AN INQUIRY INTO THE PREVALENCE OF HELMINTHIC INTESTINAL PARASITES AMONG THE NATIVES OF EAST AFRICA TOGETHER WITH SOME OBSERVATIONS ON THE TREATMENT OF HOOKWORM DISEASE.

A THESIS.

BY

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AN INQUIRY INTO THE PREVALENCE OF HELMINTHIC INTESTINAL PARASITES AMONG THE NATIVES OF EAST AFRICA TOGETHER WITH SOME OBSERVATIONS ON THE TREATMENT OF HOOKWORM DISEASE.

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INTRODUCTION.

The part of the African Continent known as East Africa comprises roughly the stretch of territory lying between the Great Lakes and the Indian Ocean. It is a territory into which European penetration is only beginning, but from its great natural wealth it is attracting settlers in increasing numbers. It is desirable for the welfare of this country, and for the health and efficiency both of the European settler and of the large resident native population, that information should be collected concerning the incidence and distribution of disease producing parasites, the best means of either exterminating them or keeping them in check, and the most satisfactory methods of treating the diseases they produce.

While on active service in East Africa during the recent war I was at one period attached to a hospital at Daressalaam for members of the Native Labour Corps, and had for a short time the opportunity of enquiring into the prevalence of helminthic intestinal parasites among adult male natives. I had the opportunity also of treating a number of cases of Hookworm Disease, and of noting the efficiency of certain anthelmintics when administered with various dosages and in different ways.

A. AN INQUIRY INTO THE PREVALENCE OF HELMINTHIC INTESTINAL PARASITES AMONG THE NATIVES OF EAST AFRICA.

I. MATERIALS AND METHODS.

The natives whose stools were examined were patients admitted to the medical wards under my care. They were therefore to some extent selected cases in that they had gained admission to a hospital, but while some of them were suffering from an attack of malaria or from diarrhoea, a good number had only trivial complaints.

Diagnosis at the Admission Room was far from easy, partly through difficulties of dialect and partly owing to the inability of the patient to describe his symptoms. They were all raw natives enrolled at their villages to act as porters, and were not trained or civilized to any great extent. The condition of each case on admission was noted, and about 30% were found to be in impaired health, the remainder being all strong well nourished men apparently in good general condition.

The morning after admission a stool was collected as far as was possible from each new case. It was usually fairly fluid in character as a dose of Magnesium sulphate was given as a routine measure on admission. Small portions of the motion taken from several parts of it were put together in a jar, which was labelled and set aside for examination. The remainder of the stool was at the same time broken up and searched for obvious parasites such as worms and tapeworm segments. The detailed examination of the stool was made in the laboratory of the Hospital under the direction of Capt. THORNTON R.A.M.C. to whom I take this opportunity of tendering my thanks for the cordial co-operation which greatly facilitated my work. Fresh preparations were always employed. A small piece of the stool was emulsified with about three times its volume of water and a few drops of the emulsion were placed on the slide and examined. A specimen from a second stool was examined about 7 days later if the patient was still in hospital. The second examination sometimes revealed ova not found on the first examination. Third and fourth examinations produced similar but rapidly diminishing results. 21 natives had their stools examined 6 times and one infection of Trichocephalus dispar previously missed was the sole result. On the whole three or at most four examinations by the smear method may be considered to reveal all the parasites present in most cases. As the exigences of the service did not permit of all the cases having their stools examined four times, and as concentration methods requiring a considerable time in carrying out could not be used as a routine method, the actual incidence of the parasites found may be considered to be somewhat higher than is given by the figures shown.

II. SURVEY OF THE HELMINTHS FOUND.

As a result of the examination of the stools of 280 East African Natives 193 or 68.9% were found to be infected with Helminths. Eight different Helminths were found to occur, four very commonly, two less commonly and two only rarely. The four common parasites were all

NEMATODA, viz. NECATOR AMERICANUS, TRICHOCEPHALUS DISPAR, STRONGYLOIDES STERCORALIS and ASCARIS LUMBRICOIDES given in order of frequency. The two less common were one CESTODE, TAENIA SAGINATA, and one TREMATODE, SCHISTOSOMA MANSONI. The two rare parasites were one CESTODE, BOTHRIOCEPHALUS LATUS, and one NEMATODE, OXYURIS VERMICULARIS, each being found once only. The last is probably fairly common but its ova are rarely seen on microscopic examination of faeces.

The following table, TABLE. I., gives the number of times each parasite was reported, and the percentage of those examined found to be infected with it. In compiling this table when two or more parasites were found together in the same individual each parasite has been reckoned as a separate positive finding.

The relative frequency of the different Helminths is such as might be expected from a consideration of the mode of infection for each. Infection with Nematodes is directly due to faecal contamination of the soil. The ova may be swallowed, or the larvae may penetrate the skin, but no intermediate host is required to complete the life cycle. When we consider that the disposal of the night-soil among the natives is most casual, that they eat with unwashed fingers and go barefoot, it is not surprising that the incidence of Nematode infection among them is high. Both Cestodes and Trematodes require intermediate hosts to complete their life cycle. The mode of infection is therefore a special one and involves the eating of raw or imperfectly cooked flesh in the one case, and the coming into contact with water containing the appropriate intermediate host in the other. The incidence of intestinal parasites of these two classes even where most common is never very high. In Porto Rica where the conditions in the rural districts are most favourable for S. mansoni, and where it is known to be endemic, the incidence has never been found to exceed 7.8% (HICKEY) (15). In the Presidency of Madras where the Hookworm incidence approaches 100% the Tapeworm incidence is less than 1% (MHASKAR) (23) In this series of East African Natives examined the incidence of Tapeworms is 3.6% and as will be seen later the incidence of S. mansoni among natives from Lake Victoria Nyanza is over 8%.

III. CHARACTER OF THE INFECTIONS FOUND.

Among the 193 individuals who were found to be harbouring Helminths SINGLE, DOUBLE, TRIPLE and QUADRUPLE INFECTIONS were present. TABLE II.

TABLE I.

HELMINTHS FOUND ON EXAMINING THE STOOLS IN 280 CASES.

	PARASITE.	CASES INFECTED.	% INFECTED
Nematoda	Necator americanus	146.	52 .14.
	Trichocephalus dispar.	57.	20 .35.
	Strongyloides stercoralis	46.	16 .43.
	Ascaris lumbricoides.	27.	9 .64.
	Oxyuris vermicularis.	1.	.36.
Cestoda	Taenia saginata.	9.	3 .21.
	Bothriocephalus latus.	1.	.36.
Trematoda.	Schistosoma mansoni.	6.	2 .14.

A. SINGLE INFECTIONS. TABLE III.

120 or 43% of the total examined had Single Infections. All the parasites reported were found occuring alone as Single Infections except B. latus which occured once only and then as one of the members of a Triple Infection. No particular parasite was relatively more common than another as a Single Infection. The order of frequency is the same as in TABLE II. which gives the total infections.

B. DOUBLE INFECTIONS. TABLE IV.

49 natives or 17.5% of the whole had Double Infections. These consisted in all but 4 cases of Two Nematodes. Of the remaining 4 cases Trichocephalus dispar was associated with T. saginata in 3 cases, and N. americanus with S. mansoni in 1 case. N americanus was present in 42 of the 49 cases.

C. TRIPLE INFECTIONS. TABLE V.

Triple Infections found numbered 21 and were present in 7.5% of the natives examined. In 15 cases three Nematodes were found together. In the remaining 6 cases two Nematodes were associated with S. mansoni in 3 cases, and with a Tapeworm in 3 cases. N. americanus was present in 20 cases, and the most frequent combination was N. americanus, Trichocephalus dispar, and Strongyloides stercoralis. All the parasites found were present as members of a Triple Infection except O. vermicularis, which like B. latus was found once only.

D. QUADRUPLE INFECTIONS. TABLE VI.

Of Quadruple Infections there were 3 or just over 1%. These infections are specially interesting as in these 3 cases there are present all the parasites which were found more than once. They summarize strikingly what becomes evident when we consider the parasites associated together in the different multiple infections. There is here merely a series of mathematical combinations, and the appearing of a parasite in a combination depends on its own frequency of incidence, and is not affected by the other members of the combination. These parasites all seem to be able to live and flourish alongside one another, and no one of them seems to exert an inhibitary influence on another. The number of Helminths a person may harbour in his intestine depends therefore on the opportunity he has had of picking up infection.

These Multiple Infections demonstrate that one to four Nematodes can frequently be acquired as intestinal parasites and that a Tapeworm or S. mansoni can be added to them should the opportunity for infection occur.

TABLE II.

CHARACTER OF THE INFECTIONS FOUND.

INFECTION.	NO. INFECTED.	% INFECTED.
Single Infections.	1 20.	42.9.
Double "	49.	17.5.
Triple "	21.	7.5.
Quadruple "	3.	1.0.
Total "	193.	68.9.
Not Infected.	87.	31.1.

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TABLE III.

SINGLE INFECTIONS. 120.

HELMINTHS	NO.
Necator americanus.	81.
Trichocephalus dispar.	16.
Strongyloides stercoralis.	15.
Ascaris lumbricoides.	3.
Oxyuris vermicularis.	1.
Taenia saginata.	3.
Schistosoma mansoni.	1.

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TABLE. IV.

DOUBLE INFECTIONS. 49.

HELMINTHS.		NO.
Necator	& Trichocephalus.	18.
"	& Strongyloides.	14.
"	& Ascaris.	9.
"	& S. mansoni.	1.
Trichocephalus	Strongyloides.	2.
"	& T. saginata.	3.
"	& Ascaris.	2.

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TABLE V.

TRIPLE INFECTIONS. 21.

HELMINTHS.			NO.
Necator.	Ascaris	& Trichocephalus.	4.
"	"	"& Strongyloides.	3.
"	"	& T. saginata.	1.
"	"	&. S. mansoni.	2.
"	Trichocephalus	& Strongyloides.	8.
"	"	& Bothriocephalus.	1.
"	"	& S.mansoni.	1.
Strongyloides, Trichocephalus & T.saginata.			1.

TABLE VI.

QUADRUPLE INFECTIONS. 3.

HELMINTHS.	No.
Necator, Ascaris, Strongyloides & Trichocephalus.	1.
" " " & T saginata.	1.
" " " &. S.mansoni.	1.

IV. THE INFECTIONS CONSIDERED IN RELATION TO THE GEOGRAPHICAL DISTRIBUTION OF THE INDIVIDUALS EXAMINED.

The part of EAST AFRICA to which the natives examined belonged lies roughly between the Equator and 13 degrees South, and between the 34th. and 40th. degree of Longitude East of Greenwich. It is about 1300 miles long by 600 miles broad and is three quarters of a million square miles in extent.

Politically it embraces part of UGANDA, KENYA COLONY (formerly British East Africa), The TANGANYIKA TERRITORY (formerly German East Africa), and PORTUGESE EAST AFRICA. Climatically it lies entirely within the Tropics, but it is divided naturally into three distinct regions from East to West. First there is the low lying Coast Belt which is flat and moist, swampy in places and extremely hot. About 100 to 150 miles inland the land rises pretty abruptly to a plateau varying in height from 3000 to 8000 feet. The Great Rift Valley cleaves this plateau from North to South. The surface of this high land consists of rolling bush covered plains in which game of all kinds abounds. It is dry and fairly healthy, The heat by day is not excessive and the nights are cool. To the West the land falls again to the shores of the Great Lakes where it is once more hot and moist.

Natives from all three regions were enrolled as Porters usually at the chief towns or villages in the more thickly populated districts. Members of several tribes might be enrolled in the same town, but the character of the country they occupied and their habits and customs would be fairly similar. In all but 9 cases the name of the district in which each man enrolled was noted.

MOMBASA, TANGA, DARESSALAAM, LINDI, and PORT AMELIA all lie on the coast, and vary in size from Daressalaam with a native town of 40,000 inhabitants to Port Amelia with a population of a few hundreds, MOMBASA is the Port for Kenya Colony and is an old insanitary Arab town. PORT AMELIA is in Portuguese East Africa. The others are all in Tanganyika Territory of which DARESSALAAM is the Capital. The natives on the Coast are all called Swahili but they are of mixed blood and of many tribes. They naturally have been most affected by the influences, good and bad, of civilation. NAIROBI is the capital of KENYA COLONY. It is situated at a height of 6000 ft. above sea level. The natives there are WAKIKUYU an agricultural and pastoral people. VOI lies about midway between NAIROLI and MOMBASA and is on the inland high region. MOCHI and ARUSHA are on the slopes of Mt. KILIMANJARA in the TANGANYIKA TERRITORY. DODOMA, MOROGORO, and ITIGI are large native villages

lying two or three hundred miles inland from DARESSALAAM, and are centres for several large moderately populated areas. The natives here live in their primitive state, wear little clothing and subsist chiefly on meal ground from maize. MWANZA and KISUMU are situated on the shores of Lake Victoria Nyanza. The peoples live by cultivating the soil and fishing, UGANDA is a British Protectorate lying round the North of the Lake. The Baganda the principal tribe are the most intelligent of all the Bantu races in East Africa, and have been civilized and educated to some extent by the Missions.

