Thesis.

Ancylostomiasis Amongst

Indian Coolies on Malayan

Rubber Estates.

By.

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Glasgow University. 1904.

Seremban

Fed. Malay. States

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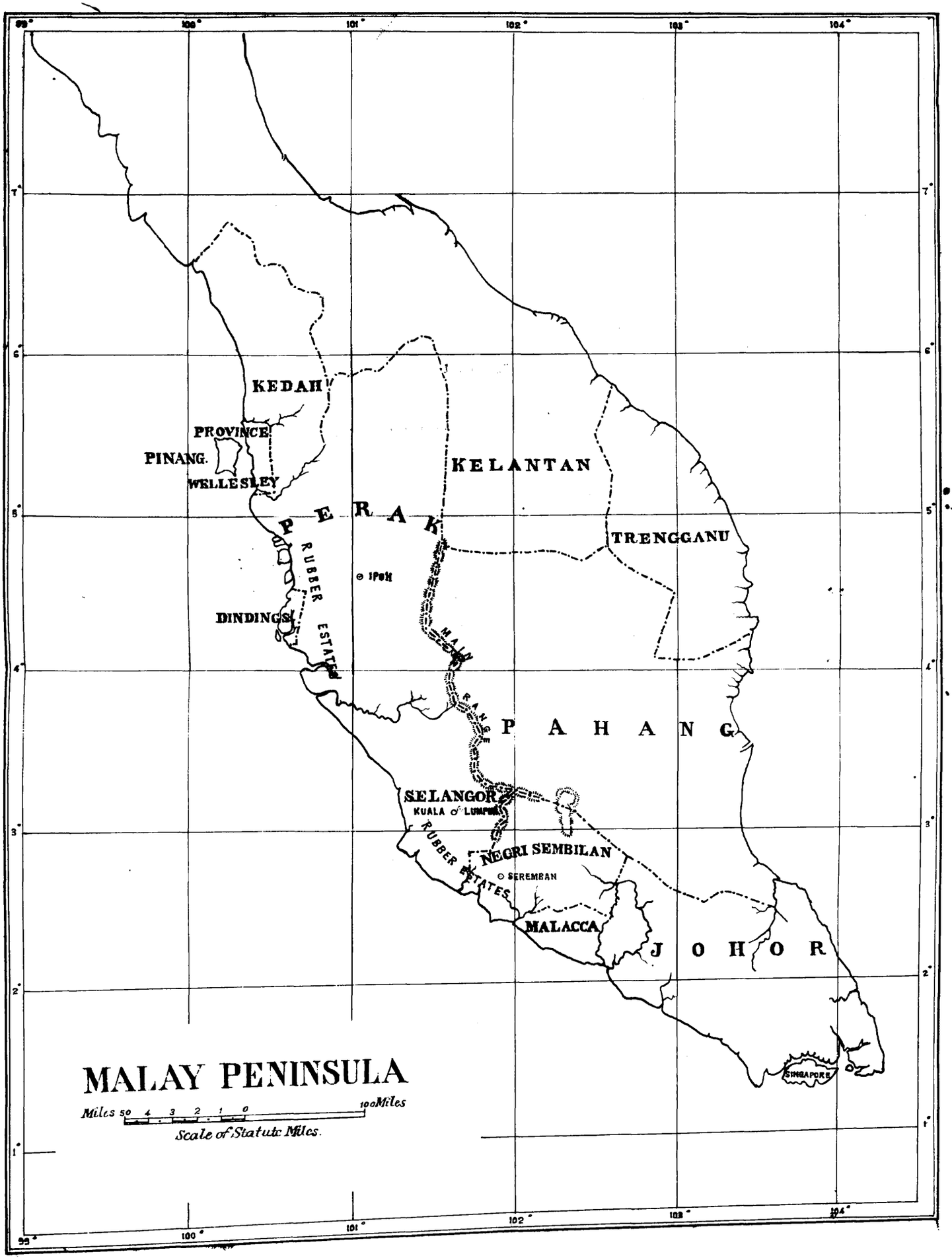
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page 1

Ancylostomiasis Amongst Indian Coolies On Malayan Rubber Estates.

Position, Climate, Geography.

The Malay Peninsula lies between the 1st and 6th degrees of North latitude and the 100th and 105th degrees of East longitude. The climate is therefore equatorial : that is, hot, moist and without extreme either of heat or cold.

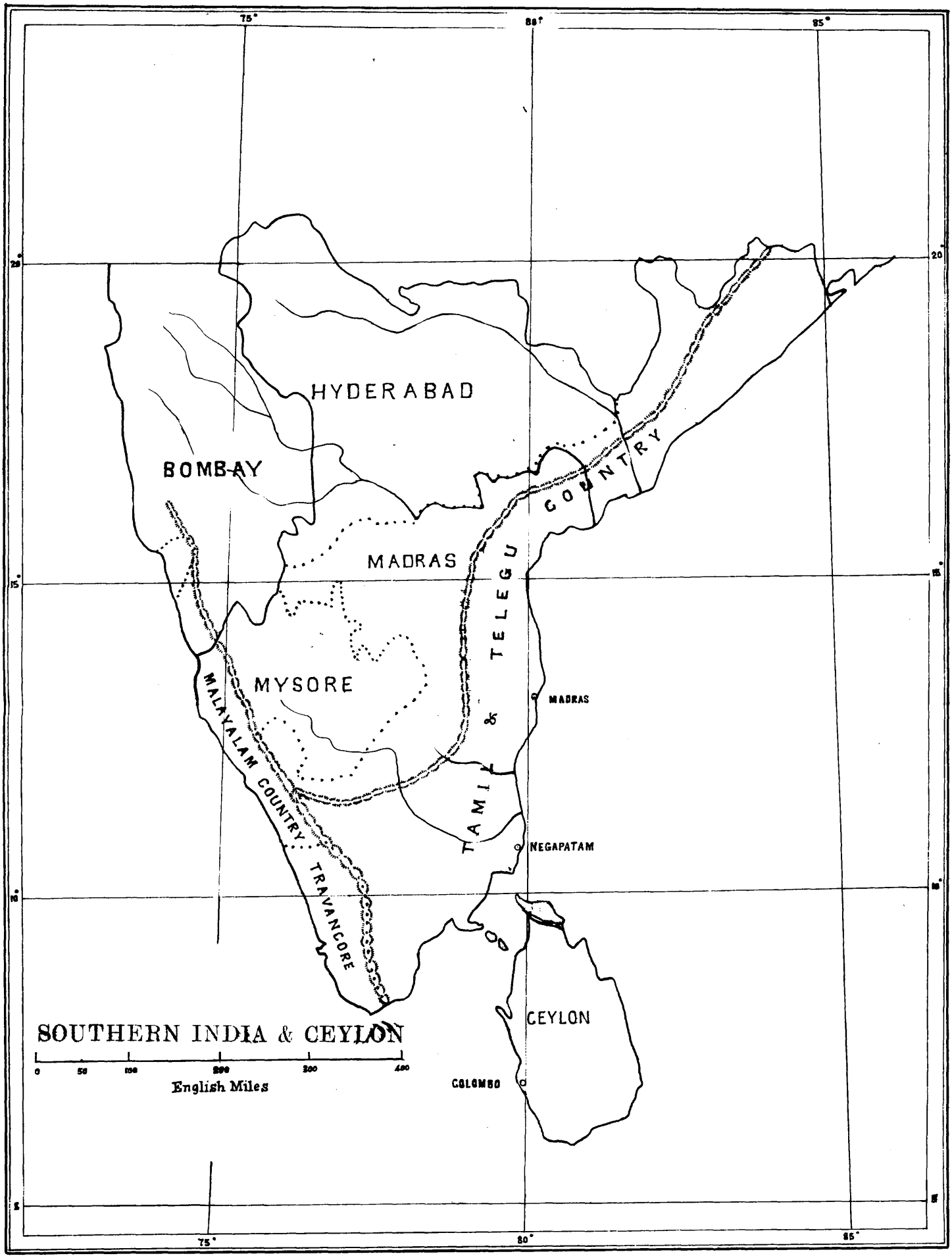
Such a climate is most suitable for the growth and propagation of many kinds of tropical parasites.

