(c) *Metazoan Infestations*

CHAPTER 12

ANKYLOSTOMIASIS

THE significance of hookworm infestation was clearly realised by Australian physicians, hygienists and pathologists long before the war, largely owing to the stimulation and assistance of the Rockefeller Commission. It was known to be endemic in the Pacific Islands, and infestation was expected among the troops once New Guinea became a combat area. In the Middle East it had not been a significant problem, though hookworm was known to be endemic in certain parts of Syria. Here, however, the most affected areas were near native settlements, and opportunities for infection were limited. Active military operations against Japan brought the subject into prominence. Hookworm was occasionally found among troops in New Guinea during the earlier war years, and by the close of 1942 the finding of ova in the faeces was not uncommon. In the Northern Territory of Australia, too, the Deputy Director of Medical Services issued a warning that the parasite was common among natives and that conditions were ripe for infection of soldiers. Preventive measures were taken to lessen possible contacts of bare skin, particularly of the feet with contaminated soil containing embryos hatched from hookworm eggs.

During and after the first New Guinea campaign ankylostomiasis was much more common, and routine microscopic examination of the faeces revealed ova in large numbers of soldiers returned to Australia either for wounds or overt illness or for rehabilitation.

The Medical Journal of Australia on 8th June 1943 reviewed the work done in the past on this disease in Australia, described governmental measures of action and control, and pointed out its possible importance in the future. Technical Instruction No. 53 was issued by the Director-General of Medical Services, Army, and later a supplementary instruction No. 73. The former of these pointed out that in a group of 130 patients with malaria examination of the blood showed eosinophilia in 31, and in 14 of these hookworm eggs were found in the faeces. Both on the mainland and in New Guinea the *Anchylostoma duodenale* and *Necator americanus* were known to be present: their life history was recounted in the instruction and the symptomatology described. Only the latter parasite was known to cause "ground itch". This eruption, chiefly affecting the feet, and less often the hands, arms and buttocks, caused great itching and burning with formation of vesicles within 48 hours, and later redness and swelling of tissues and a rash lasting some two weeks. The possibility of infestation by *A. braziliense* was also touched upon in this instruction, with its curious "creeping eruption". The general symptoms were, however, of greater importance; at the one extreme were the carriers, who merely exhibited eosinophilia and passed ova over a long period of months, and

at the other men with severe infections with intense fatigue, malaise, loss of weight, earthy pallor, epigastric pain and tenderness, enlarged liver, and, most important of all, severe anaemia, always of the microcytic type. Between these extremes lay the persons with the mild infections; even in these there might be infestation by some 500 worms. Abdominal discomfort characterised these, with dyspepsia, epigastric tenderness and anaemia, all of which might not become evident until after a latent period of perhaps six months.

At this time reports were received from all hospitals in New Guinea and on the mainland of the occurrence of ankylostomiasis. In the 17-mile area at Moresby at the 5th Casualty Clearing Station and the 2/9th Australian General Hospital both hookworm and ascaris eggs were frequently found in the faeces of soldiers who had been engaged in the recent campaigns, and similar results were later reported from other hospitals, the 2/5th and the 2/1st Australian General Hospitals near Moresby. Certain areas were found to produce the infection more than others. Buna, Sananda and Kokoda were evidently heavily infected, and many cases were also seen from Milne Bay, where the neighbouring villages were centres of infestation.

In Australia all hospitals in Queensland made similar observations. The syndrome described included eosinophilia, anaemia, epigastric discomfort and vague indigestion. A special report was compiled at the 117th Australian General Hospital in Toowoomba. Eosinophilia had attracted the attention of the physicians here and an investigation was carried out to ascertain the frequency of hookworm. Two thousand patients were examined, 1,600 of whom had come from New Guinea. One thick smear of the faeces was examined microscopically, and one specimen concentrated after the method of Willis. Repeated search was made only when gross eosinophilia was found, so that the incidence was certainly somewhat greater than that calculated. The average number of eosinophile leucoytes in the blood was 1,800 per cubic millimetre. In this group 800 were infected by hookworm, 18 by *Strongyloides,* 1 by *Ascaris,* 1 by *Trichostrongylus,* and 2 by tapeworm. The men concerned had been in hookworm-infested areas for periods ranging from a few weeks to 18 months, with an average of 4 months. In 50 patients a count showed that most of them had less than 20 female worms. Survey of the members of the military units to which these men belonged showed evidence of intense local infestation. In one instance 97 out of 99 in one unit were infected, and four brigades showed 60 per cent infection. In this series there was no history of ground itch. Except in one case anaemia was not present, but occult blood was usually found in the stools.