The number infected with Helminths, and the number of a Single and Multiple Infections found among the natives examined from each district is given in TABLE VII., and the respective percentages in TABLE VIII. The places from which 6 or less individuals were examined as might be expected form the extremes. The figures found for the other places are fairly consistent and do not vary very widely. Among these the highest incidence of infection is found for MWANZA on the Lake where 11 out of 12 or 91. 7% were infected. It is followed by UGANDA also in the Lake Region and LINDI on the Coast with 88.3% each. The lowest are ITIGI and NAIROBI both Inland with just over 55%. The incidence of Single Infections corresponds very closely to that of the Total Infections and varies between 34% and 66.7%. Double Infections range between 5.3% and 31.5% and were found for each of the districts we are now considering. The Triple Infections vary within smaller limits, between 5.3% and 16.7%, and were not found for DODOMA and NAIROBI, both inland places. Quadruple Infections were found 3 times only, twice for KISUMU and once for MOMBASA, being in 4.2% and 5.3% of the natives examined respectively. KISUMU gives the most consistently high rates of MUltiple Infections, and for KISUMU and MOMBASA alone do the Multiple Infections.exceed the Single Infections. The number of times each Helminth was found among the natives examined from the different Districts is given in TABLE IX., and the respective percentage in TABLE X.

If we again omit the extremes, the places from which 6 or less individuals were examined, we find N. americanus, T. dispar, and S. stercoralis reported for each, and A. lumbricoides for all except two, namely DODOMA and MOROGORO both in the interior of The Tanganyika Territory. These four helminths have therefore a universal distribution. The highest incidence for N. americanus is given by LINDI with 75% and the lowest by NAIROBI with 37.5. 37%. NAIROBI also gives the lowest incidence for S. stercoralis with 3.7%, the highest for this Helminth being MWANZA with 33.3%. T. dispar is most prevalent at MOMBASA on the Coast 47.3%, and least so at ITIGI, inland with 2.6% A. lumbricoides is the least common of the four. Its highest

TABLE. III.

NUMBER OF TIMES SINGLE AND MULTIPLE INFECTIONS WERE FOUND AMONG THE NATIVES EXAMINED FROM THE DIFFERENT DISTRICTS.

DISTRICT.	REGION.	No. EXAM.	No. INF.	SING.	DOUB.	TRIP.	QUAD.
TANGA	Coast.	3.	3.	2.	1.	-	-
MWANZA.	Lake.	12.	11.	8.	2.	1.	-
UGANDA.	"	12.	10.	7.	1.	2.	-
LINDI.	Coast.	12.	10.	7.	1.	2.	-
MOMBASA.	"	19.	15.	7.	6.	1.	1.
KISUMU.	Lake.	47.	35.	16.	10.	7.	2.
DODOMA.	Inland.	11.	8.	5.	3.	-	-
DARESSALAAM.	Coast.	63.	43.	28.	11.	4.	-
MOROGORO.	Inland.	16.	10.	8.	1.	1.	-
NAIROBI.	"	27.	15.	10.	5.	-	-
ITIGI.	"	38.	21.	16.	2.	3.	-
MOCHI.	"	6.	3.	-	3.	-	-
PORT AMELIA.	Coast.	2.	1.	1.	-	-	-
ARUSHA.	Inland.	2.	1.	1.	-	-	-
VOI.	"	1.	-	-	-	-	-

TABLE VIII.

PERCENTAGE OF SINGLE AND MULTIPLE INFECTIONS FOUND AMONG THE NATIVES EXAMINED FROM THE DIFFERENT DISTRICTS.

DISTRICT.	REGION.	No. EXAM.	% INF.	% SING.	% DOUB.	% TRIP.	% QUAD.
TANGA.	Coast.	3.	100.	66.7	33.3	-	-
MWANZA.	Lake.	12.	91.7.	66.7.	16.7.	8.3	-
UGANDA.	"	12.	83.3.	58.3	8.3.	16.7	-
LINDI.	Coast.	12.	83.3.	58.3.	8.3.	16.7	-
MOMBASA.	"	19.	78.9	36.8	31.5	5.3	5.3
KISUMU.	Lake.	47.	74.4	34.0	21.3	14.9	4.2
DODOMA.	Inland.	11.	72.7	45.4	27.2	-	-
DARESSALAAM.	Coast.	63.	68.2	44.4	17.5	6.3.	-
MOROGORO.	Inland.	16.	62.6	50.0	6.3	6.3	-
NAIROBI.	"	27.	55.5	37.0	18.5	-	-
ITIGI.	"	38.	55.2	42.1	5.3.	7.8	-
MOCHI.	"	6.	50.0	-	50.0	-	-
PORT AMELIA.	Coast.	2.	50.0	50.0	-	-	-
ARUSHA.	Inland.	2.	50.0	50.0	-	-	-
VOI.	"	1	-	-	-	-	-

TABLE IX.

NUMBER OF TIMES EACH HELMINTH WAS FOUND AMONG THE NATIVES EXAMINED FROM THE DIFFERENT DISTRICTS.

DISTRICT.	REGION.	No. EXAM.	N. amer.	T.disp.	S.ster.	A.lum.	O.ver.	T.sag.	B.lat.	S.man.
TANGA.	Coast.	3.	3.	1.	-	-	-	-	-	-
MWANZA.	Lake.	12.	7.	1.	4.	1.	1.	-	-	1.
UGANDA.	"	12.	8.	2.	3.	1.	-	1.	-	-
LINDI.	Coast.	12.	9.	2.	3.	1.	-.	-	-	-
MOMBASA.	"	19.	11.	9.	3.	3.	-	-	-	-
KISUMU.	Lake.	47.	23.	15.	10.	10.	-	3.	-	4.
DODOMA.	Inland.	11.	7.	2.	1.	-	-	1.	-	-
DARESSALAAM.	Coast.	63.	35.	12.	8.	4.	-	2.	1	-
MOROGORO.	Inland.	16.	8.	2.	3.	-	-	-	-	-
NAIROBI.	"	27.	10.	6.	1.	3.	-	-	-	-
ITIGI.	"	38.	15.	1.	8.	3.	-	1.	-	1.
MOCHI.	"	6.	2.	2.	-	1.	-	1.	-	-
PORT AMELIA.	Coast.	2.	1.	-	-	-	-	-	-	-
ARUSHA.	Inland.	2.	1.	-	-	-	-	-	-	-
VOI.	"	1.	-	-	-	-	-	-	-	-

TABLE X.

PERCENTAGE OF INFECTIONS BY EACH HELMINTH AMONG THE NATIVES EXAMINED FROM THE DIFFERENT DISTRICTS.

DISTRICT.	REGION.	No. EXAM.	N.amer.	T.disp.	S.ster.	A.lumb.	O.ver.	T.sag.	B.lat.	S.man.
TANGA.	Coast.	3.	100.	33.3.	-	-	-	-	-	-
MWANZA.	Lake.	12.	58.3.	8.3.	33.3	8.3.	8.3.	-	-	8.3.
UGANDA.	"	12.	66.7.	16.7	25.0	8.3.	-	8.3.	-	-
LINDI.	Coast.	12.	75.0	16.7	25.0	8.3	-	-	-	-
MOMBASA.	"	19	57.9	47.3	15.8	15.8	-	-	-	-
KISUMU.	Lake.	47.	48.9	31.9	21.3.	21.3	"	6.4	-	8.5.
DODOMA.	Inland.	11.	63.6	18.2	9.1.	-	-	9.1.	-	-
DARESSALAAM.	Coast.	63.	55.5	18.9	12.6	6.3.	-	3.2.	1.6	-
MOROGORO.	Inland.	16.	50.0	12.5.	18.7	-	-	-	-	-
NAIROBI.	"	27.	37.0	22.2	3.7	11.1	-	-	-	-
ITIGI.	"	38.	39.5.	2.6	20.8	7.8	-	2.6	-	2.6.
MOCHI.	"	6.	33.3	33.3	-	16.6	-	16.6	-	-
PORT AMELIA.	Coast.	2.	50.0	-	-	-	-	-	-	-
ARUSHA.	Inland.	2.	50.0	-	-	-	-	-	-	-
VOI.	"	1.	-	-	-	-	-	-	-	-

TABLE XI.

AVERAGE NUMBER OF DIFFERENT HELMINTHIC INFECTIONS PER INDIVIDUAL INFECTED FOR EACH OF THE DIFFERENT DISTRICTS.

DISTRICT.	REGION.	No. EXAM.	No. INF.	No. HELM. Found	AVERAGE Per PERSON EXAMINED.	AVERAGE Per PERSON INFECTED.
TANGA.	Coast.	3.	3.	2.	.67.	.67.
MWANZA.	Lake.	18.	11.	15.	1.25.	1.36.
UGANDA.	Lake.	12.	10.	15.	1.25.	1.50.
LINDI.	Coast.	12.	10.	15.	1.25.	1.50.
MOMBASA.	Coast.	19.	15.	26.	1.37.	1.73.
KISUMU.	Lake.	47.	35.	65.	1.38.	1.86.
DODOMA.	Inland.	11.	8.	11.	1.00.	1.37.
DARESSALAAM.	Coast.	63.	43.	62.	.98.	1.44.
MOROGORO.	Inland.	16.	10.	13.	.81.	1.30.
NAIROBI.	"	27.	15.	20.	.74.	1.33.
ITIGI.	"	38.	21.	29.	.76.	1.38.
MOCHI.	"	6.	3.	6.	1.00.	2.00.
PORTAMELIA.	Coast.	2.	1.	1.	.50.	1.00.
ARUSHA.	Inland.	2.	1.	1.	.50.	1.00.
VOI.	"	1.	-	-	-	-

incidence is reached at KISUMU 21.3% .O vermicularis and B. latus were as already mentioned each reported only once. The former was found in a native of MWANZA and the latter in a native of DARESSALAAM. T. saginata was not reported for every District, but the districts for which it is reported are widely scattered and fairly representative of the country. Except for MOCHI for which it was found once among 6 natives examined, the incidence is under 10%. S. mansoni was found 6 times. Once for ITIGI, once for MWANZA and four times for KISUMU, and not at all for the Coast. The rate of incidence for both MWANZA and KISUMU, both on the shores of LAKE VICTORIA NYANZA is just over 8%.

If the number of separate Helminthic Infections found for each individual examined from one district be added and the total divided by the number of Individuals examined, the average number of separate Helminthic Infections per native of that district is obtained. Similarly by dividing the total by the number of natives found infected the average number of separate Helminthic Infections per native infected is obtained. The figures for each District are given in TABLE XI.

The Districts from which 6 or fewer natives were examined again fall to the extremes. Among the remainder KISUMU gives the highest average of separate Helminthic Infections, both per person examined and per person infected, namely 1.38 and 1.86 respectively. MOMBASA almost equals it. As has already been seen KISUMU and MOMBASA were the only places where the number of Multiple Infections exceeded the number of Single Infections. MOROGORO, NAIROBI and ITIGI give the lowest figures, and they do not vary from one another by more than .07, and so are very constant, averaging .77 and 1.34 respectively.

V. THE INCIDENCE AND INTENSITY OF THE HELMINTHIC INFECTIONS IN THE COAST, INLAND AND LAKE REGIONS RESPECTIVELY.

If the Helminthic Infections found in the Natives examined from each of the several Districts be now grouped together under their respective Regions, the incidence and intensity of the Infections in each of the three Regions may be compared.

TABLE XII. gives the total number infected in each Region and the number of Single and Multiple Infections found.
TABLE XIII. gives the respective percentages. In Table XIV.

TABLE XII

NUMBER OF TIMES SINGLE AND MULTIPLE INFECTIONS WERE FOUND AMONG THE NATIVES EXAMINED FROM EACH OF THE THREE REGIONS, COAST*, INLAND*, AND LAKE.

REGION.	No. EXAMINED.	No. INFECTED.	No. SINGLE.	No. DOUBLE	No. TRIPLE	No. QUADRUPLE
LAKE.	71.	56.	31.	13.	10.	2.
COAST.	99.	72.	45.	19.	7.	1.
INLAND.	101.	58.	40.	14	4.	-

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TABLE XIII.

PERCENTAGE INFECTED IN EACH OF THE THREE REGIONS AND PERCENTAGE OF SINGLE AND MULTIPLE INFECTIONS.

REGION.	No. EXAMINED.	% INFECTED.	% SINGLE.	% DOUBLE	% TRIPLE	% QUADRUPLE
LAKE.	71.	78.8	43.7.	18.3.	14.1.	2.7.
COAST.	99.	72.7.	45.4.	19.2	7.1.	1.0.
INLAND.	101.	57.4.	39.6.	13.8	4.0.	-

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TABLE XIV.

NUMBER OF TIMES EACH HELMINTH WAS FOUND IN NATIVES EXAMINED FROM EACH OF THE THREE REGIONS.

REGION.	No. EXAM.	N.amer.	T.disp.	S.ster.	A.lumb.	O.ver.	T.Sag.	B.lat.	S.man:
LAKE.	71.	38.	18.	17.	12.	1.	4.	-	5.
COAST.	99.	59.	24.	14.	8.	-	2.	1.	-
INLAND.	101.	43.	13.	13.	7.	-	3.	-	1.

