

THE INFLUENCE IN HOOKWORM INFECTION OF THE SPECIES OF WORM AND OF THE RACE OF MAN AND ON THE CHARACTERS OF THE LARVÆ AS A MEANS OF DETERMINING THE DATE OF SPECIES DISTRIBUTION.

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Introductory Remarks.

The two hookworms proper to man, *Ancylostoma duodenale* and *Necator americanus*, usually placed at present in different subfamilies, differ considerably in morphology. The differences of a physiological nature at present known will probably be added to by future inquiry. Of these the most important is the well established fact that *Ancylostoma duodenale*, the cause of the classical examples of severe hookworm disease in tunnels and mines and of Egyptian chlorosis, is more pathogenic than *Necator americanus*. This difference was particularly investigated by Darling and others⁽¹⁾ in Malaya.

It is rather surprising that several of the best known modern text books on tropical diseases and parasitology neglect to emphasize or even to mention that the two worms are not of equal importance as producers of disease. Some hookworm campaigns have been carried through and elaborately reported on without mention of the species of worms concerned.

As to what degree of pathogenicity is possessed by *Necator americanus* there is even today great diversity of opinion, ranging from the belief that all infections even the lightest probably do harm to the view that the worm is practically innocuous whether present in small numbers or large. This sceptical attitude is probably to be found most frequently in medical men working among some of the black and brown races. The middle position, commonly held and supported by the International Health Board of the Rockefeller Foundation is that a few worms, especially if necators, do no appreciable harm but that many, even if necators only, cause more or less evident amounts of anæmia and other physical and mental damage. This is the often emphasized distinction between hookworm infection and hookworm disease.

The variety of opinion is doubtless partly explained by the fact that tolerance of infestation varies enormously with the diet and the state of nutrition, with the severity of physical labour, with age, from unknown causes classed as individual susceptibility and probably also with race.

In much of the voluminous hookworm literature, a great deal of which deals with people infected solely or predominantly by *Necator americanus*, the question of pathogenicity is taken for granted or there is a tendency to be unconvincing. There are some notable exceptions, however, which seem to furnish convincing evidence of morbidity due to heavy infections with *Necator americanus* alone in the populations and under the conditions investigated. The conditions very often include under-nutrition and sometimes overwork.

Negroes and some of the other dark races may be in a different position. The original home of *Necator americanus* is believed to be Africa and the natives of tropical Africa and races connected with them in their origins may have acquired considerable tolerance throughout the ages during which they have harboured this parasite.

A laborious investigation into the effect of hookworm and other worm infections on adult male negroes has recently been carried out in Sierra Leone by Gordon⁽²⁾. No investigation was made of the species of hookworms concerned, but the author quotes other figures for a ratio of ten to one between *Necator americanus* and *Ancylostoma duodenale* in Freetown. The conclusions drawn by the author from his figures are that they reveal no effect of hookworm infection on the hæmoglobin percentage, the physique and general fitness or the mentality, but that they suggest the possibility of some relation between a low standard of energy and very heavy infections with more than about 600 worms.

Observations in New Guinea.

The writer during three years in the Mandated Territory of New Guinea was struck by the elusiveness of hookworm disease of which he had had no previous experience. The Melanesian and Papuan natives, before the extensive mass treatments later carried out, had an infection rate of 100% or near it with *Necator americanus* and the average number of worms harboured was considerable, probably in the neighbourhood of one hundred. *Ancylostoma duodenale* was absent except for a few introduced by the Chinese in recent times. In the course of a number of experiments on adult male natives on the efficacy of anthelmintics given under various conditions it was found impossible to pick out beforehand by clinical signs and general appearance the boys who had a thousand worms from those who yielded only a few. The same impression of the difficulty of foretelling whether few or many worms would be found was derived from a series of 230 *post mortem* examinations. In none of the patients examined for suspected hookworm disease while the writer was at the laboratory of the Commonwealth Department of Health in Rabaul did the condition turn out to be of this nature.

Although the effects of hookworm infection in the natives were certainly not obvious, it is fully recognized that a carefully planned investigation might have revealed a definite effect on the blood picture or the physical development. Such an investigation in natives where malaria is endemic and malnutrition not infrequent would need a great deal of time and care to produce really sound conclusions. While in New Guinea where his access to literature was limited, the writer was inclined to attribute the resistance of the natives to the fact that only *Necator americanus* was present. It seems certain; however, that this is an inadequate explanation and probable that some racial tolerance has been acquired throughout the ages which have probably elapsed since these peoples became infested with the worm in the days before their migration to the Pacific.

The Position in North Queensland.