The rainfall is large and is, on the whole, fairly evenly distributed throughout the year, being always considerably heavier in localities near the hills than on flat land near the coast. The average in the hilly inland districts varies between 100 and 200 inches per annum.

A range of mountains stretches almost midway from North to South of the Peninsula, forming slopes and flat lands on the East and West. The jungle on these hilly and flat lands has been felled, and rubber planted, so that now some hundred thousands of acres have been converted into prosperous rubber estates.

Labour.

Indian coolies are recruited as labourers for these estates : they come from the Madras Presidency and consist of three distinct races viz., Tamils, Malayalams and Telegus. The Indian climate is much drier, the rainfall being from 25 to 50 inches.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CEYLON
COLOMBO
SOUTHERN INDIA & CEYLON
English Miles

The labourers come from villages, where they are engaged in agriculture.

Their work on rubber estates consists of weeding, tapping trees, and curing rubber in the factory, non-laborious occupations.

History of Hookworm Disease in Malaya.

About ten years ago, Indian immigrants began to arrive in this country in large numbers to work on the roads, railways and estates. Previously, Chinese mining coolies had formed the bulk of the labouring classes, and they suffered to a great extent from beri-beri, often of the wet variety, with swollen feet, legs and puffy faces. It was noticed that, after a residence of a few months, the Indians began to have similar symptoms, which were diagnosed as beri-beri, Bright's disease, heart disease, and so on. The members of the European medical profession, who perform most of the surgery, were often at a loss to account for the sudden deaths after ordinary operations. Post-mortem examinations, in many cases revealed an anaemic condition of the internal organs and the presence of hookworms in varying numbers in the intestines.

Investigations were commenced, and a very large proportion of the native community was found by stool examination to harbour the hookworm.

There was then a "boom" in ancylostomiasis, and the estate medical returns showed large increases in the numbers of those alleged to be suffering from this disease. The native apothecaries and dressers, who actually treat the patients, got into a rule of

thumb method of diagnosis, and said if a Chinaman has swollen legs and feet and is anaemic then the disease is beri-beri if an Indian ancylostomiasis.

While large tracts of jungle were being opened up for rubber planting, malaria fever became rampant and the mortality high. Malaria, ancylostomiasis and anaemia accounted for the great majority of the medical diseases, and, as large numbers of Indian coolies were dying, the matter was thoroughly investigated. The bloods, stools and spleens of some thousands of coolies were examined and the results tabulated.

On malarious places, anaemia with enlarged spleen in a majority of coolies is very common, on non-malarious the labourers get fat, happy and contented. For example, two batches of picked healthy coolies from a non-malarious part of India arrived during the same recruiting months, the first consisted of one hundred and fifty and the second of seventy. The former went to a moderately healthy place, and the latter to a malarious. After a residence of six months, in the case of the healthy place, only 5% developed enlarged spleens and lost 21% of haemoglobin, the remainder had improved in every way and gained on an average 11·9% haemoglobin: on the unhealthy place 90% had developed enlarged spleens and all of them had lost Hb. with an average loss of 15·4%.

The percentage of those infected with hookworm is much the same on malarious and non-malarious places, e.g., a thousand coolies were examined for the presence or absence of hookworm ova and the results are as follows.

	Malarious	Non-malarious
Number examined	471	559
Number infected	282	286
Percentage infected	60%	52·9%

The evidence all points to malaria as being the principal cause of tropical anaemia in this country, in the first place clinically; enlarged spleen, the frequent finding of malaria parasites with large mononuclear leucocytosis and secondary anaemia; secondly the good results of anti-malaria measures, such as open drainage of swamps, subsoil drainage of ravines, oiling of pools, distribution of mosquito nets, daily administration of quinine to coolies and segregation of the sick. During the last two years the health conditions have greatly improved, although waves of malaria are common, and the newly imported coolies harbour the hookworm to much the same extent.

Examination of Faeces.

The sick coolies admitted to the estate hospitals, suffering from the ordinary diseases, malaria, dysentery, bronchitis, ulcer etc., were examined with a view to ascertaining the prevalence and severity of infection by the ancylostome worm. Two slides from each stool were examined microscopically, two to three minutes being spent on each. Frequently ova were seen on one slide and not on the other; sometimes there were many ova, sometimes only a few. It was found best to examine day by day for some days, as ova would be present on one day and not on the next : they were difficult to find after an aperient or when a cooly was suffering

from diarrhoea or dysentery. Out of 1,000 coolies examined by this method, 569 or 56.9% were found to be infected with hookworm. This number falls short of the actual prevalence of infection, because many cases, which showed no signs of the disease during life, were found to harbour the worm on post-mortem examination.

Age.

Adult coolies were apparently infected at the rate of 60% as ascertained by stool examination.

Out of 120 children examined up to ten years of age, the following was noted.

Total number of children

	Up to two years	Two years up to ten.
Number examined	29	91
" infected	Nil	43
Percentage infected	Nil	47.2%

This would suggest that adult coolies who have to work are more exposed to infection by walking through muddy and infected soil and getting hands and feet contaminated, thereby having two channels for the larvae to enter viz., by the skin and mouth, and that young children, who play about the lines and are suckled late by their mothers, run practically no risk of infection.

Sex.

Adult male and female coolies both labourers, as a rule were found infected to much the same extent.

Total males examined	Number infected	Percentage infected.
833	462	55%
Total females		
167	93	55.6%

Analysis of Fifty Postmortem Examinations.

The intestines of coolies who had died of ordinary diseases in hospital were carefully examined; the hookworms were picked off and the lesions caused by them noted. The worm was found in forty two out of fifty examinations i.e., 84%. The number of worms varied from one to five hundred and thirty one.

Number of worms	Number of coolies	Average number of worms per cooly.
1	4	
2 to 10	11	
10 to 30	13	37.6
30 to 50	6	
50 & upwards	8	
	42	

A high infection was therefore an exception, and probably explains the apparent immunity from symptoms of so many coolies who harbour the worm.

Variety of worms.

Out of 1600 worms examined, 1451 or 90% were Necator americanus and 149 or 9.3% of the Ancylostome variety.

Sex of Worm.

Female	1015	or	63.4%
Male	585	or	36.5%

Proportion of Males to Females.

Necator americanus	1 male to 1.6 female
Ancylostome duodenale	1 " " 2.6 "

Variety of Infection.

Out of 42 postmortem examinations, the following was noted.

Single necator infection	21	or 50%
" ancylostome "	2	or 4.7%
mixed necator and ancylostome "	19	or 45.2%

Site of Worm.

The largest number of hookworms is found in the upper part of jejunum : they decrease in numbers in the lower portion of the bowel, until the ileum is reached, where they are scanty. In a few cases one or two may be noted in the stomach (one case four), and a large number may be seen in the duodenum extending to jejunum and even to ileum. In the large bowel, as a rule none are found except a few dead ones, especially, if thymol or Betanaphthol has previously been given. The worm is fixed to the mucosa for some hours after death, when it can be picked off alive; later the dead parasites can be found amongst the mucus or contents of the bowel.

Lesions in the bowel.

Very often nothing abnormal is discovered in the mucosa, even when many worms are present. In a pure necator infection, the mucous membrane may appear normal, but with the larger ancylostomes, small petechiae accompanied by a certain amount of mucus and catarrh may be present. The bowel is frequently anaemic in keeping with the general anaemia. Large numbers of worms do not necessarily mean severe anaemia, which, however, is often present with a moderate infection. Fatty degeneration of the heart, liver, kidneys etc., is seen in very few cases, as the cooly had usually died from some other disease, e.g., pneumonia, malaria or dysentery.

Relationship of Hookworm disease to Malaria Fever.

This investigation has been carried out on very malarious estates, amongst susceptible Indians.

The conclusions we have come to are as follows.

Although a very large percentage of Indian coolies (over 80%) harbours the hookworm, only 3% or 4% can be described as suffering from ancylostomiasis, as diagnosed by severe anaemia, marked eosinophilia, presence of ova in stools, dilated heart, dropsy etc., Large numbers of "fever" cases are admitted to hospital; on examination both malaria parasites and hookworm ova are found. Treatment is first directed to the malaria condition, and then to the hookworm.

So far as the Indian coolies of this part of the World are concerned, malaria fever is the predominant disease, and

ancylostomiasis secondary.