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TABLE. XV.

PERCENTAGE OF INFECTIONS WITH EACH HELMINTH IN THE NATIVES EXAMINED FROM EACH OF THE THREE REGIONS.

REGION.	NO. EXAM.	N.amer.	T. disp.	S. ster.	A.lumb.	O. ver.	T.sag.	B.lat.	S.mar
LAKE.	71.	53.5.	25.7.	23.9.	16.0.	1.4.	5.6	-	7.0.
COAST.	99.	59.6	24.2.	14.8.	8.1	-	2.0	1.0	-
INLAND.	101.	42.6	12.9.	12.9	6.9	-	3.0	-	1.0

TABLE XVI.

AVERAGE OF DIFFERENT HELMINTHIC INFECTIONS PER INDIVIDUAL EXAMINED AND PER INDIVIDUAL INFECTED FOR EACH REGION.

REGION.	NO EXAMINED.	NO. INFECTED.	HELMINTHS.	AVERAGE Per PERSON EXAMINED.	AVERAGE Per PERSON INFECTED.
Lake.	71.	56.	95.	1.35.	1.67.
COAST.	99.	72.	106	1.07	1.45.
INLAND.	101.	58.	80.	.79.	1.38.
AVERAGE.	271.	186.	281.	1.04.	1.51.

the number of times each Helminth was found is given, and in TABLE XV. the percentage infected with each. TABLE XVI. shows the average number of different Helminthic Infections found per person examined and per person infected for the three Regions.

From these tables it is evident that the natives of the Lake Region are the most heavily infected with Helminths, that those living on the Coast are almost as heavily infected, and that those living in the high inland regions have the lightest rate of infection. In round numbers 50% of the natives living inland harbour Helminths, 70% of those living on the Coast, and 80% of those in the region of the Lake. Multiple Infections are twice as common at the Lake as they are Inland. N. americanus is rather more prevalent on the Coast than at the Lake . All the other Helminths except B. latus, which was found once only and in a native of DARESSALAAM, are most prevalent at the Lake. S. mansoni is found there almost exclusively, and was not found once for the Coast. The number of different Helminthic Infections found on the average for each individual infected is also greatest for the region of the Lake where it is 1.67. Taking the average for the whole country there is one Helminthic infection for every individual, and the expectation of different Helminths per individual infected is 1.5.

VI. BRIEF ACCOUNT OF THE VARIOUS HELMINTHS MENTIONED.

The diagnostic features of the parasitic Helminths are to be found in the various standard works on parasitology. For convenience a brief account is here given of the general characteristics and life history of the various Helminths mentioned in this paper. The pathological condition the presence of these parasites may produce, and the appropriate prophylactic measures and methods of treatment, are also indicated.

A. PARASITIC NEMATODA.

1. NECATOR AMERICANUS. STILES 1903.

Necator americanus was discovered in America by Stiles in 1903, and it was considered at first to be peculiar to the New World, Ankylostoma duodenale being the Old World form. It has now been shown that the range of N. americanus is very wide, and much of the early work done on Ankylostomiasis probably refers to this parasite. It alone occurs in Central and South America. It was found by LOOSS (21) to be the only type present among the pigmies of Central Africa, and in examining material from West Africa, Uganda and East Africa

LEIPER (20) found only N. americanus. The two parasites occur together in India and Burma. MHASKAR (23) states that in the Tanjore and Madura districts in the Madras Presidency the Hookworm infection among the coolies is nearly 100%. Both species occur, N. americanus in almost every individual and A. duodenale in 10% of the people in the Madura district and in 80% of the people in the Tanjore district. A duodenale seems to be the only type present in Europe, Egypt and China. DARLING (12) considers that in the Old World the two species of Hookworm are to be found together at the Tropic of Cancer; to the north of this A. duodenale predominates and to the south N. americanus. Both types are probably importations into America, A. duodenale entering from the East, and N. americanus being carried over by Negro slaves from West Africa.

N. americanus is a cylindrical non- segmented worm (Fig. 4.) white or semi transparent in colour unless when gorged with blood when it appears reddish. The head is very narrow and pointed and terminates in a small spherical mouth capsule. The outlet of the dorsal gland forms a conical tooth-like projection rising from the floor of the mouth and on the ventral edge two pairs of chitinous semilunar plates are to be seen (Fig.7.b) The male is 7.mm. to 9mm. long and 3mm. broad (MANSON) (22) The posterior end of the male expands into a bursa copulatrix supported by chitinous rays. The dorsal ray branches at its base into divergent arms with bipartite tips (Fig8. b.) The spicules are two in number and are long and curved. The female is rather larger than the male and measures 9mm. to 11mm. in length by 4mm. in breadth (Manson). The body ends posteriorly in a spike. The vagina opens about 1mm. in front of the middle of the length of the body. The ova are clear and transparent with a smooth envelope, and usually show 4 or 8 light grey segments (Fig. 1. b.) They are an elongated oval shape and measure 64μ to 75μ in length and 36μ to 40μ in breadth. (MANSON).

Some of the differential characters of N. americanus and A. duodenale are to be made out with the naked eye. The Necator is shorter and more slender than the Ankylostome, and has a prominent dorsal curve at the anterior end which in the Ankylostome is not marked. Should a pair be found in conjugation as sometimes happens when stools are examined after an anthelmintic the characteristic Gamma position will be seen, but the male Necator is fastened to the female in front of the

middle of the length of her body, while the male Ankylostome is fastened behind the middle of the body of the female of its species. This is due to the different position of the female genital opening in the two species. The male Necator is much more slender than the female while the male Ankylostome almost equals the female in thickness. With the microscope the buccal cavity of the Ankylostome is seen to be furnished with two pairs of hook-like teeth on the ventral edge. (Fig 7. a) In the Necator these are replaced by semilunar plates and the dorsal "tooth" is conspicuous. The caudal bursa of the male Ankylostome is less deeply indented and is terdigitate. (Fig 8. a) The eggs of the Necator are slightly larger than the eggs of the Ankylostome (Fig. 1a)

The life history of the two species seems to be similar, though A. duodenale appears to be a parasite of man alone while N. americanus has been found to occur in anthropoid apes.

The adult worms live in the small intestine usually in the upper part of the jejunum. In making Post Mortem Examinations I have never found the worms in the duodenum, but in subjects recently dead I have often found them firmly adherent in large numbers to the mucous membrane of the jejunum. The lowest position in which I found them attached was at a distance of 9 feet from the pylorus. The worms are evidently given to shifting their hold frequently as their disused sites can be seen in the mucous membrame as minute extravasation of blood.

The female lays her eggs in the intestine and they pass out in the faeces, and in about 24 hours rhabditiform larvae hatch out. The larvae in the course of a week moult twice and then encyst. In this state they may be swallowed and so reach the intestine. This was believed to be the usual and indeed the only route of infection until 1897 when LOOSS (21) working with the larvae of A. duodenale accidently infected himself by allowing some of them to come into contact with his hand. To him belongs the credit of working out and definitely establishing this hitherto unknown phase of their life history . He showed that the larvae can penetrate the healthy human skin and pass into the subcutaneous tissue. There they enter the capillaries and lymph vessels and are carried to the lungs and enter the air vesicles. They pass by way of the bronchi and trachea to the oesophagus and thence to the stomach and intestines. This is now believed to be the most important route of infection. LOOSS considers that

90% of the larvae reach intestines by way of the trachea and Oesophagus. A week after reaching the intestine:the larvae moult for the third time, and 7 days later moult again.They now grow rapidly, and in about 5 weeks after reaching the intestine become adult males and females.

The disease produced by these parasites, its diagnosis and treatment will be considered in Part B.

2. TRICHOCEPHALUS DISPAR. LINNAEUS 1757.
(Trichuris trichiura.Whipworm)

This parasite has a very wide distribution and is found all over the world in both temperate and tropic zones. It was present in 20.35% of my cases, in East AFRICA. It has a very characteristic shape, the anterior part of the body being long and thread-like while the posterior part is much thicker (Fig.6). The male measures 40mm. to 45mm. in length, and the posterior part of the body is coiled into a spiral. The cloaca from which a single spicule with a long retractile sheath protrudes is terminal. The female varies from 35.mm. to 50 mm. in length and the body is almost straight. The anus is subterminal and the vagina opens near the junction of the anterior filiform part with the thicker posterior part of the body. The anterior part is longer than the posterior part in the proportion of about 2 to 1.

The eggs measure 50μ by 22μ (Manson) are brown in colour and are easily distinguished from all other intestinal ova by their having a clear pale body at each pole, (Fig.1.d.) The ova are unsegmented when they are passed and they have to spend many months in water before the embryo is developed. Infection is direct and the worm is mature within a month of the ripe embryo-containing egg being ingested. The usual habitat is the caecum. Usually they lie loose but they are supposed to be able to fix themselves to the intestinal wall by transfixing a fold of the mucous membrane with their long necks.

So far no definite pathological significance has been proved for them. They may be expelled occasionally by male fern, santonin or oil of chenopodium administered for other worms, but none of these drugs can be considered specific. No satisfactory anthelmintic for this parasite is known.

Prophylaxis consists in maintaining a pure water supply.

3. STRONGYLOIDES STERCORALIS. BAVAY 1876.

The larvae of this parasite were found in the faeces

of 46 individuals, that is in 16.4% of the natives examined. The adult male has not been discovered. The female alone is known. It is a small slender worm measuring 2mm. to 3mm. in length by .03mm. in breadth, and its most distinctive feature is a string of 5 or 6 elipsoidal eggs visible about the centre of the body. (MANSON) (Fig.10a). It penetrates deeply into the mucous Membrane of the intestinal wall and there deposits the eggs, which develope into larvae before leaving the intestine. The ova are not found in the faeces unless after violent purgation. It is the actively moving larval forms which are found on the microscopic examination of a fresh preparation. These are long, slender and transparent and have a rounded head and a sharply pointed tail. (Fig 10.b) They measure .2mm. to .3mm. in length, and .013 mm. in breadth. (MANSON). The only rhabditiform larvae with which they might be confused are the larvae of the Hookworms, but these are only to be found in stools which have been kept under suitable conditions for a day or two.. The rhabditiform larvae reach the soil with the faeces, and if it is cold and conditions are unfavourable they change into filiform larvae, and are capable of penetrating the tissues of man and making their way through the lungs and trachea to the intestine where they become adult worms. If however, it is warm and moist the rhabditiform larvae develope sexual characters, copulate and the fertilized female lays eggs. These hatch into filiform larvae which are capable of piercing the tissues.

The geographical distribution of S. stercoralis is practically coextensive with that of the Hookworms, and they are often found together.

The pathological significance of this parasite has not yet been ascertained, and no satisfactory anthelmintic is known.

Infection is brought about by faecal contamination of the soil, and prophylactic measures must be directed towards obviating such contamination.

4. ASCARIS LUMBRICOIDES. LINNAEUS. 1758. (ROUND WORM).

This worm which is one of the largest Nematodes parasitic in man is to be found everywhere from the Arctic Circle to the Equator. In temperate climates the incidence is not high, and it is found principally in children. Among native races in tropical countries it is very common. ACTON found it present in 9% of the Indian military labourers he examined in Mesopotamia. It was present in about 10% of the natives I examined in East Africa. H.C.de SOUZA ARAUJO (2) reports that

he is finding it in between 90% and 100% of the coloured races in the State of Parana in Brazil.

A. lumbricoides is cylindrical in shape and tapers at both ends. (Fig. 9.a. and b) The body is greyish in colour and has a striated cuticle which is somewhat elestic and shows two well marked lateral lines. The head is small and the mouth has a cleft upper lip and a single lower lip (Fig. 9.d.) All three lips are finely denticulate. The male measures 15 cm. to 17cm. in length and 4mm. in breadth. The posterior extremity is strongly curved and there are two well marked spicules. (Fig. 9c.) The anus is subterminal. The female is much larger then the male being usually 25cm. in length but it may attain a length of 40cm. The posterior part of the body is relatively straight and has no spicules. The genital opening is in the anterior third of the body and opens ventrally. The ovaries are long and convoluted and can usually be seen through the semi- transparent cuticle.

The ova are eliptical and measure 50μ - 75μ by 40μ - 50μ(MANSON). They have a rough surface and a multiple outline and are stained a dark brown with bile. Unfertilized eggs are frequently seen. The contents of these are more roughly granular than the contents of the fertilized eggs and the rough outer layer is much less conspicuous. (Fig. I.e.f.)

If the ova are kept warm and moist the embryo developes in the course of a few months. Dissication or freezing suspends development but does not destroy life. The embryo does not break through the shell and can remain alive it is believed for about 5 years. When the ripe embryo- containing egg has been swallowed and has reached the alimentary canal of the host, the embryo breaks through the shell. Until recently it was supposed that the embryo completed its developement in the intestine, and became sexualy mature in about a month. Recent investigations go to show that the life history is more complex. In experimental animals fed on ripe ova it is found that the larvae on hatching out from the shell leave the intestine and make their way to the liver and lungs where they appear on about the 7th day. On the 8th day they appear in the trachea and on the 9th they begin to travel down the alimentary canal to the colon and caecum. This route probably is followed in man also. The larvae have been seen in the lungs but the complete transition has not yet been traced out.