Culture of hookworm eggs was carried out by the staff of the Tropical School in Sydney: this showed that of 30 specimens examined half were *A. duodenale* and half *Necator americanus. A. braziliense* was demonstrated by animal experiments in two instances. In the early stages of this infestation cough was noticed in some patients, and X-ray films of comparable density demonstrated some temporary loss of translucency in the

perihilar regions, due probably to the changes associated with passage of larvae through the pulmonary circulation and air passages. Observations here and at other hospitals showed how little consistent was the degree of eosinophilia, which did not correspond with the density of the infection. Ova were occasionally found without any accompanying eosinophilia, and high eosinophile counts were found in patients who did not excrete demonstrable ova. At the 116th Australian General Hospital one patient was found to have 54 per cent eosinophilia.

At this time, 1943, it was believed that hookworm infestation would not prove of military importance, as the density of infection was relatively low, and the period of exposure was limited in endemic areas. Certainly little trouble was occasioned on the whole, and when the men recovered from relapsing malaria and other infections they were in good health as a rule, and were not anaemic. Some discussion arose as to the standard of cure. The treatment advocated officially was the administration of a specific vermifuge, tetrachlorethylene, carbon tetrachloride or oil of chenopodium, or a combination. After saline purgation the stools were examined, and if possible the worms counted. After 7-10 days, if re-examination of the stools showed that ova were reappearing, a further course of treatment was advised. One difficulty about this was that the drugs recommended were rather scarce, and hospitals had difficulty in obtaining all of them. Combinations of carbon tetrachloride 3 c.cm. or tetrachlorethylene 4 c.cm. with 1 c.cm. oil of chenopodium in an emulsion of magnesium sulphate in water were found to be most effective. These mixtures caused no toxic reactions and yielded up to 70 per cent of successful results. The best single drug was found to be tetrachlorethylene, but the addition of chenopodium improved it. The latter was supposed also to be useful for *Strongyloides* infestation, which was found in small numbers at this time.

Another difficulty arose in connection with repeated treatment. A certain proportion of persistent infections occurred, and the question was raised whether patients should be discharged when still passing hookworm eggs. It was neither practical nor desirable to keep them in hospital, as the number of worms they harboured was small, and constituted no special danger to themselves or others. Therefore the presence of hookworm ova *per se,* without any clinical signs of ill health, was not regarded as a reason for continued efforts to dislodge the last worm.

Later in the island campaigns more severe infestations of hookworm were encountered. These came from other areas, particularly in Bougainville. Early in 1945 the 2/1st Australian General Hospital reported that the number of cases was increasing, and a further increase was expected. Though many of the men had mild symptoms only, there were numbers seen who suffered from a very acute infection. This was apparently by the *Necator americanus,* as severe ground itch was experienced, usually on the lower part of the body, and coming on in a few minutes after contact with the soil of infected areas. In this area there was evidence of recent Japanese occupation, and it seems likely that heavily infested troops

had fouled the ground shortly before. Five to seven days after the itching cough was noticed, and later epigastric pain. Lieut-Colonel Sangster, of this hospital, records that this pain was sometimes quite severe, and that its onset was usually several weeks after the pulmonary symptoms. Searches for ova were not successful till over five weeks after the itch. Eosinophilia was as a rule of high degree. In a few instances ova were never found in the stools, as in one patient from 2,500 adult worms were recovered in four specimens. Higher worm counts have been found: one patient had 3,500. The most striking feature of this series in Bougainville was the occurrence of a few very acute anaemic states of rapid onset due to hookworm. In one, lung abscess occurred, and in several of these patients blood transfusion was necessary, as vermifuges alone were not sufficient to restore health even with massive doses of iron.

Similar experiences were reported from other areas at the same time. At Jacquinot Bay a survey showed an infestation rate of about 13 per cent. Eosinophilia was present in all infected men: similar degrees of eosinophilia were found in a series of men with skin diseases, but whether the two were related or not was not determined. At Aitape in the autumn of 1945 numbers of cases were also seen. Some men needed a couple of weeks in hospital, the symptoms suggesting a continuous syndrome. An irritating cough often persisted for several weeks after the removal of the worms from the alimentary tract. Two patients showed a radiographic picture of pulmonary infiltration which subsided within a month. A suggestion was made at this time that the increased incidence of hookworm in the 6th Division might account in part for the increase of malaria, assuming that the presence of the worms could hinder absorption of atebrin. No evidence of this was found.

During the operations in Borneo hookworm also occurred, the signs and symptoms conforming to the usual pattern. An attempt was made to hatch worms at Balikpapan, but without success, so the type could not be ascertained. Bougainville appeared to be the most heavily infested area occupied by the Australians in the South-West Pacific Area.

Some of the important points emerging from these experiences with *Ankylostoma* are the need for thinking of hookworm in the presence of eosinophilia, for realising that heavy infestation may be present even though ova are not found in the stools, and for remembering that this may occur even within a comparatively brief period if the degree of infestation of the local area is sufficiently high. The indications for treatment were taken to be the finding of ova, unexplained eosinophilia, with abdominal symptoms, ill health or anaemia.