The harbouring of hookworms lowers vitality, predisposing persons to other diseases such as dysentery, pneumonia, malaria, often leading to a fatal termination.

The smaller necator americanus worm largely predominates and may account for the lessened amount of morbidity.

Symptoms.

The disease commences very gradually, and often is noticed when a cooly is recovering from some other disease, or hookworm ova are found at the hospital routine examination of blood and faeces.

The estate managers have a rule, that, if a cooly does not turn out to work he must go to hospital, and so it is often found that a labourer, who is put down as lazy or malingering, harbours the hookworm, with slight symptoms of ancylostomiasis.

Others are admitted to hospital with some simple complaint such as epigastric pain, constipation or "fever", but often there are no symptoms at all.

Some, who feel disinclined or unable to work, come complaining of breathlessness on slight exertion, when signs of anaemia are noted.

A small proportion are brought in with swollen feet, legs and face, utterly incapable of any work. Signs of anaemia are seen in various grades. The patient is weak, his mucous membranes are pale; he has oedema round the ankles, up his legs and even to his scrotum; the face is swollen, and in severe cases, there

is ascites. The stomach is out of order and he may have epigastric pain or heartburn. Constipation is common, but some have diarrhoea.

The eggs are easily found in the stools, often together with those of Ascaris Lumbricoides and Trichocepalous Dispar.

The urine is as a rule free from albumen.

The blood changes in mild cases resemble those of simple anaemia with diminution of the red cells and haemoglobin; sometimes the reduction in the amount of the haemoglobin is in excess of the reduction in corpuscles resembling chlorotic blood. In severer cases, the blood is thin and watery, and coagulates with difficulty; there is a great diminution of both haemoglobin and red cells, and the blood films on examination resemble those of pernicious anaemia with poikilocytes, megalocytes and microcytes.

The eosinophile leucocytes are increased, but as a malaria infection is so often present, the eosinophilia is masked by a mononuclear leucocytosis.

Fever.

Usually there is no increase of temperature, which may be abnormal. In some cases, there is a mild irregular pyrexia in which the temperature rarely rises above 100 degrees Fahrenheit, and which is uninfluenced by quinine. This usually disappears when the patient has got rid of his worms and has been well purged.

Mental symptoms.

Coolies suffering from the disease are averse to exertion

of any kind, and are often slow in body and mind.
Death may ensue in profoundly anaemic cases from sudden cardiac failure, but a chronic diarrhoea or dysentery usually ends the scene.

Description of Species of Hookworm.

The ancylostome worms belong to the Nematoide class, and family Strongylidae.
The genus Necator americanus comprises 90% and the Ancylostomum duodenale 10%, so far as this country is concerned.
These worms have cylindrical bodies, a deep oral capsule, and during life are flesh coloured. The mouth opens into a cavity, in which the opening of the oesophagus is situated. Armatures, such as teeth, thickenings or spines are frequent at the orifice of the buccal, oral or oesophageal capsule. The opening of the female genitals is near the middle, and in the female the anus is subterminal, the tip of the tail being bluntly pointed. The male is smaller, the cloaca is terminal, and surrounded by four membranous flaps, strengthened by chitinous ribs forming the copulatory bursa. There are two long unequal spicules.
The two genera can be distinguished without measurements by the naked eye; in Necator the head is more abruptly bent back in both sexes, and in the male the copulatory bursa is not in the middle line, but directed to one side.

Necator americanus.

The commoner worm has a cylindrical body, is smaller, more slender,

and slightly thinner anteriorly. The head is acutely bent dorsally : the mouth has a ventral pair of prominent semilunar plates, and a dorsal pair of ill developed plates. The opening of the dorsal head gland forms a conical projection into the floor of the mouth, and deep in the cavity appear one pair of dorsal and one pair of ventral submedian lancets.

The female is 9 to 11 mm in length and ·5 mm in breadth : the vulva is situated in the anterior half of the body near the middle.

The male is 7 to 9 mm long by ·35 mm broad.

The bursa consists of two large lateral lobes joined to a dorsal median lobe, which appears as if divided into two, and to an indistinct ventral lobe. There is a slight ventral enlargement just posterior to the point at which the bursa joins the body wall. The costa dorsalis is divided at its base into two diverging branches, which are bipartite. The common base of the costa dorsalis and costa dorsalis externa is very short, while the latter ray is long and slender. The costa lateralis externa is closely joined to the costa lateralis media. The spicules are long and slender and terminate in barbed points.

Ancylostomum duodenale.

The body is elongated, tapering from back to front in both sexes. The mouth is terminal, with a chitinous wall, which ventrally carries two pairs of hooklike teeth, and dorsally one pair. Close to the base of the outer ventral tooth opens the single celled head gland, running through nearly half the length of the body.

In the floor of the mouth, there are two ventral chitinous plates and the prominent opening of the dorsal head gland.
The female is 10 to 13 mm long by 1 mm broad, and has the vulva at the junction of the middle and hinder parts of the body from which a short vagina opens into two tubes, which are divisible into ovijector, uterus, receptaculum seminis and an ovary. The male measures 9 to 10 mm and ·5 mm in breadth. It has a copulatory bursa at the posterior end, umbrella-shaped and supported by chitinous rods, which have the following arrangements.
In the median dorsal line is the costa dorsalis, dividing into two small branches ramified at their tips. Postero-laterally, there is one root on each side - the single costa dorsalis externa in front of which is a single broad lateral root, dividing into the costa lateralis posterior, the costa lateralis media, and the costa lateralis externa. In front on each side is the costa ventralis.
The male generative organs consist of a testis in the form of a tube, an oval vesicula seminalis, and a long cement gland, whose secretion fixes the male to the female during conjugation, and a spicule sac.

Life-History.

The following account applies to both worms.
The female lays the eggs in the jejunum : they are oval, with broad rounded poles, surrounded by a colourless shell, inside which lies an oval granular mass separated from the shell by a considerable space. They measure ·05 mm to ·03 mm in ancylostome

and ·06 mm to ·03 mm in necator. On its way down the alimentary canal the ovum divides into two and then into four segments, in which condition it is often found in the faeces. In twenty-four to forty-eight hours, if conditions of air, water and heat are favourable, the embryo can be seen coiled up in the egg, from which it escapes as a larva and feeds on the foecal matter. Moisture and heat are the main conditions, and the best temperature is a uniform 75° F, whilst the moisture is always contained in the faeces or on the ground. The embryos, when hatched out, are needle-shaped, and pointed posteriorly measuring roughly 200 μ in length by 15 μ in breadth. They are actively motile, rhabdite in form and possess a long cylindrical terminal mouth opening into an oesophagus, narrow at first, and then swelling out into a bulb with three valves : the straight intestine with its surrounding granular material opens into an anus at some distance in front of the tip of the tail. The larvae live in moist earth or water and rapidly get larger; they cast off their skin, becoming narrower, the anatomy of the oesophagus and mouth changes, and a new skin forms inside the chitinous cuticle. At the end of five days feeding and growth now cease, and the motionless, encysted embryos can live in moist earth or water for months on the food material enclosed in their own cells, undergoing a final stage of development. Man is infected if the embryos are swallowed, and this often happens from eating or mixing food with fingers soiled with earth or drinking water containing ancylostome larvae.

Professor Loos has shown what would appear to be the more important method of infection. During the stage of encystment, the larvae may become active and move upon wet surfaces : they can penetrate the skin through the hair follicles, causing eruptions and sores, known as " water itch, " a common complaint among the Tamil coolies in Malaya.

From the hair follicles, they force their way via the subcutaneous tissue into the venous bloodvessels and lymphatics. By the bloodvessels, they easily reach the right heart and lungs; many are killed in the lymphatics, but some get through to the blood, and in this way are carried to the lungs. They now work their way out of the capillaries into the lumen of the air cells, and travel up the bronchi, trachea and larynx into the oesophagus, and so through the stomach to the intestines. When the larvae have reached this stage, they are not destroyed by the acid contents of the stomach, and pass on into the duodenum, where they undergo ecdysis, and attach themselves to the mucous membrane of the small intestine. The time occupied by this journey is believed to be from seven to ten days.