The number found together in the intestine in temperate climates is usually small. In the tropics large numbers may be found. I have on several occasions removed

between 30 and 40 from the intestine post mortem. The worms are sometimes passed spontaneously at the anus, and less commonly at the mouth or nose. This parasite is of considerable pathological importance It may enter and block the bile duct: it may penetrate the intestinal wall, pass into the peritoneum and set up peritonitis. A knot of them have been known to obstruct the bowel. Their presence in the intestine may cause nausea, dyspepsia, melaena, anaemia and malutrition, and may produce nervous disturbances in children.

SANTONIN is the most efficient anthelminthic. Grs. 5 followed by a purgative, and given on each of two alternate mornings removed all the worms in each of my cases.
The best prophylactic is pure drinking water, and in the tropics where the night-soil may have been used as manure, all vegetables should be boiled or carefully washed with boiled water.

5. OXYURIS VERMICULARIS. LINNAEUS. 1767. (Threadworm).

This parasite has a universal distribution, and is a very common parasite of children.

The ova are rarely seen on microscopic examination of the stools. They were found once only in the faeces of the 280 East African natives examined. MHASKAR(23) found them in the faeces of 14 of 605 individuals examined in India, although the adult worms were obtained in 99% of a series of 1700 convicts in the same district who had received treatment.

The adult worms are white in colour, and have a striated cuticle which projects outwards from the anterior part of the body as flanges. (Fig.5). The lips are thin and retractile and the oesophagus is large and is provided with a bulb. The male measures 2-5mm. in length .(MANSON). The posterior part of the body is spirally curved and shows 6 papillae, and the spicule is single and hooklike. The adult male is difficult to find as it usally dies after impregnating the female. The female is larger and measures up to 10 mm. in length. The tail is long and pointed and the anus is situated about 2mm. from the tip. The vulva is situated in the anterior third of the body.

The usual habitat is the caecum. When the female is ready to lay the eggs it travels down to the lower part of the intestine and deposits the eggs in the faeces. These are glossy and oval in shape but are slightly

flattened on one side. (Fig.1.g.) They have double contoured rather thin walls and measure 50-54μ by 20-27μ (MANSON). When fresh they contain a clear non- granular embryo which later becomes coiled and nematode-like. The embryo is almost fully developed when the ova are passed, but it does not leave its shell until it reaches the stomach of its host. There the shell is digested and the larva:escapes. It travels down the small intestine undergoing a series of moults and attains maturity.

The females sometimes escape spontaneously at the anus and may wander into the vagina or urethra. The irritation this wandering involves provokes scratching and the ova may be conveyed by the fingers to the mouth and re-infection secured. The continued presence of these parasites in the intestine may give rise to reflex mental disturbances and to anaemia. The scratching caused by the irritation of the wandering females may produce an eczematous condition of the skin. Treatment consists first of all in preventing reinfection. The worms in the caecum cannot be directly attacked, but an aperient from time to time and an occasional anthelmintic enema of salt and water, or water containing a few drops of the Tincture of Perchloride of Iron to wash out the worms in the rectum will gradually reduce their number and in time clear them altogether. Enemata of Infusion of Quassia are also found useful.

B. CESTODA.

1. TAENIA SAGINATA. GROEZE. 1872.

T. saginata is one of the commonest tapeworms parasitic in man. It is found in all parts of the world where raw or imperfectly cooked beef is eaten. In Abyssinia and in the North West Provinces of India it is exceedingly common. In America and in Western Europe it is comparatively rare.

This tapeworm when entire measures from 4 to 10 metres in length. The scolex is pear shaped and is furnished with 4 hemispherical suckers which are often pigmented. There is no rostellum or hooks such as are found on the scolex of T.solium. A small sucker-like organ replaces the rostellum. (Fig.11.ab.) The neck is long and thin. The proglottides often number 1200, and when mature measure 16-20mm. in length by 4-7mm. in breadth. The genital pores are marginal and alternate fairly regularly, and the uterine branches are fairly numerous numbering 20 to 35. In T. solium the branches number from 7 to 10. (Fig.12 a.b.)

The ova are ovoid, 30-40μ long and 20-30μ in diameter. (MANSON). The shell is double: the outer, the shell proper, is thin and transparent, and the inner, the embryophore, is thick and radially striated. Inside the shells is the onchosphere and in it three pairs of embryonic hooklets can be made out. (Fig.2.b.) The three pairs of hooklets diverge rather more widely in the ova of T. saginata than in the ova of T. solium, and the shell of T.saginata is the more transparent but in actual practice it is not easy to distinguish between the ova of the two species (Fig.2 a)

The ripe proglottides are passed, and then they break up, and the ova may be swallowed by the ox in grazing. The onchospheres are set free in the alimentary canal of the ox,bore through the wall of the intestine and are carried to the muscles of the body where they develope into cysticerci. Developement does not proceed further unless they are ingested by man the definitive host. In the stomach of man the scolex is liberated and passes to the small intestine where it fixes itself to the wall by means of its suckers.

This parasite is rarely dangerous, though it may sometimes give rise to abdominal pain or occasionally produce some anaemia. The ethereal extract of male fern is the most efficient anthelmintic against this parasite.

Propoylaxis consists in thoroughly cooking all beef to be eaten, and in burning all segments passed.

2. DI-BOTHRIOCEPHALUS LATUS. LINNAEUS. 1748.

This parasite was met with in only one of my cases. It is less common than T. saginata but it is widely distributed throughout the Old World.

The adult tapeworm inhabits the small intestine of man and also of the dog and cat. It may attain a length of 10 metres, and it is easily distinguishable from the other tapeworms of man by the great breadth and relative shortness of its proglottides. These may number 4000. The scolex is oblong and about 3mm. in length. It has two longitudinal grooves extending the full length of the head and no suckers, rostellum or hooklets. (Fig.11.c) The mature segments are thin and flat at the margins but the central portion is bulged out by the uterus which convoluted and distended with eggs lies medially. The genital pore also is median. (Fig.12 c)

The ova measure 70μ by 40μ (MANSON) They are ovoid, translucent and dark green in colour, and the shell is smooth and operculated. (Fig.2. c) Two intermediary hosts are required to complete the life cycle. The egg on

coming into contact with water gives exit to a coracidium which is a ciliated onchosphere contained within an embryonic envelope. In two or three days the onchosphere escapes from the envelope and is ingested by certain fresh water crustacea, in the intestinal canal of which it remains for two or three weeks and is transformed into a procercoid larva, an elongated sphere finely clothed with hairs. When ingested by fresh water fishes the larvae are liberated. They penetrate the stomach wall and finally become encysted in the muscular tissue of these fishes as plerocercoid larvae. When ingested by man with raw or imperfectly cooked fish they develope into the adult bothriocephalus in the intestinal canal. (MANSON)

This tapeworm may inhabit the intestine without producing any ill effects, but occasionally it may give rise to a very profound anaemia.

Treatment is as for other tapeworms and prophylaxis consists in thoroughly cooking all fish.

C. TREMATODA.

SCHISTOSOMA MANSONI. SAMBON. 1907.

Schistosoma mansoni was the only Trematode the ova of which were found in the stools of the 280 East African natives examined. It occurred in 6 cases. THE distribution of this parasite is a tropical one and is at present somewhat limited, but it is feared that its range may be extended. Miss PORTER (24) reports finding it in natives living in Johannesburg. So far no authentic indigenous case has been reported in India. (KEMP and GRAVELY 17). It is found in Central Africa, South America and the West Indies. Like Necator americanus it is probably of West African origin and was taken over to America by the negroes and found there a suitable intermediate host.

The male is white in colour, is about 1 cm. long and has a cylindrical appearance owing to the body being folded round ventrally to form the gynaecophoric canal in which the longer and more slender female is carried. There is an oral and a ventral sucker and the outer surface of the body behind the ventral sucker is covered with wart-like tubercles. The two suckers are set close together. The alimentary canal commences at the level of the oral sucker and bifurcates at the level of the ventral sucker. The two parts unite

again while still in the anterior half of the body to form a single median intestinal tract. (Fig.13b)

The female is darker in colour than the male and measures 1.5cm. in length. (Fig.13a). The middle portion is enfolded in the gynaecophoric canal of the male while the extremities of the body are free. The genital opening in both sexes is placed immediately posterior to the ventral sucker.

The parasites inhabit the portal and mesenteric veins. When the female is ready to lay the eggs it leaves the male and proceeds to the ultimate venules in the wall of the rectum and deposits the eggs in the submucous tissue. They sooner or later pass out with the faeces. The ova measure 150μ by 56μ (MANSON) are oval in shape and are characterised by a very definite lateral spine. In S. haematobium this spine is terminal and in S. japonicum it is wanting . (Fig 3.a.b.c.)

The egg when passed contains a ciliated miracidium which if the egg is in contact with water escapes and swims freely about. The miracidium enters a fresh water snail and forms sporocysts. The sporocysts migrate to the liver and multiply by fission and then within the sporocyst innumerable bifid-tailed cercariae develope. These on maturing escape into the water and may penetrate the skin of some suitable vertabrate host. They proceed by way of the lymphatics and blood vessels to the liver and in about six weeks attain sexual maturity. (MANSON).

The presence of the ova in the wall of the rectum gives rise to considerable inflamation, and the stools may contain blood and mucus. In severe cases the infiltration of the tissues round the rectum may give rise to tumour like swellings. The ova are sometimes deposited in the liver and produce a form of cirrhosis, or they may cause pneumonia through being deposited in the lungs.

The damage done to the tissues by S. mansoni and its ova is not always reparable and some permanent damage usually remains. Further damage can be prevented however by destroying the adult worms and the ova. A satisfactory method of doing this was introduced in 1919 by CHRISTOPHERSON (6) working at Khartum. He found that intravenous injections of Antimony tartrate killed the adult worms and the ova of both S. haematobium and S. mansoni. He gives $\frac{1}{2}$gr. in 40-50 minims of sterile normal saline intravenously every other morning 3 to 4 hours before

the first meal. The dose is increased by ½gr. every injection until a maximum of 2-2½grs. is reached. This dose is maintained until 20-25 grs. have been given. If more of the drug is required he recommends an interval and then a second course. Among cases examined two years after this treatment he found no relapses. He considers that Antimony tartrate has a profound and specific effect on Schistosoma in all stages and kills the adult worms in situ, the embryo in the ova in the wall of the bladder or rectum, and the miracidium. Antiluetin and Colloidal Antimony have been found to have the same action, but they are not so convenient in the Tropics as Antiluetin is difficult to obtain and Colloidal Antimony requires to be freshly prepared as it is not stable.

To avoid infection in countries where this parasite is present a pure water supply is necessary and it is well to refrain from wading or bathing in ponds and streams.

VII. CONCLUSIONS.

Helminthic intestinal infections are widely distributed and exceedingly common among the natives of East Africa.

They are most frequent in the Lake Region, almost equally so on the Coast, and are least common in the high-lying Inland Region.

Infections with one, two or more parasites occur. The ova of four separate Helminths were found in a single stool. Multiple infections are most common in the Lake Region.

Nematode infections are the most frequent. Necator americanus is the most common Nematode. It is present in all parts of the country but is most prevalent on the Coast. It constitutes a serious menace to the health of the community. Ascaris lumbricoides, Trichocephalus dispar, Strongyloides stercoralis and Oxyuris vermicularis are also found, and are very common and widely distributed. Though offering a less serious menace to health than Necator americanus the elimination of these parasites from the human intestine is none the less desirable.

Infestation with Cestodes is fairly common, the most frequent Tapeworm being T. saginata. Bothriocephalus latus is occasionally found.

Infection with the Trematode, Schistosoma mansoni is found principally in natives from the shores of Lake Victoria Nyanza where it appears to be endemic. It was found also in one case coming from an inland part of the Tanganyika Territory.

This extreme prevalence of Intestinal Helminths is of great economic importance, not perhaps in that they obviously swell the death rate, but in that they reduce the efficiency of large numbers of the population and render them more liable also to fall victims to some other disease.

The rate of infection with these parasites is kept up by the promiscuous habits of the natives in the disposal of faeces. This is allowed to contaminate the surface of the soil, water and vegetation.

Some of those harbouring Intestinal Helminths show symptoms of malnutrition and anaemia. Many are apparently in good health and do not obviously suggest that they are disseminating Helminthic ova continuously and widely.

Before any area can be considered to be healthy, the native in that area must be instructed in the sanitary disposal of faeces, and it should be seen that these instructions are carried out. The stools of each individual should be examined and those whose stools contain ova should receive appropriate anthelmintic treatment.

B. SOME OBSERVATIONS OF THE TREATMENT OF HOOKWORM DISEASE.

I. A SHORT ACCOUNT OF HOOKWORM DISEASE, ITS MORBID ANATOMY, SYMPTOMS, PROGNOSIS AND DIAGNOSIS.

Hookworm Disease or Ankylostomiasis as it was generally called prior to the discovery of Necator americanus is a disease which when severe is characterised by anaemia, cardiac incompetence, and oedema, and which is due to the presence in the small intestine of Ankylostoma duodenale or of Necator americanus.

