

Original Articles.

THE PATHOGENIC EFFECTS OF HELMINTHIC INFECTIONS.

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THE question of the pathogenicity of various helminthic infections, and particularly of hookworm infections, has long been a matter of dispute. The general opinion is that hookworm infections are as a rule harmful, *Ascaris* infections much less so, and *Trichuris* infections practically innocuous. In support of this view, particularly with respect to hookworm infections, there is a great mass of evidence in the form of clinical observations and effects of treatment on individuals and collective groups in schools, estates, industrial institutions, etc. The majority of these observations have been made on people of the white race, and without reference to the intensity of the infections. The effect of light hookworm infections is a matter of considerable difference of opinion. Lane (1917) summarizes the situation as follows:—"Opinion regarding hookworm infection has constantly passed through three stages in the individual or the community. The first of these phases is an unreasoned conclusion that disease and death occurring in an infested subject are caused by that infestation. The second phase, based on the realization that in the tropics more persons than not are infested and that they appear to be in normal health, lays to the credit, or discredit, of the parasite no ill effects, unless the infestation be a massive one and makes the host obviously a sick man. The third stage consists of a realization, based on careful records of widespread improvement in health and energy following the freeing of infested persons of their infestation, that even mild infections have an influence for the bad on their victims." Lane quotes passages from reports of the Rockefeller Sanitary Commission which he says show quite clearly that the officials of the Commission started with their minds satisfied that mild infections were a matter of no moment to the host, and ended up thoroughly convinced that even very mild infections constitute a grave handicap to the unfortunate harbourers. Lane further quotes letters from managers of tea estates in the Darjeeling districts, where there is widespread but for the most part mild hookworm infection, which express satisfaction and in some cases enthusiasm over the effects on the health of the coolies of anti-hookworm treatment. Similar reports of improved health and augmented efficiency have been recorded from many different industries in many parts of the world.

It must be pointed out, however, that most of these mass observations add little to our knowledge of the effect of *light* hookworm infections, since all grades of infection are grouped together, and improved health and efficiency in a comparatively small number of heavily infected individuals or of a few especially susceptible individuals in the entire group might be sufficient to produce the observed improvement. Clinical observations on individuals have repeatedly shown that individual susceptibility is an important factor, and that the number of worms necessary to produce an evident effect on health may vary enormously. Ashford (1913) for instance, states that in Porto Rico many cases containing more than 1,500 worms showed little if any anæmia. Darling, Barber and Hacker, from their studies in Java, came to the conclusion that 250 worms on the average cause measurable loss of hæmoglobin, and think that it is reasonable to assume that 50 worms would cause 1/5th as much, whether or not their effect was counter-balanced by non-interference with reserve powers of the host by other causes. These authors concluded that a given number of worms would on the average cause more loss of hæmoglobin in women than in men, and more in children than in women, and that their effects are accentuated by weakening of reserve powers by malaria, malnutrition, overwork or other causes.

In my own study (1925) of 100 individuals in the Alipore Central Jail, 67 of whom were lightly infected with hookworm, but only six of whom had more than 1,000 eggs per gram of fæces, no difference in the hæmoglobin percentage between infected and non-infected individuals could be found. Mhaskar and Kendrick (1923) found a similar lack of correlation between hæmoglobin content and hookworm infection in light cases in Madras. Megaw (1920), on the other hand, in a study of over 4,500 jail inmates in various parts of the United Provinces (India) found a distinct correlation between the state of health, as shown by the prisoners' history sheets, and the degree of infection as determined by egg counts.

The most interesting recent contribution to this subject is a paper by Gordon (1925), on "The Effect of *Ancylostome*, *Ascaris* and *Trichuris* Infections on the Health of the West African Native," in which he reports some interesting and significant work based on a study of 137 African natives in Sierra Leone. The subjects included 49 youths averaging 18 years of age, attending school; 40 city police of all ages from 23 to 50; and 48 gaol prisoners of all ages from 17 to 49. Examination of these natives was carried out by the officers in charge of them with respect to the following characteristics:—(1) Physique and general fitness, as determined by a physical examination; (2) mentality, as determined by mental alertness and ability to learn; and (3) energy, as determined by the keenness with which an individual attempted any

mental or physical task allotted to him; the men were placed in order of merit in A, B or C class in each of these three categories. In addition two other tests were made in the laboratory; (1) hæmoglobin percentage, as determined by the Tallquist scale, and (2) presence of albumen or casts in the urine.