In the skin, they undergo their second ecdysis, beginning the third stage of development, during which the provisional buccal capsule is formed. A third ecdysis in the intestine in four to five days after their arrival commences the fourth stage characterised by the provisional buccal capsule armed with a dorsal and ventral pair of teeth : the sexes now become differentiated and the permanent buccal capsule is formed. The

fourth ecdysis four to six days later results in the appearance of the adult worms.

They now measure 3 to 5 millimetres in length and in about eight days, the generative organs begin to attain maturity; the first copulations take place and a few days later the first eggs appear in the foeces, thus completing the cycle of development, of which the portion after infection occupies four to six weeks.

Drug Treatment of Hookworm Infection.

The object of treatment is to expel the worms, not an easy matter, and often successful only after repeated attempts. Before commencing, the general condition of the patient should be enquired into, especially the heart, as the drugs used are powerful.

We have to deal with undisciplined, ignorant Tamil coolies, often of poor physique, suspicious of Western medicine, and whose one desire is to be out of hospital, working for wages which to them are sufficient to enable them in a few years to return to India, where they need not work again.

The native dressers, who administer the drugs, have as a rule very little experience of disease, lack initiative, resource and often authority.

The hospitals on the estates are situated in country districts, at some distance from the outstations, so that European supervision at night is practically out of the question.

The art of nursing is unknown, and, rest in bed, the ensuring of a low diet, the administration of purgatives cannot be relied upon.as coolies will wander about, steal any available food, and evade medical treatment.

The following is the routine treatment :-

the day before the patient receives only congee, that is, a kind of rice gruel; at night he gets a dose of salts or white mixture; at 7 a.m. next morning the drug is administered in two doses at an hour's interval, at 10 a.m. another purge is given and at 3 p.m. he goes on to the ordinary diet.

The stools are collected, strained and the worms searched for. The treatment usually requires to be repeated three or four times at intervals ranging from two days to a week. The foeces are examined from time to time for ova, when further medication may be necessary.

We have usually to be content with expulsion of the greater number of the worms. Tonic treatment with iron and arsenic is given for some weeks, and the cooly receives good curry and rice, his normal diet.

The following drugs have been tried with more or less success.

Thymol.

This is a very poisonous drug in large doses i.e., 20 to 30 grains repeated in an hour, and in weak patients may be

followed by collapse. It is soluble in alcohol and oil. In the estate hospitals, it is very easy for a cooly to get gin or native toddy, or to receive a dose of castor oil by mistake, and many sudden deaths have occurred from these causes, so that thymol, as a routine drug for treating hookworm disease in coolies has been largely given up, and is reserved for Europeans, Eurasians, or educated natives under nursing supervision.

Eucalyptus Oil and Chloroform.

Thirty drops of eucalyptus oil, forty of chloroform, and ten drachms of castor oil are mixed, and after the usual starvation and purgation, half is given first thing in the morning and the remainder in half an hour followed in two hours by a saline purge. The coolies like this form of treatment, but it is not so efficacious as thymol, and requires to be repeated oftener: this method is not used greatly as anything from ten to fifteen doses are very often necessary, tiring to both patient and physician.

Beta-naphthol.

This drug can be given in gelatine capsules up to sixty grains for a treatment, the usual doses being 30 grains followed by 20 grains for adults. It is much the safest form of treatment in the hands of unskilled dressers, and where large numbers of patients require treatment. Apart from a feeling of warmth and burning in the stomach, no bad effects follow its administration: it should be avoided when the urine contains albumen, and in kidney diseases.

The results are not so good as with thymol, so it requires to be repeated at regular intervals.

Beta-naphthol is specially valuable in the treatment of the many mild cases where hookworm ova are found at the routine examination, and where the exhibition of large doses of thymol to many native patients would certainly be followed by accident.

In very anaemic and debilitated patients, it is also given when thymol would be dangerous.

Oil of Chenopodium.

This form of treatment is the most recent and most successful. Its action appears to paralyse the worm, making it loosen its hold on the mucosa so that an efficient purge must follow, if the drug is to be successful. It is best given as follows :- forty drops of oil of chenopodium, one drachm of gum of acacia and one ounce of water are well emulsified; the patient is prepared in the usual way and half is given at 7 a.m., the other half at 8 a.m., followed by one or two ounces of castor oil or a large dose of salts at 10 a.m., An easy way is to give 20 drops of the oil on a piece of sugar and repeated.

The treatment can be given twice a week without great discomfort, apart from a feeling of giddiness, when the dose may be diminished to thirty drops or even twenty.

Large numbers of worms have been expelled by this drug.

Some thousands of cases of hookworm infection have been treated, and ten will now be described briefly. Very often, the number of worms does not seem to bear any relationship to the amount of anaemia, and with a few worms severe signs are often present, while hundreds of parasites will be expelled from patients, who have been admitted for other diseases with no special symptoms of ancylostomiasis.

Case 1. Photos 1 and 2.

Suppiah, male Tamil cooly age 18, Seremban Rubber Co., was admitted to hospital February 4th 1916 complaining of general weakness and swelling of two months' duration.

Condition on Admission.

The face is swollen, the eyelids puffy : there is extreme pallor of conjunctival and buccal mucous membranes. The feet and legs are swollen and pit easily; the abdomen is protuberant, but he is really thin.

He has breathlessness and palpitation on exertion, and the vessels in his neck pulsate markedly.

The heart is dilated : the apex beat is small and the cardiac impulse noted just below his nipple in the fifth space : the precordial dulness is $4\frac{5}{4}$ inches. A well marked systolic murmur is heard over the whole cardiac area, best over the base and left edge of sternum.

The pulse is soft and compressible numbering 96 per minute.

Case 1 Suppiah Tamil. Sorembon Estate.
Severe anaemia and dropsy due to hookworm and malaria infections. Recovery.

Photo 1

Fever.

The evening rise of temperature ranges between 99°F and 100°F.

Spleen.

The spleen is enlarged and its lower edge is felt 4" below costal margin.

Liver.

This organ is swollen and tender, and its lower border is noted 2" below costal margin in nipple line.

Lungs. normal.

Urine. normal.

The foeces contain ova of hookworm and those of trichocephalous Dispar.

The blood is thin and watery : there is great diminution of both haemoglobin and blood cells : no malaria parasites are seen, but there is a mononuclear leucocytosis, showing the presence of a malarial infection.

Treatment.

He was given the usual purge and put on to quinine sulphate ten grains three times a day.

Betanaphthol was given 50 grains, divided into 30 and 20 grains and repeated on three different mornings, when a small number of worms ranging from 6 to 10 was collected on each occasion.

The foeces were examined from time to time for ova with negative results, and the anthelminthic repeated.

Case 1. Suppiah. Tamil Seremban Estate.
Great improvement after seven weeks treatment.