MORBID ANATOMY.- The condition found post mortem is that of a severe anaemia. The heart is dilated and flabby, all the organs are anaemic and show fatty degeneration and there is usually fluid in the serous cavities. As already mentioned, if the subject has been dead for a few hours only, the worms will be found firmly adherent to the mucous membrane of the jejunum, but if some interval has elapsed since death they will be found lying free in the mucus in the lumen of the bowel, and their recent places of attachment can be seen as minute circular extravasations of blood on the mucous membrane of the bowel wall. How the anaemia is produced is not definitely known, but probably the absorption of a toxin produced by the parasites, and the loss of the blood which the parasites either consume or waste are both factors. The Uncinariasis Commission to the Orient found reason to believe that 10 to 12 worms in a man may cause a haemoglobin reduction of 1%. This can be measured where the average worm counts are above 200. When the number of worms present is below this figure the blood forming organs can keep up the haemoglobin percentage and the resulting anaemia is slight. In severe cases the worms present may in number exceed 1000, the blood forming organs become exhausted and a severe anaemia is the result. A.duodenale is much more malignant than N.americanus, a given number of Ankylostomes producing a greater degree of anaemia than an equal number of Necators.

SYMPTOMS. In a considerable proportion of the cases the number of worms present is small and the individual concerned does not complain of impaired health. He shows no obvious symptoms, and there is only the results of the examination of the faeces to show that he harbours hookworms.

The cases which show symptoms may be divided into

three classes, mild cases, moderately severe cases and severe cases.

MILD CASES. In the mild form there is a slight pallor of the skin, but the mucous membranes are not markedly anaemic. The secretion of sweat is diminished slightly. Digestive disturbances are usually an early symptom, and the patient complains of a feeling of fullness in the epigastrium, and occasionally of heartburn. The appetite is as a rule increased. There is some mental lethargy and sleepiness, and work is inattentively done. The result of an inquiry into the effect of Hookworm Disease on the mental developement of school children in North Queensland shows that in children infected with Hookworms there is a measurable mental sluggishness, and that mental developement is retarded in proportion to the massiveness of the infection. (WAITH and NEILSON .28).

A blood examination shows a distinct eosinophilia. The red corpuscle count is still normal, but the haemoglobin index has fallen to about 80%. The patient is not incapacitated at this stage and can continue with his work.

MODERERATELY SEVERE CASES. In these cases pallor both of the skin and of the mucous membranes is pronounced. The skin is dry and rough due to the diminished activity of the sweat glands and there is considerable itching. The appetite is increased, but there is pain in the abdomen and indigestion. To allay the uneasiness in the stomach there is a tendency to eat inert substances such as chalk and earth. The bowels are sometimes constipated but oftener loose. The patient complains of palpitation, there is often some cardiac hypertrophy, and systolic murmurs may sometimes be made out. Hyperaesthesia of the abdominal wall and diminished knee jerks are common, and visual disturbances and tinnitus aurium may be present. The patient is lethargic and intelligence is dulled. Albuminuria is frequent.
Eosinophilia is marked. The red corpuscles are only slightly reduced in number, and the haemoglobin index has fallen to between 50 and 70%. There is no wasting, the subcutaneous fat is still present and the patient appears fairly well nourished.

SEVERE CASES. Severe cases are fortunately not relatively common. They show all the symptoms of a profound anaemia, and disturbances of the alimentary, circulatory and nervous systems are very great. There is surprisingly little wasting even in severe cases, and what wasting there is, is usually masked by

oedema. I had 5 cases in which oedema was present. It appeared first in the left foot and leg, and then involved the right foot and right leg. The face was next affected and the oedema gradually became general. Fluid then appeared in the serous cavities and the ascitis soon became very great.

The appetite is sometimes feeble but often voracious, and nausea and vomiting are frequent. At this stage epigastric pain is severe and the desire for inert substances is increased. Diarrhoea is frequent, but blood is rarely seen in the stools. The patient complains of palpitation and precordial pain. The pulse is small and rapid, the heart is enlarged, ~~(and)~~ a presystolic murmur may be audible, and pulsation is visible in the veins of the neck. There is a liability to syncopal attacks and dyspnoea is sometimes distressing. There is constant headache, and mental deterioration may be marked. The knee jerks are abolished. The temperature may remain subnormal or there may be frequent febrile attacks. The haemoglobin index is now very low, sometimes below even 20%. The red corpuscle count however is still fairly high, usually between 2 and 3 millions. Eosinophilia may now be absent.

PROGNOSIS. Prognosis in all but the very severe cases is good. After the Hookworms have been expelled the symptoms disappear and there is a steady rise in the haemoglobin percentage without any other treatment being given to bring this about. BROSIUS and BISHOP$ (3) find the gain in haemoglobin to vary between 20% and 50%, being most marked in children, less rapid in young adults and slow after middle life. Among the workers on plantations it is found that after treatment they can do more work and do it better, and that their wage earning capacity is increased. It is also found that on plantations where treatment has been given there is a lowered morbidity rate among the workers and infant mortality is diminished. (SCHAPIRO. 25.)

Prognosis in very severe cases is bad. Even if anthelmintic treatment can be ventured upon and the worms expelled, the damage done is irreparable and the blood forming organs are exhausted. Of the three cases I had in which the oedema became general and the ascitis marked, one died and the other two though still in the ward when I left it, were evidently going rapidly down hill.

DIAGNOSIS. The diagnosis of Hookworm Disease may be arrived at in three ways.

1. From the General Symptoms.

2. By Finding the Parasite in the Stools after an Anthelmintic.

3. By Finding the Ova in the stools on Microscopic Examination.

All three methods are of value. The presence of the parasites or their ova in the stools is conclusive proof of the presence of the disease even though no general symptoms be apparent. On the other hand symptoms may be present for which all other causes than Hookworm Disease have been excluded, and yet neither parasites nor ova be present in the faeces. The diagnosis need not necessarily be cast aside, however, as it sometimes happens in the later stages of the disease that the parasites have disappeared though the results of their presence persist.

1. Diagnosis from General Symptoms.

In a temperate climate where anaemia appears among workers in a place which is moist and has a high and even temperature the diagnosis of Hookworm Disease is not beset with very great difficulties. In the Tropics however where the several symptoms of the disease may be caused by many and varied agents, the difficulties of arriving at a diagnosis are greatly increased.

Hookworm Disease is often confused with Malaria which is the most common cause of tropical anaemia. Enlargement of the spleen which is present in the anaemia of MALARIA and absent in that of Hookworm Disease is not a satisfactory means of distinction, as in a malarial district many individuals have enlarged spleens and no apparent anaemia. It is therefore, possible in a case of anaemia with an enlarged spleen that the anaemia is due to Hookworms and the large spleen to previous malaria. The colour of the sclerotics is of considerable value as a distinctive feature. In the anaemia of malaria they have an icteric tint, while in that of Hookworm Disease they have a peculiar pearly appearance. MANSON (22) states ROGERS has pointed out that whereas in Malaria the loss of haemoglobin is in proportion to the loss of red corpuscles, in Ankylostomiasis it is in excess of this.
The presence of oedema in the more severe cases is a valuable symptom, but confusion may occur. Beriberi is

characterised by oedema but the presence of paretic symptoms usually serves to distinguish it. Other conditions have recently been described in which oedema was present and Hookworm ova were absent from the stools. One form was observed among Turkish prisoners during the War, and cases of oedema of the face and legs passing off in about 6 days are reported by de CASTRO (5) as having occurred among West African porters in the East African campaign. The nature of there cases of oedema is unknown, but they add to the difficulties in the diagnosis of Hookworm Disease.

A history of previous ground-itch is of considerable value but it may not be elicited in every case. FRICK (14) among 1000 white and coloured American troops infected obtained a history of ground-itch in only 633 cases. Whenever Hookworm Disease is suspected an examination of the faeces should be made.

2. Diagnosis by Finding the Parasites in the Stools after an Anthelmintic.

This is the most accurate method of diagnosis and sometimes discloses an infection when microscopic examinations had failed to reveal ova. The stool is poured into a sieve with a mesh of not less than 50 to the inch, and is washed through it by means of a not too powerful stream of water. The insoluable portion of the stool and the worms present is then emptied on a tray, preferably dark brown in colour to give a suitable back-ground, and covered with salt solution. The worms if present can then be easily seen and picked out and counted and their species and sex discovered. This method can be used in jails and hospitals where the number to be examined is not too large and the cases are under close supervision. Where large numbers of individuals living in their own houses are to be examined as is done by The International Health Board of the Rockfeller Foundation it is not practicable and the third method of diagnosis is employed.

3. Diagnosis by Finding the Ova on Microscopic Examination of the Stools.

There are three fallacies in this method of diagnosis. There may be males only present in the intestine, the females may not be laying at the time the specimen of stool is secured, or there may be no eggs present in the specimen examined. Except after a dose of an

anthelmintic when the females may cease laying for a day or two, the first two conditions are rare. Much work has been done in evolving methods of avoiding the third fallacy. Once a slide has been prepared the ova if present on it, and if not obscured by the presence of an excessive amount of other material are easily discovered and recognised . What is required is a method whereby, when the ova present in the stool are few, they may be concentrated without too elaborate a technique and an undue expenditure of time, and light infections thereby recognised.

The principal methods of preparation at present employed are.

1. The Smear Method.

A specimen of the stool the size of a hazel nut and made up of small pieces taken from various parts of the motion is emulsified in about three times its volume of water or normal saline, and a few drops of the emulsion are placed on a slide and examined. As a rule ova appear on the slide in all but very light infections. This is the usual routine method, and a large number of stools can be examined by one observer in the course of a day.

The next three methods are concentration methods in which use is made of fluids of such a specific gravity as to cause the ova either to fall readily or to float.

2. Bass Method.

A piece of stool is emulsified with saline, centrifuged and the fluid decanted off. The deposit is mixed with Calcium chloride solution sp.gr.1050 and again centrifuged and the fluid decanted off. The deposit is now mixed with Calcium chloride solution specific gravity 1250 and centrifuged once more. The ova are now floating on the surface, are pipetted off and transferred to a slide and examined. (DOCK and BASS 13).

3. Lysol .Method.

In this case a piece of wide glass tubing closed with a cork is used in the centrifuge. A piece of stool is emulsified with a solution of 2% Lysol and centrifuged. The ova are deposited in a film on the cork. This is washed off and examined.

4. Brine Flotation Loop Method.

This method is described by KOFOID and BARBER (19). The specimen of the stool is thoroughly stirred with concentrated brine. A circular filter about one-eight to one- quarter of an inch in thickness and made of No.0 or No. 1 long fibre steel wool is pushed down to the bottom of the vessel and takes with it most of the coarser material. The mixture is allowed to stand for an hour when the ova will be found floating on the top, and can be removed with a wire loop one-half inch in diameter and placed on a slide for examination. This method is claimed to be both accurate and simple and twice as rapid as methods requiring a centrifuge. FRICK (14) used this method in examining the stools of soldiers in the United States and found it very satisfactory.

These three methods frequently disclose light infections which may have been missed by the Smear Method, but a fair expenditure of time is required in carrying them out, and a considerable number of material particles are still present on the slide.

5. The Levitation Method.

This method has recently been devised by CLAYTON LANE.7. It takes advantage of the slight stickiness of Hookworm eggs whereby they tend to adhere to the slide. It is not available for the ova of most other Helminths. The eggs of Ascaris lumbricoides, Trichocephalus dispar and the Tapeworms for instance do not possess this property. ½c.c. of stool is well shaken up with water and strained through gauze with a mesh of 100 to the inch. This allows the ova to pass through and keeps back coarse particles. It is then centrifuged and the whole of the deposit is placed on a slide and gently stirred, and it is allowed to stand for 5 minutes to let the ova settle. The slide is then passed gently into water, moved along under it and taken carefully out, when everything but the Hookworm eggs is found to have been washed off, and these are left unobscured by the fine particles of faecal material which are usually present on slides prepared in other ways. CLAYTON LANE claims that by this method of preparing the specimen a ten-fold concentration of the ova is produced.

If the egg has begun to disintegrate, or if developement has proceeded, this property of adhering to the slide is lost. Further investigations by CLAYTON LANE (8) on the effects produced on the ova by various preservatives show that hycol, salhycol and

cyllin produce rapid death of the ova and also prevent dissolution for a week or so. This makes the examination of preserved stools possible. It allows of the stools being examined at a centre at some distance from the place where they are obtained, and also of their being put aside in times of pressure for examination later, thus avoiding the necessity of a fresh stool having to be obtained. By these means a considerable saving in the expense of the investigation may be made. LANE considers that one microscopist with sufficient subordinate assistants to prepare the slides can make from 100 to 200 examinations per day.