Infestation rates varied: a survey of the 1st Australian Infantry Brigade showed a rate of 28.5 per cent. In some individual units the rate was much higher; the risk of infection from natives was illustrated by the finding of a 100 per cent infection rate in the Angau Hospital at Finschhafen in 1944. Infestation rates also varied according to the stage at which patients were examined. For instance, "tropical eosinophilia" appeared at Tarakan, with gradual onset, malaise, fever, colicky upper

abdominal pains, nausea and vomiting. The liver was tender but not enlarged, and eosinophile cells varied in number from 11 to 84 per cent of total leucocytes. Nothing else was found, but of the diseases endemic in such areas hookworm was the most likely.

The 8th Division as prisoners of war also suffered from hookworm. Dunlop records that 20 per cent of men examined in camps in Tamarkan, Chungkai and Tamuang in Thailand had hookworm. During the wet season this percentage increased; this was not surprising, as many of the men had no boots and worked barefoot. Here, too, infection by *Strongyloides stercoralis* was very prevalent, affecting about half the men. At Nakom Paton in July 1945 Fisher noted an outbreak of ground itch. Thirty men who had been working in a vegetable garden manured by human faeces simultaneously complained of intense itching of the feet. Many of them had a vesicular eruption. After several days they had an acute respiratory disturbance with substernal discomfort, fever, and cough with occasional sputum, but no objective signs in the lungs. A few instances of creeping eruption of the feet were seen.

During eighteen months at the hospital at Nakom Paton *Strongyloides* was the commonest incidental finding in hundreds of microscopic examinations of stools. It was suggested that this may have caused the creeping eruptions as *Ankylostoma* was uncommon there.

There were, of course, great regional variations in the distribution of these parasites. After the liberation of these prisoners those who passed through the 2/14th Australian General Hospital were examined for intestinal parasites, and the percentages of infestation found were *Ankylostoma* 25 per cent, *Ascaris* 12 per cent, and *Strongyloides* 8 per cent.

STRONGYLOIDES STERCORALIS

This worm has been mentioned already. It was found in many men coming from many areas in the South-West Pacific and South-East Asian zones. A study of sixteen cases of this infestation was published by Lowe and Lancaster. They pointed out that the parasite is known to exist in Queensland. Heydon and Green in 1931 found white people in the Atherton Tableland to be infected, and it has been occasionally reported elsewhere. Though resembling *Ankylostoma* in its general habits it has been found more resistant to treatment, and therefore more prone to give rise to sequels which are truly recurrences. The ova hatch before or shortly after entering the lumen of the bowel, and as a rule are seen only after diarrhoea or purgation. Rhabditoid larvae are produced which become filariform, usually after evacuation, and at this stage are able to penetrate the skin. Re-infection may occur by the larvae entering through the perianal skin, thus perpetuating the cycle. Erythema or petechiae may be produced in the skin or perianal region like ground itch.

In the 117th Australian General Hospital Lowe and Lancaster found about a quarter of the patients had some skin irritation at the time of infection. Pulmonary symptoms and abdominal discomfort were common.

Eosinophilia was usually of a higher grade than with *Ankylostoma,* ranging from 1,100 to 12,600, with an average of 4,300 per cubic millimetre.

Treatment was more difficult than for hookworm. Gentian violet was tried, 1 grain thrice daily for two periods of eight days with a week's intermission, also preparations of antimony and emetine, as well as the usual vermicides, but the results were not very satisfactory. As with hookworm some residual worms were hard to dislodge, and the possibility of reinfection made cure hard to attain.

In Burma and Thailand the risk of infection was great as can easily be seen, and treatment being limited by slender and often absent resources, recurrences were common. At Ye in Burma investigation showed a 50 per cent infestation rate. Even simple preventive measures such as protection of the feet were difficult to carry out. Observation of men with relapses has shown that abdominal disturbances are common, including diarrhoea. Associated infections by *Entamoeba histolytica* have been found fairly often. A series of 30 men who had worked in muddy unhygienic conditions in Thailand were investigated. All had diarrhoea of compulsive type, but had a history of dysentery. Microscopic examination revealed larvae in 24, larvae and ova in 5 and ova only in one. The rhabditoid larvae were sometimes seen up to 70 per field. More evidence of infestation was found where mess orderlies were infected.

ASCARIS LUMBRICOIDES

This round worm was occasionally found. In Burma and Thailand it was not uncommon as the figure quoted above for one area shows. In Syria the incidence among the native population was known to be high; it was reported to vary from 5 to 35 per cent in various areas. Abdominal disturbances and vomiting sometimes appeared to be caused by this worm. Treatment was not always satisfactory, even with the recognised vermifuges. Santonin was not always obtainable, but was as a rule effective. Oil of chenopodium was believed to be more effective for *Ascaris* and *Strongyloides* than other drugs, hence its inclusion in the "cocktail" draught usually employed. Gentian violet, introduced into the Middle East formulary for thread worm infestation was also tried, but without apparent success.

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