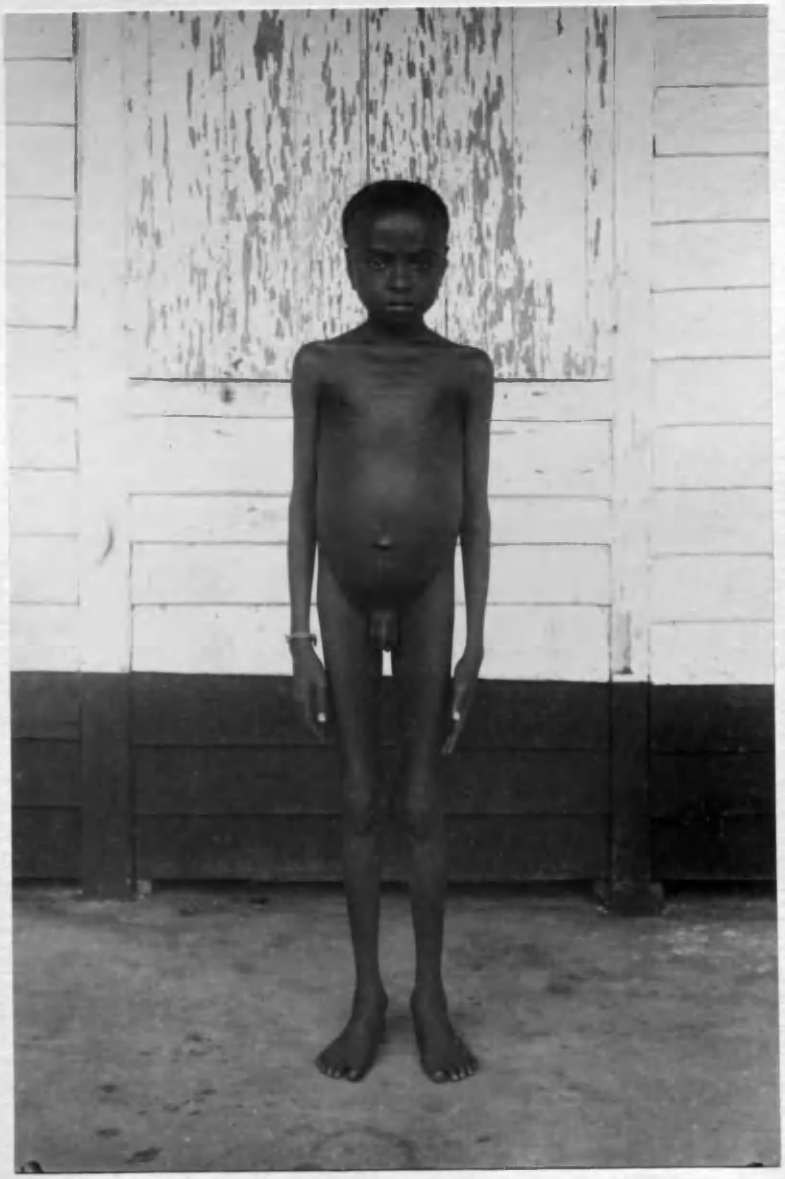


Photo. 2

Patient was put on to a tonic containing Iron, arsenic and tincture of digitalis, and received ten grains of quinine daily. After a residence of seven weeks in hospital, he returned to the lines, and proceeded to work.

Note.

The malaria element in this case contributed greatly to the severity of the symptoms.

Case II. Photo 3.

Karavan VII, male Malayalam cooly age 26, Anglo-Malay Rubber Co., was admitted to hospital February 15th 1916 complaining of "fever," weakness, and slight swelling of the feet of ten days' duration.

Condition on Admission.

He was brought to hospital by his friends. The temperature was 103°F and the pulse was soft, compressible numbering 100.

Benign tertian malaria parasites were found in his blood and he was given thirty grains of quinine daily.

February 18th.

He now had no fever : the face was swollen and puffy, and the mucous membranes slightly pale : the feet and legs were oedematous and pitting on pressure was obtained over the skin bones.

The tongue was furred, the bowels constipated : round worm and

Case II

Karavan VII Malayalam coolie Anglo-Malay Rubber Co.

admitted for benign tertian malaria and hookworm infection. Feet & legs slightly swollen and face full & puffy under eyes. Complete recovery.

Photo 3

hookworm ova were found in the foeces.

Spleen.

This organ was enlarged and its lower edge could be felt 2" below costal margin.

Liver. nil.

Lungs. nil.

Kidneys. nil.

Heart.

There is a soft blowing murmur over pulmonic area and down left side of sternum, with slight cardiac dilatation.

Treatment.

Twenty drops of oil of chenopodium on ordinary granular sugar were given on an empty stomach and a large dose of purgative administered three hours later. The stools were strained and over two hundred worms collected.

The treatment was repeated on three occasions with negative results.

Ova were looked for from time to time but none found.

Santonin was given for the round worms.

Patient was put on to a quinine, Iron and Arsenic tonic for three weeks, when he returned to his work.

Case III. Photos 4 & 5.

Benjaliah, male Telegu cooly age 29, Anglo-Malay Rubber Co., was admitted to hospital 21st March 1916 complaining of "fever"

Case III Ranjaliah, Telegu. Anglo-Malay Rubber Co.
Hookworm infection, general swelling of body.
Face full + puffy. Recovery.

Photo 4.

Case iii Benjahah Telegu cooly, Anglo-Malay Rubber Co.
Hookworm infection. generalised swelling feet & legs
pit on pressure, face puffy, heart slightly dilated
Simple anaemia with marked eosinophilia Recovery

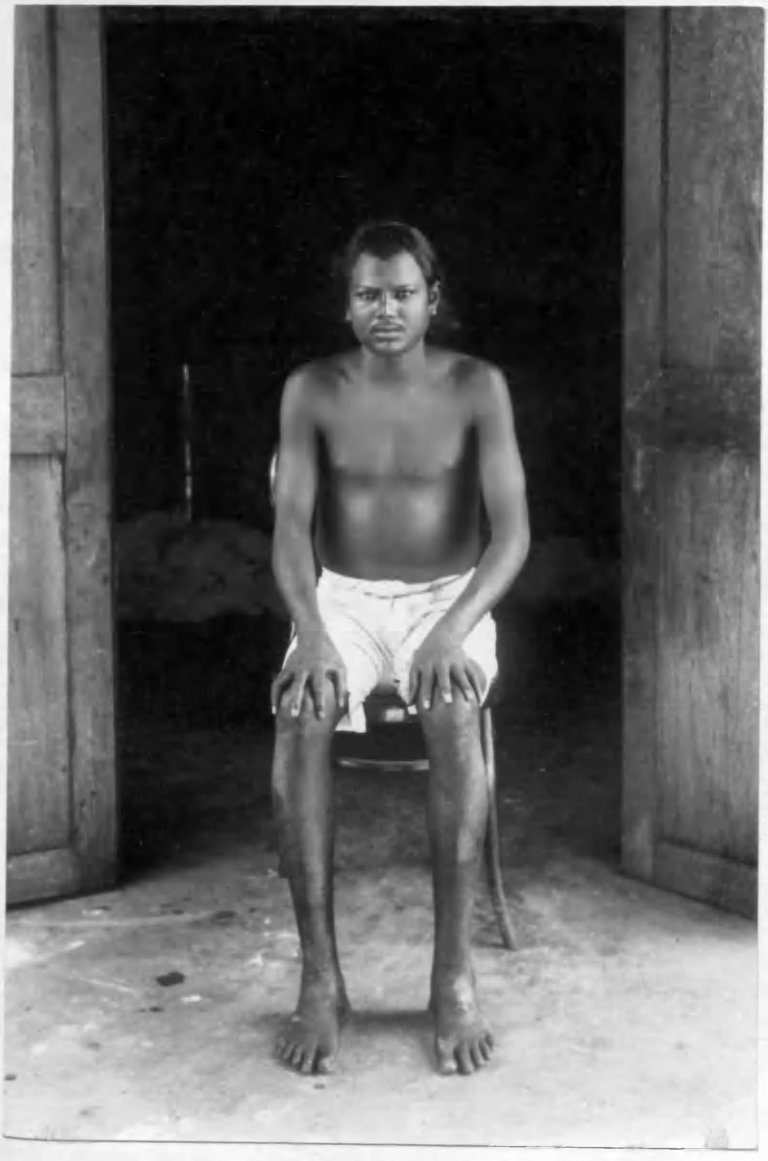


Photo 5.

and headache of two weeks' duration.

Condition on Admission.

He is a big man, slow, clumsy and lethargic; his face is swollen and the skin over his shins pits on pressure. He has no fever, the pulse is 100 per minute, soft and compressible. He feels tired and unable to do his tapping and gets breathless when he is carrying the latex buckets. The tongue is slightly furred, the appetite poor, bowels regular, the faeces contain ancylostome ova.

Heart.

The apex beat is in fifth space just below nipple: the precordial dulness is 4" : a loud blowing systolic murmur is noted at apex, heard best in the fourth space between nipple and midsternal lines. The second sound is accentuated in pulmonic area.

Spleen.

The lower border is felt $4\frac{1}{2}$" below costal margin.

Lungs. nil.

Kidneys. nil.

Blood.

No malaria parasites seen, but a 25% eosinophilia is noted.

Treatment.

He was put on to quinine hydrochloride thirty grains a day for a few days.

Forty drops of oil of chenopodium in two doses were given, and thirty worms passed : the repeat produced twenty-five worms. He was put on to an iron tonic for a couple of weeks, and the anthelminthic repeated, but only a few parasites were obtained. No ova were found after repeated examinations, and he returned to his work feeling "better in his body."

Case IV. Photo 6.

Komarachee, male 28, Tamil cooly Seremban estate, was admitted to hospital on 28th January 1916 complaining of weakness and swelling of his feet and legs of two weeks' duration.

Condition on Admission.