WRENCH (30) has modified Lanes Method by emulsifying the piece of stool to be examined with Hydrochloric acid and Ether, and placing an excess of the emulsion on a coverglass made by cutting a slide into three parts. The coverglass is placed on a slide, the emulsion being kept uppermost, and 5 minutes are allowed for the ova to settle . Slide and coverglass are then both depressed under water to allow the excess to wash off. He considers this much more efficient than LANES Method. He considers also that pipetting off the excess from the coverglass instead of washing it off is much simpler more speedy and almost as efficient. There are many other methods and modifications of the above methods in use. Each worker tends to evolve a method of his own or to modify an existing method to suit the requirements of his particular work. The method to be adopted in any particular case is the one which will give the best results with the amount of time and money which can be expended.

II. THE TREATMENT OF HOOKWORM DISEASE. DRUGS AND METHODS OF ADMINISTRATION.

Many drugs and many dosages and methods of administration of these drugs have been tried and are still being tried to procure the expulsion of Hookworms from the intestine. There is as yet no concensus of opinion. The principal drugs in present use are Thymol, Betanaphthol, Oil of Chenopodium, and Oil of Eucalyptus,. These anthelmintics are used empirically, and as when proper precautions are taken they are not ordinarily soluble in the intestine, they are given in toxic doses in the expectation that they will act on the parasites without producing unpleasant or dangerous effects on the host. CAIUS and MHASKAR (4) give succinctly the present day rationale of hookworm treatment as follows:- 1, to administer an alkaline mixture so as to remove the mucus which surrounds the worms; 2, to starve the patient or keep him on a low diet so as to have the intestine free from food debris

and secretions which would retard the action of the anthelmintic: 3, to wash out the intestine and expose the worms by means of a purge; 4 to administer the anthelmintic in such a dose as is deemed necessary for the destruction of the worms, and to repeat this at definite intervals in order to keep the drug at the same degree of concentration; 5, to starve the patient and prevent him from partaking of any substance which will dissolve the anthelmintic and thereby increase its absorption; 6, to expel the unabsorbed portion of the drug and eventually the worms by means of a purge: 7, to prohibit the use of solvents till the complete removal of the anthelmintic. The method of preparing the patient therefore is pretty much the same in the case of all the drugs used. The patient is put on a light or milk diet for at least a day before treatment is begun, and the evening before a purge is given to empty the bowel. The drug to be used is given on an empty stomach first thing in the morning in either one or in several doses with an interval between each. Some time after the last dose a purgative which is not a solvent of the drug used, is given to expel the parasites and the unabsorbed portion of the drug. After the bowels have moved the patient may be given food.

THYMOL is the drug which has been most widely used in the treatment of Hookworm cases. It is found to be of considerable efficiency when given in sufficiently large doses. HOWARD (16) gave 10 grains daily except Sunday. The results were disappointing. In very few cases did the ova disappear from the stools, and as the treatment had often to be carried on for months, the patients became tired and tended to drop it. The total amount of Thymol required was large and made the treatment expensive. He found 60 grains given in two doses and given at intervals of 7 days cured about 50% of the cases in two treatments and most of them in three treatments. He continued giving the treatment until the stools were free from ova when examined on the 7th, and 14th. days after the last course. This he found a very satisfactory method for treating large numbers of cases in their own homes. DARLING BARBER and HACKER (10) counted the total worms expelled from each case, and based their comparisons on the proportion of the total worms expelled by the first treatment. They found that 90 grains of Thymol given in three doses expelled 97.8% of the total worms. Larger doses produced vomiting and so reduced the efficiency. Smaller doses produced a rapid falling off in results, and two treatments with a saller dose did not produce a good summation of results. CAIUS and MHASKAR (4) find 60 grains the most efficient dosage. When given in one dose it removed 99.4% of the total worms present, and when given in three doses of 20 grains 95.8%. They

consider that Thymol up to a dosage of 60 grains is a perfectly safe drug and that no restriction of food nor after purge is necessary.

Toxic symptoms and even fatal issues have been reported after the use of Thymol as an anthelmintic. On only one occasion in my series of cases treated with Thymol did anything untoward happen. One morning after two doses each of 45 grains of Thymol had been administered to three patients in the Ankylostomiasis Ward by the R.A.M.C. orderly in charge of my four wards, the native Baganda orderly in charge of the Ankylostomiasis Ward turned ill, and was replaced by another boy. This boy was unaware that the three who had been given Thymol were to have no food. It was the time of the forenoon bowl of arrowroot, and being natives whose chief interest in life is food they joyfully accepted a bowlful each. Shortly after they had taken it I understand, they became excited and staggered up and down the ward in an intoxicated state. The white orderly and myself were working in another of the wards at the time, and when we were summoned we found all three lying insensible. On being shaken all three woke up. They were a bit dazed but it soon passed off and none of them seemed to be any the worse of their experience. There must have been just enough oil in the arrowroot, they had received to dissolve and allow to be absorbed sufficient Thymol to produce an intoxicating effect. Fortunately it was slight, but it served to demonstrate that the use of Thymol as an anthelmintic was not without danger. The symptoms described as usually occuring in Thymol poisoning are vertigo, headache, tinnitus aurium and disturbances of vision, followed by giddiness and incoherence. The pulse is at first slowed but later becomes rapid and weak. The face is cyanosed and clammy, and delirium and coma preceed a fatal issue. Castor Oil should never be given as a purgative during treatment with Thymol.

I have not been able to find much reference to the use of BETANAPHTHOL as an anthelmintic for Hookworms in the literature I have consulted. MANSON (22) states that given in doses of 15 grs. repeated at intervals of two hours for two or three times and followed by a dose of salts, it is nearly as efficacious, is cheaper, is much less unpleasant, and is therefore to be preferred to Thymol, but that it is irrating to the kidneys, and haematuria is reported to have followed its administration.

DARLING", BARBER and HACKER (10) made a trial of Betanaphthol, 20 grs. in capsules, two doses with two hours interval, but the results were not encouraging only 26.7% of the total worms present being removed.

SMELLIE (26) in the treatment of 79 cases gave a dose of 6 grammes i.e. 93.6grs. on each of three successive mornings. He found this fairly efficient as an anthelmintic, but severe toxic effects followed in 4 cases. These cases developed anaemia, icterus and haemoglobinuria, and the spleen liver and gall bladder were enlarged. The drug seemed to have a specific action on the red blood cells. The symptoms were those of an extensive blood destruction with probably in the severe cases some destruction of the blood forming cells in the bone marrow also. The white cells were not affected. This haemoglobinuria is probably the haematuria mentioned by Manson. The cause of the succeptibility is not known, but the three of these four cases which were severe had each a history of malaria and Smellie suggests that the blood cells in such cases are more fragile. He concludes that Betanaphthol in 18 gramme (280.8 grs) doses is so toxic as not to be recommended for general use.

OIL of CHENOPODIUM is now being widely used in the treatment of Hookworm Disease. It is found to be very efficacious in the expulsion of Hookworms but like all anthelmintics it is toxic in the higher doses. The oil is partly absorbed and is excreted partly by the kidneys but chiefly by the faeces. Castor Oil as the after purgative increases the toxic symptoms especially giddiness. The toxin appears to affect the nervous system principally, and the symptoms are vertigo, deafness, disturbances of vision, tingling of the cutaneous nerves and later incoherence and coma. FRICK (14) in treating 1100 American troops with two doses of 1c.c. Oil of Chenopodium with a two hours interval had 304 cases with a slight vertigo. 154 had pricking of the hands and feet, and 32 had either to be kept or sent back to camp in an ambulance.

On account of these toxic properties it is necessary to reduce the dose to the smallest possible amount consistent with getting a good expulsion of worms. DARLING, BARBER and HACKER (10) found that three doses in capsules had the largest vermifugal effect of any treatment given, and was slightly superior to 90grs. Thymol, removing 98.9% of the total worms present. In smaller doses the efficacy was well maintained, and two treatments with half-maximum doses, that is three doses with .5c.c. given on two occasions produced the best results obtained, 99.6% of Necators and 97.5% of Ankylostomes being removed. Thymol in less than maximum doses did not give anything like as good results.

Ankylostomes are more resistant to treatment than Necators and Oil of Chenopodium is found to be more effective than Thymol in removing these. It is also more efficient in removing worms of all other species. (DARLING BARBER and HACKER) 10.

The drug is usally administered in capsules. When given in the manufacturers capsules the results are often disappointing. The best results are obtained when the drug is freshly filled into capsules immediately before being given. KNOWLTON (18) found that soft gelatine capsules were less satisfactory than soluable capsules.

DARLING (12) considers that Oil of Chenopodium is 5 times cheaper than Thymol for equivalent results.

OIL of EUCALYPTUS is usually given in the form of the mixture suggested by MANSON. The formula is Oil of Eucalyptus 30 minims, Chloroform 45 minims, Castor Oil 10 drachms, given in two doses. It is fairly safe, is not unpleasant to take, but is found to have very little efficiency and requires to be administered over a long period to have any appreciable effect in reducing the number of worms present. SURVEYOR (27) has modified the formula, increasing the dose of Oil of Eucalyptus and gives Oil of Eucalyptus 75 minims, Chloroform 90 minims, Tr.Digitalis 20 minims, and Castor Oil 20 drachms. This is divided into four parts and given with an hours interval between each part, and the treatment is repeated twice a week until no ova are found in the stools. He finds this fairly satisfactory and free from danger. Oil of Eucalyptus is not usually given when Thymol or Oil of Chenopodium can be used.

OIL of CAJUPUT is not much used. CAIUS and MHASKAR(4) state that it is toxic in doses of 90 minims and that this dose is of little value in removing Hookworms. They cannot recommend it as an anthelmintic. OIL of ABSINTHE and OIL of TANSY were also tried and found unsatisfactory.

WRENCH (29) tried among other drugs METHYLENE BLUE, BUTEA SEEDS, CAMPHOR combined with Menthol and Thymol, TURPENTINE, CLOVE OIL, PEPPERMINT OIL, and COPAIBA and found none of them to be of any use except Turpentine and the value of this was very slight.

III. DEFINITIONS OF "CURE".

Theoretically a case of Hookworm Disease is cured when the symptoms present have disappeared and there are no worms left in the intestine. Practically what constitutes a "cure" has not been defined. Some workers demand that after ova have failed to be discovered in the stools an extra treatment should not expel any parasites. The time and expense required to ascertain this is not always considered justifiable. HOWARD (16)

working under the Rockfeller Foundation required the stools to be negative on the 7th. and 14th. days. A few days must elapse between treatment and the examination to allow the females which may have been inhibited by the anthelmintic to begin laying again. As a general rule the absence of ova from the faeces 10 or more days after treatment may be considered a "cure". WRENCH (29) made an extensive series of examinations and did not consider a case to be cured until 29 negatives spread over 8 weeks had been obtained. Some of his cases relapsed after the 40th day. These cases CLAYTON LANE (9) considers to have been reinfected. In this present series of cases if no ova were found in the stools on the 5th. and also on the 10th. day after the last dose had been given the case was considered cured and discharged.

IV. DRUGS AND METHODS OF ADMINISTRATION USED IN THIS SERIES OF CASES TREATED.

The drugs which were available and which were used in treating this series of cases were Thymol, Betanaphthol, and Oil of Eucalyptus. I should have liked to have tried Oil of Chenopodium but it could not be procured at that time.

Treatment was not commenced while the patient was suffering from any acute condition such as dysentery, malaria or active cardiac disease, and if he was in a debilitated condition he was prepared for treatment by a period of rest and suitable dieting.
When the case was considered fit, or when as usually happened he was in fairly good health the following course was adopted.

Two days before treatment patient put on milk diet.
Evening before treatment dose of salts given.
No further food given.
Dose of Drug first thing in morning. 7 a.m.
Dose repeated 2 hours later. 9 a.m.
Salts given 2 hours later. 11.a.m.
When bowels had moved a light meal was given.
Next day ordinary diet.

When the treatment was repeated on the third day milk diet was continued until this treatment had been given.

This procedure was the routine one in the administration of Thymol and Beta Naphthol. The natives treated seemed to experience no inconvenience in taking the prescribed dose in powder form. Oil of Eucalyptus was given in the form of Mansons Mixture, after two days milk diet

and a purge the evening before.

Except on the one occasion already mentioned no toxic effects were observed as resulting from any of the drugs administered.

V. RESULTS OBTAINED FROM THE DRUGS EMPLOYED.

A. THYMOL SERIES.

The first 4 cases treated were given 40 grs. Thymol in two doses. Five days later the stools were examined and ova found in all five.

The next 2 cases were given 60grs. Thymol in two doses with a similar result.

The amount given was then increased to 180grs., two doses of 45grs. being given on each of two days with one day interval. 40 cases received this amount as a first treatment and 12 showed negative stools on the 5th. and 10th. days thereafter.

7 cases were given 240grs., that is two doses of 60 grs. on each of two days. 3 were cured. This was the largest amount of Thymol given at one time.

The cases may be tabulated as follows: (T. = Thymol.)

Thymol. First Course of Treatment, 53 cases.

T. 20grs.	2 doses.	cured	0	of 4	cases treated	-
T. 30grs.	"	"	0	" 2	"	"	-
T. 45grs.	2 doses on 2	days	12	" 40	"	"	30%.
T. 60grs.	"	"	3	" 7	"	"	42.9%

The number of those whose stools were still positive after the first course of treatment with Thymol to receive a second treatment with this drug was 27. The second treatment was given in the same way as the first and gave these results.