In Townsville in the North Queensland coastal area a limited experience of ancylostomiasis has revealed a very different picture from that of New Guinea. The infection rate is far lower, but several patients with severe hookworm disease with very advanced anæmia have been seen and investigated. They have been white adults who have acquired heavy infections in the sugar farm districts. The cases of serious disease encountered so far, however, have been caused by *Ancylostoma duodenale*.

There can be no question that the investigation of ancylostomiasis in a country should include the determination of the prevalence and distribution of each species throughout it. In Queensland the position seems to be of particular interest as both species are present and seem to have an irregular or patchy distribution. Owing to the practical difficulties of applying the only method hitherto at their disposal, that of worm counts, the conclusions of the Australian Hookworm Campaign as to the distribution of the two species may require modification.

In North Queensland coastal area both species are common enough. Cases of pure or nearly pure infections with each species as well as mixed infections occur. The common occurrence of *Ancylostoma duodenale* was noted by Breinl before the days of the Hookworm Campaign⁽³⁾ and in the museum of this Institute are numerous specimens of both species collected by him. Of a number of observations recently made, one may be mentioned. Cultured larvæ were examined from two infected children in the Townsville Orphanage. In one who had come into the Institution from a district North of Townsville six months previously, only larvæ of *Necator americanus* were found, in the other who had been eight years in the Orphanage, only larvæ of *Ancylostoma duodenale*.

Hookworms have probably been imported into North Queensland from two main sources, *Necator americanus* by the Kanakas from the Pacific who formerly worked in the cane areas, *Ancylostoma duodenale* by southern Europeans of whom a good many are now settled in certain parts of the country. A certain number of both species have probably been brought in by the Chinese also. Remembering that the country is not thickly populated and the comparatively recent date of hookworm introduction we seem to have a probable explanation of the patchy distribution of the two species. What hookworms if any were originally harboured by the aborigines of Northern Australia is unknown and unfortunately it is now probably too late to find out. The Hookworm Campaign found *Ancylostoma duodenale* in some of them, but whether handed down from their remote ancestors or acquired in more recent times from Chinese or Japanese visiting the northern coasts can now probably never be known.

The Worm Count Method of Determining the Species Distribution.

The only method hitherto available for finding out the species distribution of hookworms in a country has been that of worm counts which consists

in the examination of the stools passed for two or three days after an anthelmintic. The method has obvious practical difficulties especially in a white community and cannot be applied on a large scale even to native races. The difficulties met with doubtless explain the meagreness of information as to species often noticeable in reports of foreign hookworm surveys.

The Method by Examination of Larvæ from Fæcal Cultures.

A more practicable method is evidently needed. Several writers have described differences between the larvæ of *Necator americanus* and those of species of the genus *Ancylostoma*, although others have reported that no easily recognizable differences could be found. The eggs of *Necator americanus* and *Ancylostoma duodenale* also differ in measurements, but not sufficiently to afford a means of determining the species without the laborious process of measuring large numbers and plotting the results.

The writer has made a study of the "mature" larvæ, that is those which have reached the infective stage beyond which no further development takes place outside the body of the host. As a practical diagnostic method it is much more convenient to work with this stage than with the earlier ones when the morphology of the larvæ is rapidly changing. It has been found that the differences between the mature larvæ of *Necator americanus* and those of *Ancylostoma duodenale* are in fact striking and readily seen after a little experience. The generic diagnosis can be rapidly made from either living or suitably preserved larvæ with an objective of one-sixth or one-third of an inch focal length or even with a two-thirds and a fairly high eyepiece.

Herein a sufficiently simple and practicable method of species determination is available in routine hookworm work and surveys. It has already been tried here on the specimens collected by one of the units of the Australian Hookworm Campaign. The small fæcal specimen ordinarily obtained in hookworm surveys is divided into two parts and if ova are found in one of them, the other is cultured with earth in which nematodes have been killed by heat. After about a week at a suitable temperature the larvæ are isolated by the Baermann method or a modification of it. One should be used which prevents the passage of any but the finest particles of earth. The larvæ are then mounted and examined either alive or suitably fixed and cleared.