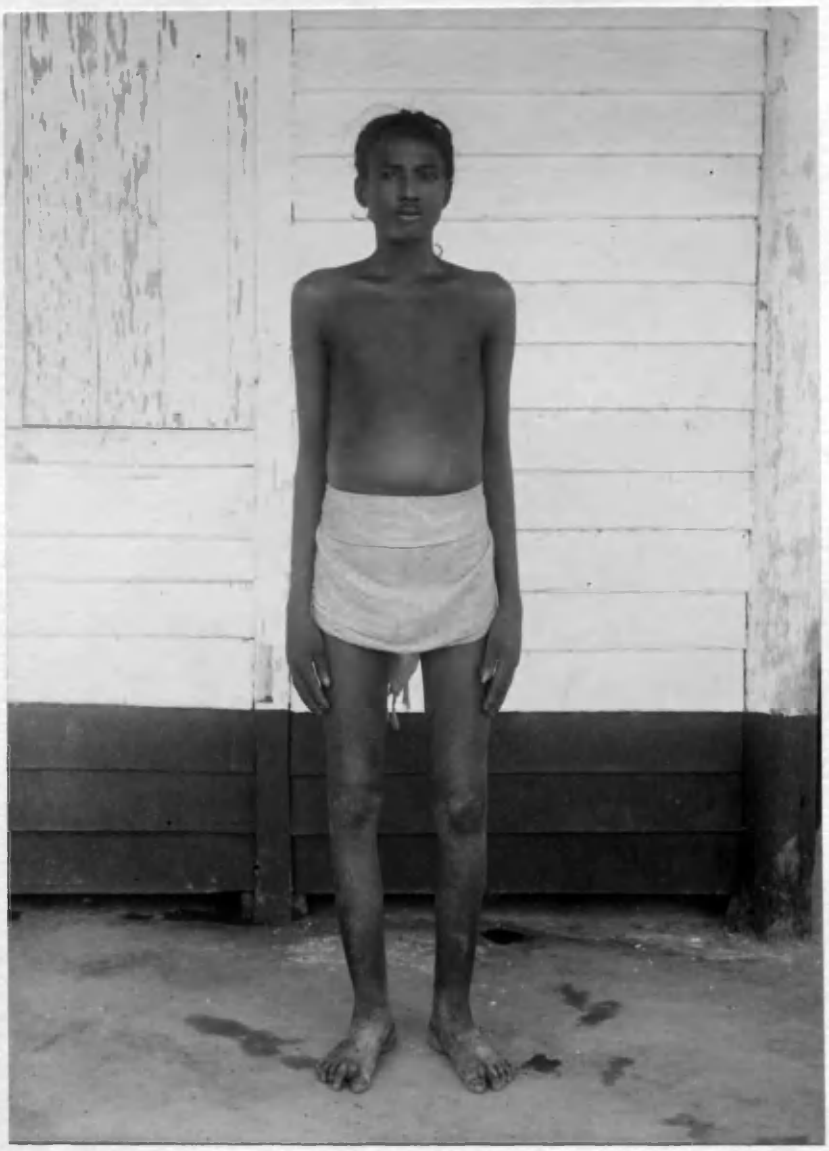
His face looks full and swollen and in the mornings his lower eyelids are distinctly puffy. The feet and legs are oedematous, and there is distinct pitting on pressure over the skin bones. The mucous membranes are pale : the tongue is furred, the appetite poor, the bowels constipated, the foeces contain larvae of strongyloides stercoralis and ancylostome ova. The temperature is 99°F and the pulse 120 per minute, soft and regular.

Heart.

The apex beat is immediately below nipple in fifth space : there is cardiac pulsation in second and third spaces : precordial dulness measures 4" : a soft haemic murmur is heard at the base and along the left edge of the sternum.

Case IV Photo 6. Hookworm infection

Komarachee 28, male Tamil Seremban Estate admitted with swollen legs, feet and face. Cardiac dilatation and simple anaemia. Recovery.



Spleen.

The lower edge is felt 1" below costal margin.

Liver. nil.

Lungs. nil.

Urine. nil.

Blood.

There are no malaria parasites. The haemoglobin and corpuscles are diminished about 20%, showing a condition of simple anaemia.

Treatment.

He was given an aperient and put on to thirty grains of quinine a day. A few days later, twenty drops of oil of chenopodium were given on soft sugar, followed by a large dose of white mixture, when twenty hookworms were collected. This was repeated in a week and twenty five worms expelled. No ova were found in the foeces on repeated examination. He received three weeks tonic treatment and chenopodium was again given with negative results. All his symptoms disappeared and he absconded two days later to resume his work.

Case V. Photo 7.

Ramadoo, 25, male Telegu, Rubber Estates of Johore, was admitted to hospital on 21st March 1916 complaining of swollen feet, legs and face of a week's duration.

Condition on Admission.

The face is swollen, the lower eyelids are puffy :

Case V Photo 1

Ramadoo 25, male Telegu Rubber Estates of Johore admitted 21.3.16 with swollen feet, legs, + face, cardiac dilatation severe anaemia. Ring scabation parasites & ova of hookworm found. Combined malaria & hookworm infection Death.

there is pitting on pressure over his feet and skins.
The conjunctivæ are pale : he is breathless on exertion, and the vessels of the neck pulsate visibly.
The temperature is 101°F, and the pulse is rapid and soft numbering 100.

Heart.

The organ is slightly dilated : the apex beat is just outside nipple in fifth space, the precordial dulness measures four inches. A soft systolic murmur is heard best at midsternum and also at base and apex.

Lungs. nil.

Liver. nil.

Spleen. nil.

Urine.

Small amount of albumen present. The appetite is poor, and he tends to be sick after food, the bowels are constipated and the fæces contain many hookworm ova.

Blood.

Ring forms of subtertian malaria were found. There was severe secondary anaemia with diminution of haemoglobin and red cells, and a mononuclear leucocytosis.

Treatment.

He received quinine treatment for malaria combined with tincture of digitalis and liquor strychnia.
For a few days, he appeared much better, but he suddenly died

of cardiac failure. No treatment for ancylostomiasis was given, as it was decided to allow the heart to become stronger. The combined malaria and ancylostome infections were responsible for the severe symptoms in this case.

Case VI.

Sinnakolandi, male Tamil, 28, Anglo-Malay Rubber Co., was sent to the estate hospital by the assistant manager, because he was lazy and did not turn out to weed.

Condition on Admission.

He had no special complaint except that he felt weak and got very tired, when he attempted to work. He was listless, disinclined to move and answered questions very slowly. The spleen could be felt 3" below costal margin : the other organs appeared healthy.

There were no malaria parasites in the blood, the eosinophilia was 10% : there was a slight diminution of haemoglobin and red cells.

The fdeces contained ancylostome ova and those of trichocephalous Dispar.

Treatment.

He received 30 grains of quinine hydrochloride for a few days.

Sixty grains of Betanaphthol were given in two doses and 150 worms obtained : the repeat produced 50, and a last treatment 40.

After repeated examination, no ova were found and he returned to work, saying "his body felt better."

This case is a fairly average type of hookworm infection seen in this country.

The anaemic symptoms are slight; the cooly is unable to work, and if he is neglected, he becomes prone to malaria or dysentery with often a fatal issue, as the hookworm infection is not observed.

No photo was taken, as patient looked the same as any ordinary cooly.

Case VII, Photo 8.

Karuppannan, 24, male Tamil cooly, was admitted to the Seremban Estate hospital complaining of "fever" headache, weakness, loss of appetite, and swelling of feet and legs of a month's duration.

Condition on Admission.

His face was swollen, the lower eyelids puffy, the skin over the feet and legs pitted on pressure : he was weak, breathless and languid.

The temperature was 98°.6, the pulse 100, feeble and soft.

The tongue was furred : he did not care for food, the bowels were loose and the faeces contained hookworm ova.

The heart was dilated : the precordial dulness measuring 4¼" : blowing haemic murmurs were heard over the cardiac area.

Lungs. nil.

Case VII Photo VIII

Karuppannan 24 Male Tamil Seremban Estate
admitted for swollen feet legs & face, weakness, cardiac dilatation
and fever anaemia. Hookworm infection and malaria cachexia
Death due to terminal diarrhoea

Spleen felt 2" below ribs.

Kidneys. nil.

Blood.