Thymol. Second Treatment. 27 cases.

T. 30grs.	2 doses on 2 days	cured	2	of 4	cases treated	50%
T. 45 "	" "	"	5	" 12	" "	41.7%
T. 60grs.	2 "	"	1	" 11	" "	9.1%

Most of the cases still not cured received Beta naphthol as their next treatment as will be shown later. 6 cases however received a third treatment with Thymol with the following result.

Thymol. Third Treatment. 6 cases.

T.45grs.2 doses on 2 days cured 2 of 3 cases treated "66.6%

T.60grs. " " " 0 " 3 " " -

In the first treatment with Thymol the 60grs.dose was slightly more efficacious than the 45grs.dose. In the second and third treatments there is a distinct inferiority to the 45grs.dose. It was found that the 45grs. dose was the most generally suitable, and was fairly efficient, when given four times, twice on each of two days with one day interval. Smaller doses were not efficient and larger amounts did not sufficiently increase in efficiency to justify their use.

The results given by 4 doses of Thymol 45grs.were as given above :-

First Treatment.	12	cured	of	40	cases treated.	30.0%
Second Treatment.	5	"	"	12	" "	41.7%
Third Treatment.	2	"	"	3	" "	66.6%

If all the 28 cases whose stools were still positive for Hookworm ova after the First Treatment, had been given a Second Treatment, then the total number cured by the two treatments would have given an indication of the value of two treatments. Though all the 28 cases did not receive a Second Treatment still the value of two treatments can be ascertained by adding to 12 cured by the First Treatment 5/12 of 28 viz.11 (taking the nearest lower whole number) which is the expectation of cures among 28 cases receiving a Second Treatment.

Similarly the value of ~~the~~ Three Treatments can be ascertained. The following results are thus obtained for treatment with 4 doses of 45grs. Thymol, 2 doses being given on each of two days with one day interval.

One Treatment.	12 cures	from	40 treated.	30%
(Two Treatments. 12+5/12 of 28 i.e.	23 cures	"	40 "	57%)
Three Treatments 23+2/3 of 17 i.e.	34 cures	from	40 treated	85%.

These results are pretty similar to those already mentioned as being obtained by HOWARD when using Thymol in the treatment of Hookworm Disease.

B. BETA NAPHTHOL SERIES.

The series of cases treated with Beta naphthol was begun shortly after the Thymol Series had been commenced and was run concurrently with it.

The first 8 cases treated with Beta-naphthol were given 15grs. of Beta-naphthol three times a day for about a fortnight. When the stools were examined at the end of this time only one was negative.
This method of treatment was accordingly given up. Beta-naphthol was then administered in larger doses in the same manner and with the same precautions as Thymol.
30 cases were in this way given a First Treatment with Beta-naphthol.
The doses given and the results obtained were as follows.
(B .— Beta-naphthol.)

Beta-naphthol. First Treatment. 30 cases.							
B.20grs.2 doses.	cured	0	of	1	case	treated.	
B.30grs.	"	0	"	1	"	"	
B.30grs 2 doses on 2 days	"	3	of	5	cases	treated	60%
B.45grs	"	10	"	22	"	"	45.4%
B.45grs.2 doses on 3	"	0	"	1	case	treated.	

Of the 17 cases whose stools were still positive after this treatment 10 received a Second Treatment with Beta-naphthol.

Beta-naphthol. Second Treatment 10 cases.							
B.30grs 2 doses on 2 days	cured	0	of	1	case	treated.	
B.45grs "	"	2	"	3	"	"	66.6%
B.60grs "	"	1	"	3	"	"	33.3%
B.45grs 2 doses on 3 days	"	2	"	3	"	"	66.6%

Only 1 case received a Third Treatment. This case was given Beta-naphthol 45grs. 2 doses on 2 days and was cured.

In the treatment of this series various dosages of the drug were tried, and it was found that the results did not improve in proportion as the dose was increased. The various dosages tried between 30grs. given 4 times and 60grs. given 4 times gave more or less similar results. In one or two cases the two doses per day were given for three days with one days interval between the days on which the drug was given, but the results did not justify the time required. The most efficient and most economic dose is probably 45grs given twice on each of two days. No unpleasant symptoms or after effects were observed with even the largest dose of Beta-naphthol given.
If the first two cases which were treated with Beta-naphthol, and which were given a doseage which was evidently inadequate, are omitted the other cases

can be grouped together to give the result of a First Treatment with Beta-naphthol. The result of the Second Treatment is similarly obtained. Only one case received a Third Treatment.

First Treatment. 13 cured of 28 cases treated. 46.4%
Second Treatment 5 " " 10 " " 50.0%

Finding the summation of results as was done in the Thymol Series we get:-

One Treatment 13 cures from 28 treated 46%
Two Treatments 13+5/10 of 15)
i.e. 20 " " 28 " 71%.

C. Oil of Eucalyptus Series.

Oil of Eucalyptus was given in the form of the mixture recommended by Manson, the formula being Oil of Eucalyptus 30 minims,
Chloroform 45 minims, Castor Oil 10 drachms, given in two doses first thing in the morning. This mixture was given on two days with one day interval to 9 cases. When the stools were examined afterwards only 1 was negative. A second treatment was then given to 4 of the cases, still positive, and again only 1 case had negative stools. Mansons Mixture was then given up and Thymol and Beta- naphthol were given to the cases still uncured and most of them were ultimately cured.
Put in tabular form the results obtained were:-

First Treatment. 1 cured of 9 cases treated. 11%
Second Treatment 1 " " 4 " " 25%
Two Treatments. 1+1/4 of 8 i.e. 3 cures from 9 cases treated. 33%.

Oil of Eucalyptus given in the form of Mansons Mixture was not found satisfactory as an anthelminthic for Hookworms.

D. Thymol and Beta-naphthol Series.

This series is a branch from the Thymol Series. When it was found that the repeated administration of Thymol was not giving a particularly good summation of results, Beta-naphthol was given as the next treatment to some of the cases whose stools were still positive, and the results were found to be encouraging. The results obtained were the following.

Beta-naphthol after 1 treatment of Thymol cured 6 of 8 cases 75%.
Beta-naphthol " 2 " " " " 4 of 8" 50%
Beta-naphthol " 3 " " " " 2 " 3" 66%

Changing the treatment from Thymol to Beta-naphthol therefore cured 12 of the 19 cases so treated. Summing the resulting cures from one treatment with Thymol followed by one treatment with Beta-naphthol we have

1 Treatment Thymol. 12 cures of 40 treated 30%
1 Treatment Thymol.
followed by 12+6/8 of 28 i.e.33 cures from 40 treated 82%
1 Treatment B.naphthol.

This result is much better than the result given by two treatments with Thymol, and practically equals the result given by three treatments with Thymol.

E. Beta-naphthol and Thymol Series.

Finding that the change from Thymol to Beta-naphthol was giving improved results, cases which had not been cured by one or more treatments of Beta-naphthol were given Thymol as their next treatment. This series is therefore a branch of the Beta- naphthol Series. The results of this change of treatment were as follows.

Thymol	after	1	treatment	of	B.Naphthol	cured	5	of	7	cases.	77%
Thymol	"	2	"		"	"	2	of	3	"	66
Thymol	"	3	"		"	"	1	"	1	"	100

The change of treatment from Beta-naphthol to Thymol cured 8 of the 11 cases whose treatment was so changed.

Calculating as before the total cures for two treatments the First with Beta-naphthol and the Second with Thymol we find

1 Treatment B Naphthol 13 cures from 28 treated 46%
1 Treatment B Naphthol
followed by 13+5/7 of 15 i.e.23 cures from 28 " 82%
1 Treatment Thymol.

The percentages of cures given here as resulting from a Second Treatment with Thymol following a First Treatment with Beta-naphthol is the same as that already found for a Second Treatment of Beta-naphthol following a First Treatment with Thymol.

Summary of Results of Treatment.

1 Treatment with		Oil of Eucalyptus.	11% cures.
1	"	Thymol.	30% "
1	"	Beta-naphthol.	46% "

2 Treatments with Oil of Eucalyptus	35%	cures.
2 " " Thymol	57%	"
2 " " Beta-naphthol.	71%	"
1 Treatment with Thymol followed by 1 Treatment with Beta-naphthol.	82%	"
1 Treatment with Beta-naphthol followed by 1 Treatment with Thymol.	82%	"
3 Treatments with Thymol.	85%	"

Oil of Eucalyptus for one treatment and for two treatments gives the lowest results of any of the three drugs used. Two treatments with Oil of Eucalyptus is less efficient than one treatment with Beta-naphthol, and only slightly superior to one treatment with Thymol. Of the two drugs Beta-naphthol and Thymol, Beta-naphthol given in a similar way and in similar doses to Thymol, is the more efficient both in the results given by one treatment and by two.A First Treatment with Thymol followed by a Second Treatment with Beta-naphthol, and a First Treatment with Beta-naphthol followed by a Second Treatment with Thymol are equally efficient, and surpass two treatments with any one of the three drugs. A First and a Second Treatment of this nature are almost as efficacious as three treatments with Thymol.

VI. CONCLUSIONS.

Oil of Eucalyptus in the form of Mansons Mixture is not an efficient anthelminthic for Hookworms. The results produced by one treatment are poor, and repeated treatments do not produce a good summation of results.

Thymol is moderately efficient when given in two doses of 45grs. administered on each of two alterate days. Small doses are not satisfactory, and larger doses do not produce sufficiently improved results to justify their use. The summation of results from repeated treatments is not good. The giving of Thymol in anthelminthic doses involves a certain amount of danger from its toxic properties.

Beta-naphthol is more efficient than Thymol when given in a similar manner and in equally large doses. Doses of 15grs three times a day even when given for a considerable number of days are practically useless as an anthelmintic. Larger amounts than two doses of 45 grs. given on each of two alternate days do not produce an increasing efficiency in proportion to the dose. Two treatments give a fairly good summation of results.

The best summation of results is attained by giving either Thymol or Beta-naphthol in the First Treatment and the other of the two drugs in the Second Treatment. The result obtained is the same which ever of the two drugs is given

first, but as a First Treatment with Beta-naphthol cures rather more cases than a First Treatment with Thymol it is advisable to give Beta-naphthol first. In this way fewer cases remain to require a second treatment. Two treatments by this method cure almost as many cases as do three treatments with Thymol. Changing the drug in this way, by reducing the number of treatments required to produce a cure, should effect a considerable saving in time, inconvenience and expense in the treatment of Hookworm Disease.

In all tropical countries with a large native population heavily infected with Hookworms, the problem of the control and ultimate eradication of this parasite is an important and very big problem. Infection and reinfection must be prevented by sanitary measures to avoid soil contamination. The stools of all the natives must be examined, and those who are found infected cured. That this can be done is possible but it involves the outlay of considerable sums of money over a lengthy period. The problem thus resolves itself into a question of expense. The devising of efficient yet inexpensive sanitary measures, improvement in the methods of diagnosis, and the evolving of better and less prolonged methods of treatment will all tend to bring the desired end nearer attainment.

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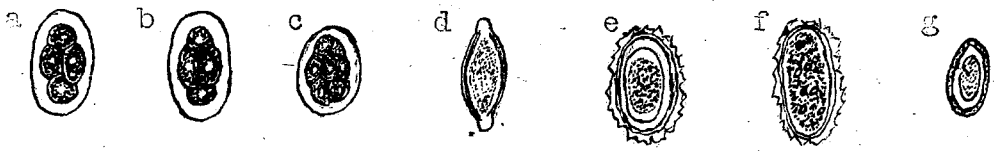

Fig.1. Ova of Nematodes.

a. Ankylostoma duodenale; b, Necator americanus; c, Strongyl--oides stercoralis; d, Trichocephalus dispar; e, Ascaris lumbricoides; f, Ascaris lumbricoides, (unfertilizied); g, Oxyuris vermicularis.

Fig.2. Ova of Cestodes.

a, Taenia solium; b, Taenia saginata; c, Dibothriocephalus latus.

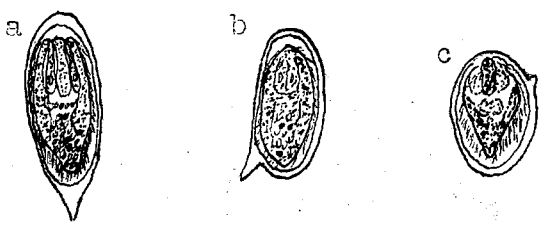

Fig.3. Ova of Trematodes.

a, Schistosoma haematobium; b, S.mansoni; c, S.japonicum.

(Magnified by 200. MANSON.)