By this method it can be determined readily which species is present or whether both are, provided the disparity in numbers of the larvæ obtained is not too great. In very light infections, of course, no larvæ at all may be got. Details of the methods of culture and isolation used which cannot be gone into here, affect the chances of success very much. The method at present throws little light on the relative numbers of worms harboured by an individual, even if the proportions of the larvæ obtained be found by counting. The relative egg laying rates of *Ancylostoma duodenale* and *Necator americanus* are at present unknown, although much work has been devoted to the attempt to determine

that of *Necator americanus* and that of *Ancylostoma duodenale* is believed to be greater. Further there are no means of knowing whether the ratio of mature larvæ obtained to eggs cultured in the case of one species is at all similar to that in the other. In fact different cultures from the same specimen often give different relative numbers of larvæ. It never happens that all the eggs produce mature larvæ. No doubt it would be possible to make the larval environment in different cultures more uniform, but difficult to make it identical when different fæcal specimens are used.

Details of the features by which these larvæ may be distinguished as well as observations on the mature larvæ of *Ancylostoma braziliense* and *Ancylostoma caninum* of the cat and dog and of the methods employed will shortly be published elsewhere.

The method is, of course, applicable to the examination of specimens of earth from localities suspected of containing hookworm larvæ, an important procedure in routine hookworm control work. It has been tried here with specimens of earth forwarded from other parts of Queensland. The hookworm larvæ isolated, usually, of course, accompanied by numbers of free-living nematode larvæ, can be diagnosed as belonging to the genus *Necator* or that of *Ancylostoma*, but the separation of mature larvæ of *Ancylostoma duodenale* from those of the dog and cat ancylostomes is another matter and cannot be done with ease and certainty.

Summary.

The fact that the two species of human hookworm have not the same pathogenic importance is emphasized, as well as the need to determine the prevalence and distribution of each in survey and control work. The practical difficulties of attempting this by the method of worm counts are pointed out and a better method suggested, that of examination of larvæ cultured from small fæcal specimens.

References.

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- ⁽²⁾ R. M. Gordon: "The Effect of Ancylostome, Ascaris, and Trichuris Infections on the Health of the West African Native," *Annals of Tropical Medicine and Parasitology*, 1925, Volume XIX.
- ⁽³⁾ A. Breinl: "Report for the year 1910 of the Australian Institute of Tropical Medicine," 1911, page 12.

SECTION VI.—OPHTHALMOLOGY.

NON-SUPPURATIVE INTRAOCULAR INFECTIONS (INCLUDING RETROBULBAR NEURITIS)

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CONSIDERATION of the structures liable to be affected under the title of non-suppurative intraocular infections comprise affections of the iris and

ciliary body, of the vitreous, of the chorioid and retina and of the optic nerve.

These will be dealt with under the headings of ætiology and treatment.

Ætiology.

Intestinal auto-intoxications are in some cases claimed to be the cause of iritis and cyclitis.

In affections of the teeth and gums, the tonsils and accessory sinuses the factor concerned is toxic material formed as a result of bacterial action on and in the diseased area. Recently a discussion took place in London on the frequency of focal infection of the optic nerve and nerve head diseases of the accessory sinuses. The consensus of opinion appeared to favour the incidence of optic neuritis rather than the retrobulbar condition. As far as my own experience goes it would seem that the affection has been rather that of a descending retrobulbar inflammation accompanied as it not infrequently is by some inflammatory reaction of the nerve head visible by the ophthalmoscope. I raise this point purposely with the idea of obtaining the views and experiences of members.

The next factor is metabolic disorders of which diabetes is the type.

The fourth ætiological cause is diseased organs producing altered chemical action from hypersecretion (Basedow's disease) or hyposecretion (as in cyclitis). In tetany we see optic neuritis. In nephritis we have two views as to the causation of the eye lesions. According to Zur Nedden the retinal changes are due to toxic matter formed by the decomposition of kidney substance which possesses a special affinity for the retinal tissues. The older view is that the connexion between the two states is found in vascular changes, in the increase of blood pressure or in the retention within the body of sodium chloride owing to its insufficient excretion by the kidneys.

In the fifth place there are the parasitic causes. Tuberculosis may involve the iris, ciliary body, chorioid, retina or optic nerve, as may syphilis. Microorganisms may infect the globe endogenously without giving rise to suppuration.

Infection from perforating injuries of the globe that fall short of suppuration, or from intraocular foreign bodies may be a cause.

Endogenous infection may act by setting in action a chronic plastic inflammation, as for example, plastic iritis and similar affections from organisms from nasal, tonsillar or dental sources or from influenza. Again, we have tuberculosis, syphilis and gonorrhœa and the causal agent of rheumatism, all of which can be blood-borne to the globe as emboli, there to begin their specific reaction in the eye tissues. In endogenous infection of wounds the trauma of the globe determines the lodgement of circulating germs in this area through its lowered resistance.

Treatment.

Acute Iritis.

I give here a short account of the routine treatment. I am accustomed to use atropine sulphate 2% either as drops or ointment, combined with