The red cells and haemoglobin were greatly reduced, showing a condition of severe secondary anaemia. No malaria parasites were noted, but a mononuclear leucocytosis denoted a malarial infection.

Treatment.

He received treatment for malaria. A few days later, Betanaphthol in fifty grain doses was given on two separate occasions, and forty five hookworms were expelled.
He was put on to an iron and arsenic tonic and improved for a time.
Unfortunately he developed a diarrhoea, which proved fatal.

Case VIII. Photo 9.

Suppiah, age 17, male Tamil, a new cooly from India, was admitted to Anglo-Malay Rubber Co's hospital for observation.

Condition on Admission.

He is a thin young Indian, but has no evidence of disease about him. His only complaint is that he is not allowed to go and work; his fæces are heavily infected with hookworm ova.

Treatment.

He was given forty minims of oil of chenopodium in

Case VIII. Photo IX

Suppiah, age 17, Tamil, Anglo-Malay Rubber Co new coolie from India, this youth, heavily infected with hookworm. Chenopodium treatment given before commencing work

two doses of twenty each, when 120 worms were collected. He next received a tonic of quinine, iron and arsenic, and chenopodium was again administered with negative results. The fæces were examined from time to time, but no ova found, so he started work after a fortnight's stay in hospital.

Note.

This is the type of infected cooly who develops pernicious malaria after a short residence in this country, and is admitted to hospital with severe symptoms such as swollen feet, legs, face, enlarged spleen, dilated heart, secondary anaemia, and is carried off by a terminal dysentery or low form of pneumonia.

Cases IX, Photo 10.

(a) Taller man. Applamanian.

(b) Shorter man. Sinnappan.

(a) Applamanian, male Telegu, 35, Rubber Estates of Johore, was admitted to hospital 24th May 1916 complaining of swollen feet, legs and face with breathlessness and palpitation on exertion of ten days' duration.

Condition on Admission.

His feet and legs are oedematous, pitting on pressure : the face also is swollen especially under the eyes. He says he is weak and cannot carry his buckets for holding rubber latex.

Cases IX Photo V

(a) Appalamaistan.

(a) Taller Telegu
(b) Shorter Tamil.

Taller Telegu. 35. Punkha Estates of Johore admitted for swollen feet legs & face. Anaemia, hookworm infection. Cheesopotrin treatment

(b) Simmappan 30 Tamil. subtertian malaria & hookworm infection

Recovery

death due to cerebral malaria.

Heart. Haemic murmurs are heard and the apex beat is just below nipple in fifth space, showing slight dilatation.

Blood. Haemoglobin 40%

Blood count (1) Large mononuclears 15%
(2) Polymorphonuclears 67%
(3) Lymphocytes 13%
(4) Eosinophiles 5%

No malaria parasites were seen.

Lungs. nil.

Urine. slight trace of albumen.

Liver. nil.

Spleen. lower edge felt 1½" below ribs.

Gastro-Intestinal Tract.

His appetite was poor, the tongue furred, and he felt blown out after his curry and rice. The bowels were constipated and the faeces contained hookworm ova.

Treatment.

After an aperient, he was put on to quinine, thirty grains a day for a few days, even although he had no rise of temperature.

During the next ten days, he received four treatments of 40 drops of oil of chenopodium, when over a hundred worms were collected.

He was given a quinine, iron and arsenic tonic for a week; all his symptoms disappeared and he was discharged after negative stool examination on three occasions.

(b) Sinnappan, male Tamil, 30 years old, Rubber Estates of Johore, was admitted to hospital complaining of inability to work and swollen feet and face of a week's duration.

Condition on Admission.

He is a thin cooly : his feet and legs are slightly swollen and his lower eyelids are puffy. He is anaemic and gets breathless, when he walks up the rubber slopes.

Heart. Haemic murmurs are heard at the base and the precordial dulness is slightly increased. The pulse is soft and compressible numbering 100 : the temperature is 98°F.

Blood. Haemoglobin 30%

Differential Count.	Polymorphonuclear	56%
	Large mononuclear	17%
	Lymphocytes	22%
	Eosinophiles	6%

A few rings of subtertian malaria were noted.

Lungs. nil.

Spleen. Lower edge felt 4" below ribs.

Urine. nil.

Gastro-Intestinal Tract.

He was dyspeptic and did not eat his rice. The faeces were heavily infected with hookworm ova.

Treatment.

He was given an aperient and two days quinine treatment.

One treatment of 40 drops of chenopodium was administered and

nearly 50 worms were collected. Next day, he developed a high temperature, when many rings of subtertian were found in the blood. He was given quinine intramuscular injections, but did not respond to treatment. Later he became restless and irritable, showing signs of cerebral irritation : he wandered out of hospital at night and was found dead in the rubber next morning.

Note.

Quinine treatment should have been given for at least a week, before commencing the anthelminthic. In this country, where the double infection is seen in the great majority of cases, the malarial element is fraught with more danger, and the hospital rule is to push quinine vigorously at first and then to deal at leisure with the worm condition.

Case X. Photo 11.

Krishnamah, male Telegu, 25, Rubber Estates of Johore, was found at the labour muster to have swollen feet, legs and face and was sent to hospital for treatment.

Condition on Admission.

He had no complaint and had performed his task that morning of tapping rubber trees.

His feet, ankles and legs were swollen and pitted on pressure : the face was full and the lower eyelids puffy. The conjunctivae were pale, a soft haemic murmur was heard at midsternum, the

Case X Photo XI

Krishnamah male Telegu 25. Rubber Estates of Johore.
admitted to hospital with swollen feet legs & face
Subtertian malaria and hookworm infection

Recovery.

temperature was 99°F, the pulse soft numbering 100 per minute.

Lungs. nil.

Urine. acid. Specific Gravity 1010, clear amber colour, no albumen or blood.

Spleen was felt two inches below ribs.

Blood. Ring forms of subtertian malaria were found. Haemoglobin registered 40% and blood count was as follows :-

Polymorphs	44%
Large Mono	14%
Small Mono	37%
Eosinophiles	4%

Digestive System.

His mucous membranes were pale, the tongue slightly furred, the bowels regular, the faeces contained ova of hookworm.

Treatment.

He received thirty grains of quinine for four days. Next 40 minims of oil of chenopodium were given and 35 worms collected; this was repeated and 20 worms were obtained. Repeated stool examination proved negative and after two weeks of tonic treatment, he returned to work.

His symptoms of swelling disappeared, and the haemoglobin registered 60%.

He was freed from both malaria and hookworm infections, the former being the more important.

Methods of Prevention.

In Malaya all nationalities are found to harbour the hookworm.

The Malays living in their Kampongs or villages are infected in large numbers, but mildly so. They very seldom show signs of ancylostomiasis, as they are an indolent people and do not, as a rule, work as labourers on estates, thereby not being so much exposed to debilitating diseases like malaria, pneumonia, and dysentery. They have a great aversion to European medical treatment, and are very seldom seen in hospital.

The Javanese, who have been taught by the Dutch to work on estates, are heavily infected, but being a more virile and independent race than the Indians, rarely seek hospital treatment, unless compelled by their headmen.

The Chinese, working on tin mines, acting as shopkeepers, tradesmen, and tappers on rubber estates are found on admission to hospital to be also infected but not to the same degree as Malays or Javanese.

The Indian races, who have the least stamina, are directly under the control and receive the paternal care of the Government, in the way of an Indian Immigration Department, hospitals and European medical officers. They are infected with hookworm to a very high degree.

At the routine examination of sick Europeans, we have found a small number with hookworm ova in the stools, but not showing

any signs of ancylostomiasis.

There is no doubt that the infection is imported by the Indians, Javanese, and to a lesser extent by the Chinese. and has spread and increased among all classes in Malaya.

Every year, large numbers of Indian immigrants arrive during the recruiting season in this malarious country, and very soon develop malaria fever, or bowel trouble, requiring hospital treatment.

Malaria parasites, the entamoeba histolytica, and hookworm ova may be found, and as many coolies die with signs of dropsy, which may be brought about by any one or a combination of these organisms, the native dressers often report the deaths as due to ancylostomiasis. Every year the estate death returns show a large mortality ascribed to hookworm disease, the greater percentage of which is due to malaria cachexia, or post-dysenteric oedema and debility, with a slight ancylostome infection as an incident.

