressed his view that the worms obtained 56-61 days after the ingestion of the ova were considered to represent the complete adult stage. Presence of a stage of parasitism within the tissue of the host during the course of larval development has been suggested by Monnig (1927). Dorman (1928) made his observations that the host gets infection by ingesting ova which have undergone incubation and adult worms capable of producing ova may be removed in about 36 days. Itagaki (1930) concluded from the results of his experiments that the juveniles hatch in the proventriculus in 36 hours and begin to penetrate the caeca on the 4th day. Some of the juveniles penetrate the caecal glands, form nodule and attain maturity. He explained that development to the adult stage is preceded by an early migration of the juveniles through the subserous and muscular coats. Baker (1933) studied the post embryonic development and expressed general agreement with earlier workers. The author, further, indicated that the variations in the normal development was due to the appearance of Histomonas pathogen in the host. The most complete study on the life cycle of this worm was made by Clapham (1933) who explained that the first stage which was a rhabditiform larva remain confined within the shell. First molt occurred in the shell and the infective stage embryo with a filariform oesophagus developed.
Hatching took place in the caeca and 2nd molt occurred after 48 hours of the initial infection. After about 96 hours, 3rd molt took place and differentiation continued. Fourth molt was completed on 10th day and young adults emerged out typical in all morphological respects, and eggs could be found in the faeces at about the 24th day from the initial infection.

The author also investigated the possible migration of juvenile in the host tissue during the course of their development as reported by earlier workers, and discarded it completely. Migration of juveniles within the host was reviewed by Madsen (1962) who concluded that the juveniles instead of having a normal course of development enter into a tissue phase involving the mucosa and submucosa layers and later return to the gut lumen.

Indications are also available about the completion of the life cycle involving an intermediate host. Frank (1953) had shown that Musca domestica and Lucilia sp. can carry embryonated eggs of the worm from one host to another mechanically. He has also demonstrated experimentally that the grasshoppers which are eaten in large number by turkeys can carry the eggs in their gut for 96 hours and can initiate development. Recently Lund et al. (1966) reported that the earthworm can transmit infection among turkeys serving as vector.
Much of the literature is available on its association with diseases. It was observed by Riley and James (1921), Van Es and Martin (1923), Beach and Freeborn (1930) as the causal organism of Typhlitis among poultry. Morgan and Wilson (1938) reported 'Tuberculosis' of poultry due to this parasite. Clapham (1938) noted advance stages of Leukaemia in fowls with heavy infection of this worm. Dauglieva (1966) noted the haematological changes in the blood of the host in a way that the amount of the total protein decreased and there was an increase in globulin fraction simultaneously.

Graybill and Smith (1920) reported that enterohepatitis or black-head, a highly infectious and fatal disease, caused by protozoan parasite, Histomonas meleagridis, could be induced by feeding young turkeys with embryonated eggs of Heterakis gallinarum. Their suggestion was conferred by Tyzzer (1934) who reported the identification of the protozoan in the epithelial cells of the gut of a young nematode. Under field conditions population of Heterakis nearly always carry Histomonas pathogen, as the protozoans are capable of surviving only for short duration outside in the poultry farms, unless they are localized in worm's egg. Majority of the hosts thus become infected with the parasite, so much so, that according to the
estimates of Lund (1958) about 1000 ova are sufficient to induce Histomoniasis in at least 90% of the fowl population.

There are conflicting reports on the association of the juveniles and the worms with the wall of the caeca and its glands. Most of the workers believe that the larvae remain in intimate association with the wall of caeca and some of these actually penetrate into the mucosa layers which leads to the formation of nodules; whereas, few are of the view that the worms do not have any tissue phase at all.

First report on the formation of caecal nodules due to this parasite was given by Itagaki (1930) while making an aetiological study of these nodules. The author observed that in early stages of their formation the juveniles penetrate the sub-mucosa from the caecal glands and encyst in the muscular layer where these continue to grow. Baker (1931) also reported the formation of nodule in the caeca of fowl infected with Heterakis and suggested that the initial cause of nodule formation may be parasitic or bacterial, the irritant acting on the caecal glands of the mucosa led to the thickening, which later transformed into larger nodule formation. But Clapham (1933) expressed doubt about the formation of any lesions or nodule in the caeca due to this worm. Further, Wickware (1947) while working on the same problem observed that even in the case of caeca free from
'Heterakiasis' the caecal lesions were present which led him to believe that the nodules were not caused by the worm but due to some other reasons not known.

Grigorev (1959) studied the pathogenicity of Heterakis infection in detail and described the formation of two types of nodules in the caeca of the fowl, one is the uncomplicated nodules lymphoid or lymph glandular type, and other nodule complicated by Heterakis infection. The affected mucosa showed infiltration of lymphoid cells and necrosis of the epithelial cells. In the liver, hyperemia of the vessels, hyperlasia of the lymphoid cells and eosinophilia were observed. He believed that some of the adults enter in the already formed nodules and thus cause atrophy and necrosis of the epithelial cells. Meads and Taylor (1963) examined caeca of the birds infected with Heterakis and found it enlarged and spotted with lesions, each containing an immature worm. They also suggested vitamin A deficiency as a contributing factor in the production of these lesions. Nath and Pande (1963) have reported erosion of caecal wall due to the presence of adult worm. Their information is based on the study of 'Heterakiasis' in nature. Kaushik and Sharma Deorani (1969) demonstrated the formation of nodule during their study on the tissue response of Heterakis gallinarum infection in chickens.
Because of the absence of precise knowledge concerning the life processes of *Heterakis gallinarum*, very little information is available on its control and other preventive measures. A number of chemicals were utilized in the control operation and with the exception of phenothiazine which was partially successful, no other drug initiated a dependable efficiency. First report on the use of phenothiazine was given by McCulloch and Nicholson (1940) who suggested that 0.05 to 0.5 grams is a satisfactory individual dose with average effectiveness ranging from 95 to 100% and that the large and repeated doses are non-toxic. Olivier et al. (1943) were of the view that an intake from 0.5 to 1.0 grams of phenothiazine within 6½ to 7½ hours to individual poults is necessary for complete removal of the worm. Guthrie and Harwood (1942) observed that tablets containing 33 parts of phenothiazine, 66 parts of nicotine bentonite and 1 part of sodium stearate were found to be very effective in removing most of the worm from the host. Wehr and Olivier (1946) reported the inability of phenothiazine to prevent maturation of the worm, and is effective in expelling the worm only when these attain maturity. A new chemical Enheptin-T was introduced by Horton-Smith (1951) against heterakis infection. Anthelmintic activity of Piperazine citerate was tested by Shumard and Eveleth (1955) against *Heterakis gallinarum*.
infection and was found to have little efficacy. Larson and Hansen (1957) also found piperazine to be least effective against heterakids, but gave promising results in reducing the incidence of typhlitis. Sub-cutaneous injection of 90% w/v solution of methyridine in water at the rate of 1 ml per 10 pound body weight was advised by Fernando and Jayasinghe (1963) as an effective control measure against this infection. Schanzel and Hubacek (1964) reported a 0.5% aqueous solution of Methyridine as highly effective when given orally. Fedotova (1969) used Hygromycin B as an anthelmintic against Heterakis gallinarum and found 75 - 90% effective.