The degree of infection in these individuals was determined by the Stoll egg-counting method, without knowledge of the status of the individuals with respect to other tests. Careful analysis of the correlation between the degree of infection and the classification according to each of the above tests was made. In spite of the fact that many of the infections were very heavy (12 out of 114 having an average of more than 10,000 eggs per gram of fæces) no significant correlations were found in any case except the "energy" classification. There was no noticeable effect of Ancylostome (*Necator*), *Ascaris* or *Trichuris* infections on hæmoglobin percentage, physique and general fitness, mentality, or presence of albumen or casts in the urine. On the other hand the figures suggest the possibility of some association between hookworm infections of more than 15,000 eggs per gram of fæces, and the low standard of energy observed in such cases; the small number studied of such intense infections, however, makes it obvious that further work must be done to justify conclusions. Dr. Gordon is careful to state that his work deals solely with the West African male native and applies only to that race. It is certain that the white race is far more susceptible than the negro race; I have had occasion to observe this on numerous occasions in the Southern United States. Gordon points out that this tolerance may be shared by some at least of the Indian races, judging by hæmoglobin tests made by Mhaskar and Kendrick in Madras and Chandler in Bengal, but he overlooked Megaw's significant work in the United Provinces, referred to above.

It is unfortunate that Gordon did not include some tests of physical and mental endurance in his examinations since this would appear to be more important than short duration tests of mental and physical keenness and energy. There can be little question but that hookworm infection does cause severe anæmia in the white race and recent investigations by De Langen (1924), suggest that the effect is caused by a direct toxic effect on the blood-forming organs. The ability to make good an injury to the blood system, with the attendant results on other systems, may be sufficient so that no evident effect is present, yet a certain amount of energy and vitality *must* be used up to constantly repair the damage done, and as a result it is readily conceivable that resistance to fatigue, exhaustion and disease may be proportionately lowered. Up to a certain point the repair can keep pace with the damage, so that there is no hæmoglobin reduction; only when the infection is sufficiently heavy so that the repair cannot keep pace with the injury or when the reserve

power is weakened by other causes, is there any evident anæmia. It would appear from Dr. Gordon's work that this point is not reached nearly so quickly in the negro as in the white race. It seems to me not improbable that this may be associated with the development of a racial immunity—an ability to cope with the toxic effects of the parasite by some means not understood—resulting from age-long association of host and parasite, for it is a well-known fact that hosts and parasites do tend towards a mutual tolerance, where the injurious effects of one on the other are minimized. There seems to be good reason for believing that *Necator americanus* was brought to America by the African slaves, and it has always seemed to me significant that the adapted negroes showed much more marked tolerance than the unadapted whites.

If Dr. Gordon's observations on West African negroes do apply, even in a less degree, to Indian races, then hookworm infection in many parts of India may be considered practically harmless, for although a high percentage of people in India are infected, the infections are rarely heavy, as judged by egg counts, and of many hundreds of egg counts made in Bengal, not more than 10 per cent. exceed 1,000 eggs per gram of fæces. In one series of 127 cases in Eastern Bengal, 61 per cent. of whom were infected according to Lane's D.C.F. method, 46 per cent. of those infected had less than 100 eggs per gram, and not a single count exceeded 400 eggs per gram. It does not appear probable that if infections of 10,000 eggs per gram produce no noticeable symptoms in West African negroes, that infections of less than 1,000 eggs per gram would have an appreciable effect on Indians. However, until mental and physical endurance tests and accurate data on resistance to disease can be obtained, judgment on this point should be reserved.

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