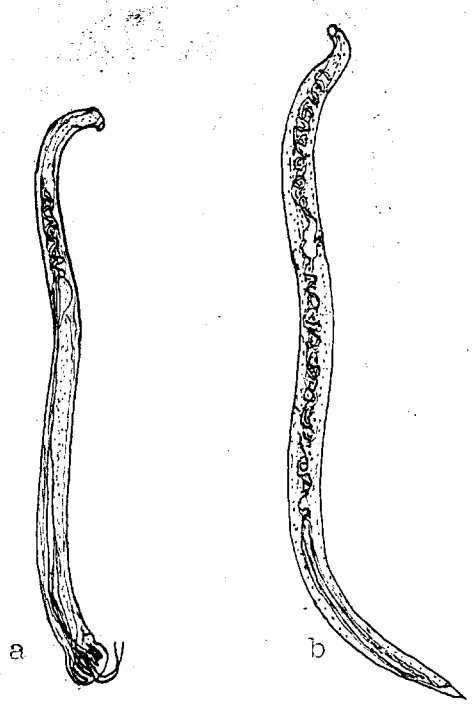

Fig.4. Necator americanus.
a. Male. b. Female. (Mag.x 25)

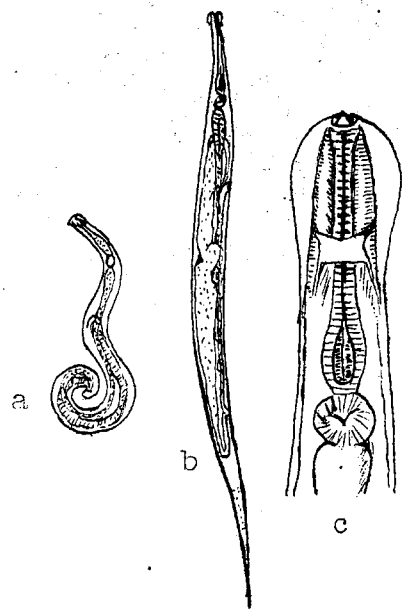

Fig.5. Oxyuris vermicularis.
a. Male. b. Female. (x 8).
c. Head. (Magnified).

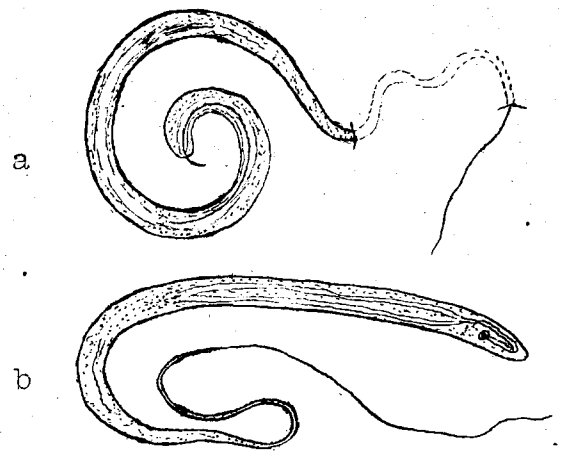

Fig.6. Trichocephalus dispar.
a. Male. (x 3) b. Female. (x4)

(After PLACENTIA, BRUMPT, LUSTIG, and MANSON)

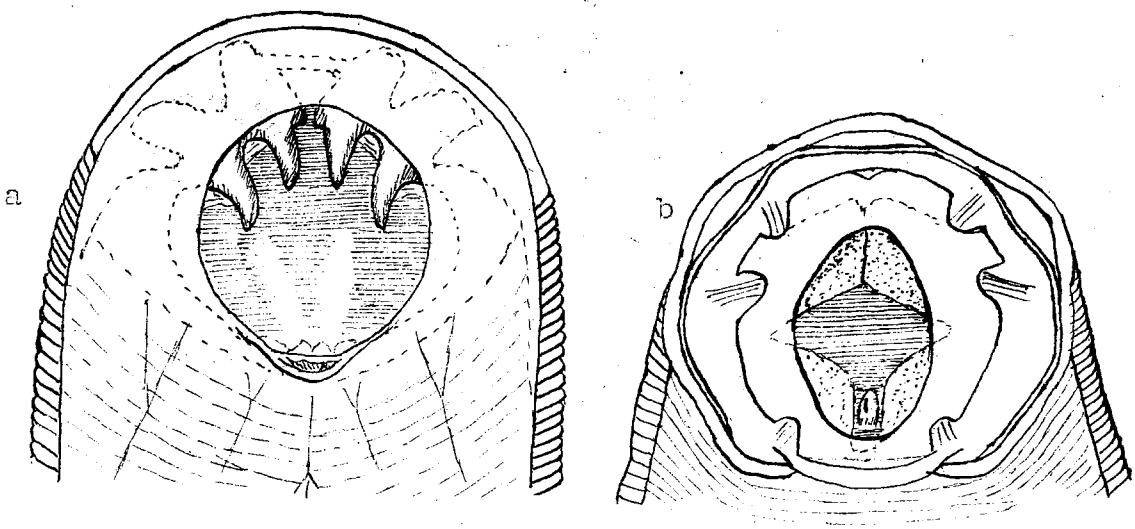

Fig.7. Mouth Capsule.

a. Ankylostoma duodenale. b. Necator americanus.

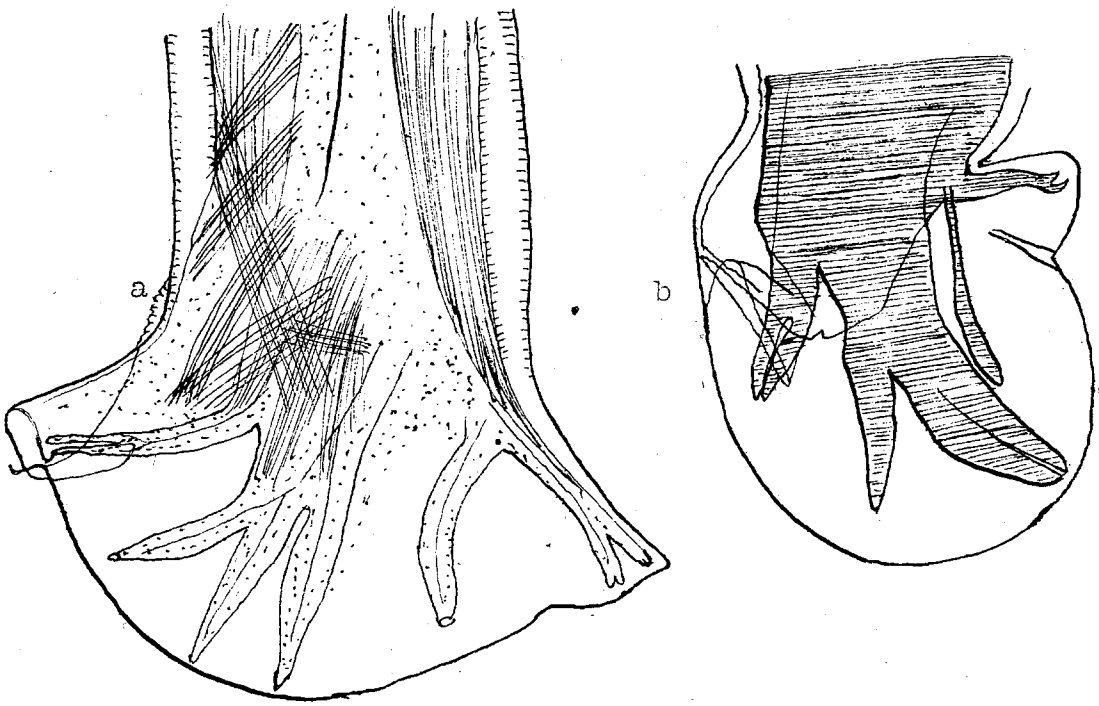

Fig.8. Caudal Bursa.

a. Ankylostoma duodenale. b. Necator americanus.

(Magnified. After LOOSS.)

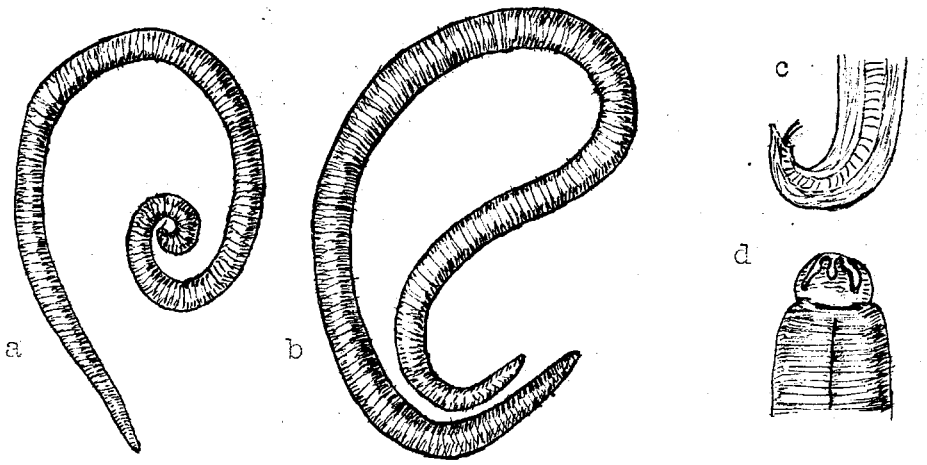

Fig. 9. Ascaris lumbricoides.

a. Male. b. Female. c. Posterior extremity of male. (Mag.)

d. Head. (Mag.)

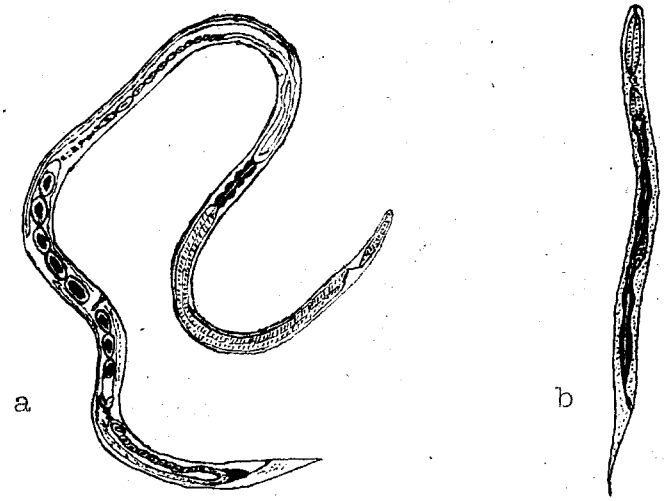

Fig. 10. Strongyloides stercoralis.

a. Female. (x72). b. Young larva from faeces. (x170).

(After BRUMPT and LOOSS.)

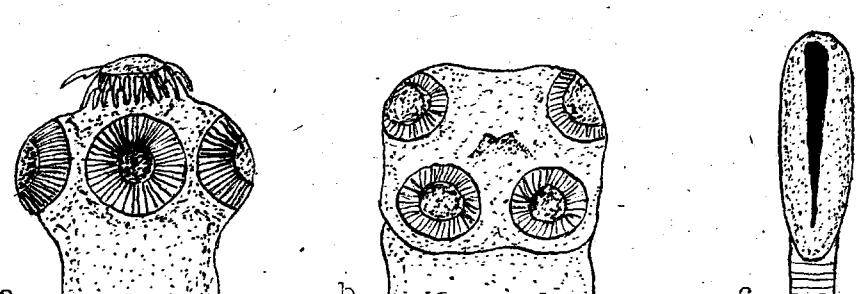

Fig. 11. a.Head of Taenia solium. x 45. b.Head of Taenia saginata. x 25. c.Head of Dibothriocephalus latus. x 25.

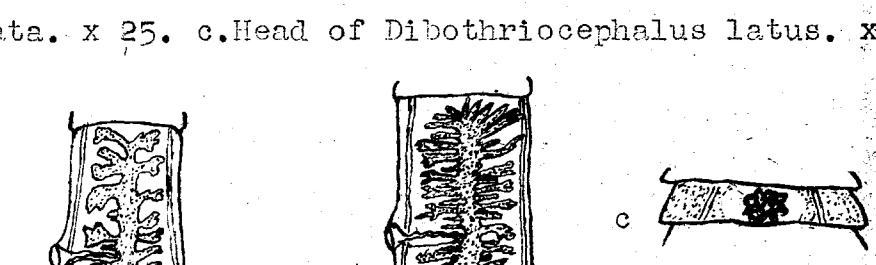

Fig. 12.Mature segment, T.solium. x 2; b. Mature segment, T.saginata. x 2; c. Mature segment, B.latus. x 2

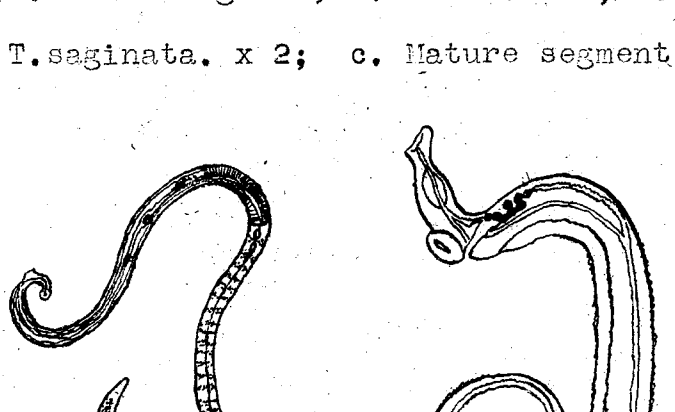

Fig. 13. Schistosoma mansoni.
a. Female.b. Male. (x 20)

(After PORTER, KRAPF, and MANSON.)