The methods recommended and adopted by the estate authorities for dealing with this condition will be shortly described.

When new coolies arrive from India on to an estate, they are sent into the estate hospital for a week or so.

We have found by stool examination that almost 60% of the new arrivals harbour the hookworm without showing signs of ancylostomiasis.

Betanaphthol treatment is given till no ova are found, and the coolies next proceed to the lines, where they live in rooms

built five or six feet from the ground. The earth beneath the buildings is well beaten and cow-dunged or cemented to prevent the formation of pools or puddles where hookworm eggs might develop into larvae and infect the coolies through their bare feet. Bricked drains are built round the lines to deal with the heavy tropical rains. The surroundings are kept clear of all vegetation and sand or fine laterite earth is spread over the open spaces used for recreation by the coolies on their return from work, with a view to keeping them dry and preventing the formation of stagnant water. In some cases the neighbourhoo of the lines is sprinkled over with lime in the hope that it may prevent the development of larvae. The floors of the rooms, the steps, railings, and the handles of agricultural implements and tapping knives have been washed in one in twenty carbolic for the purpose of killing off larvae.

Latrines.

As the disease is spread in this warm, moist climate by indiscriminate and unregulated, superficial deposition of faeces on the ground, latrines of various kinds have been erected for the use of the cooly labour forces. The Indians, in their own villages defaecate at any convenient place near their huts, and, when they arrive on the rubber estates, they do the same, so that an adult population has to be educated to the use of latrines. In order to encourage them, the latrines are placed at any easy distance, a good broad path provided, scavengers are employed to keep them clean, and a lamp kept burning at night.

We have harangued, threatened, rewarded, fined and used every means in our power to get a better use of these buildings and we consider the result very good if 80% of the coolies avail themselves of this hygienic measure.

Three main types are employed.

(1) Elongated buckets are used in the compartments and the faeces destroyed in a small crude incinerator.

(2) Deep pits are dug and a detachable, portable superstructure placed over them. The floor has holes for the coolies' use. The latrine is well limed daily and kept scrupulously clean.

(3) A corrugated iron superstructure on wheels is put over a shallow trench and moved on every month to a fresh one. Jeyes' fluid or some other cheap disinfectant is poured into these shallow latrines daily.

As the disease spreads by the development of the ova in faeces into larvae, which live in moist earth and find their way into the human body through the skin or by the mouth, Europeans and other intelligent people are warned not to walk about on their bare feet in the bungalow, or in the compound or fields. Coolies will not wear boots or shoes, and such measures as dipping their feet in tar and sand every morning before going to work are not feasible. The scrappers, who pick up the scrap rubber from the ground, get their fingers covered with dirt and require more

treatment in hospital for hookworm disease than the tappers who cut the tree bark at some distance from the ground.
Coolies on return from work are advised to bathe while the rice is boiling, in the hope that their hands, which they put to their mouths, will be clean.
Every month a muster of the labour force is held and coolies with skin eruptions on their hands and feet are set aside for treatment.
Most cases are due to the itch mite, but other ill-defined eruptions with vesicles and pustules called "water itch" by the dressers may be caused by the entrance of hookworm larvae.
Coolies with swollen faces, feet or legs or with signs of anaemia those, who suffer from breathlessness or are designated "useless or lazy" are sent to hospital for stool examination and receive appropriate treatment.

Conclusions.

(1) Indian coolies, working as agricultural labourers on rubber estates in Malaya are infected with hookworm disease to the extent of over 80%.

(2) The infection is not a severe one, and large numbers of worms are the exceptions.

(3) Death per se from hookworm disease occurs in a small percentage.

(4) The small necator americanus worm largely predominates, and may account for the smaller amount of morbidity.

(5) Malaria fever is the principal factor in the causation of " Tropical anaemia " and hookworm disease only secondary.

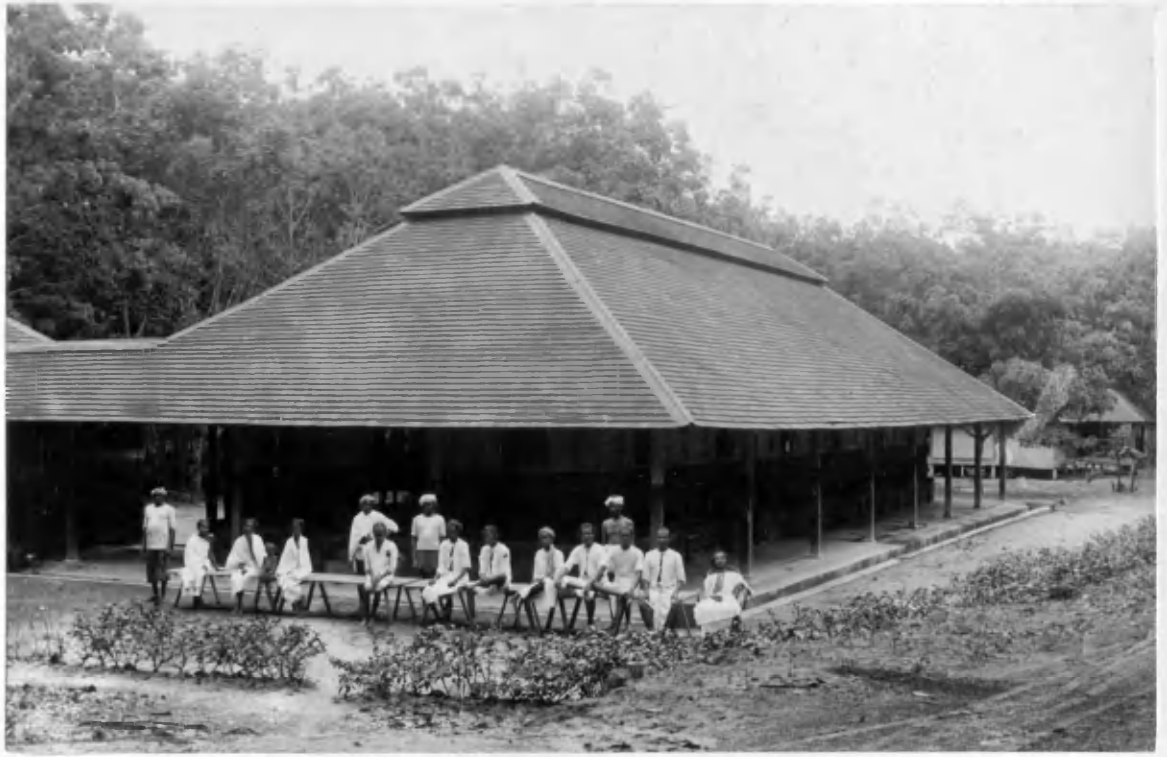
(6) Measures directed against malaria have been successful in reducing the sickness rate amongst the general population.

(7) Measures for hookworm infection amongst uneducated coolies are only partially successful.

(8) Ancylostomiasis in Malaya is not the severe and often fatal disease it was supposed to be.

Estate Hospital Rubber Estates of Johore. Photo XII

A small number of Indian cooly patients in foreground.



Permanent Lines Anglo-Malay Rubber Co.

Compound Kept free from vegetation except grass: fine laterite
cbroad over, brick drains provided. Four hundred coolies live
in these lines: very few cases of hookworm or malaria infection. Plate XIII

Permanent, good type of cooly lines Anglo-Malay Rubber Co. Photo XIV
Ground beneath lines is cemented, brick drain all round,
bathing place provided: surroundings covered with fine sand from stream.

Old type of coolie line Rubber Estates of Johore. Attap roof: fire places on ground behind corrugated iron; brick drains. fine laterite round about. Malarious estate and hookworm disease common. Photo XV

Permanent line. Rubber Estates of Johore. Kitchens at ends: brick drains
provided. Trees rather near. Fine laterite spread round about.
Earth below lines condemned. Central corridor with rooms on each side.

Photo XVI

Serembun Estate. Latonia. Elongated buckets used in compartments. Night coil destroyed in small increments.

Plate XVII

Anglo-Malay Rubber Co. Latrine, shallow trench used for a month's + building moved on. Daily disinfectant put into latrine.

Photo XVIII

Anglo-Malay Rubber Co. Latong, portable + detachable with one side down. deep pit. Liming done daily. Pl. XIX