REPORTS OF THE TRYPANOSOMIASIS EXPEDITION TO THE CONGO

1903-1904

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XIII

REPORTS OF THE TRYPANOSOMIASIS EXPEDITION TO THE CONGO

1903-1904

OF THE

LIVERPOOL SCHOOL OF TROPICAL MEDICINE AND MEDICAL PARASITOLOGY

BY

J. EVERETT DUTTON, M.B., Vict.

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AND

CUTHBERT CHRISTY, M.B. Edin.

WITH A COMPARISON OF THE TRYPANOSOMES OF UGANDA AND THE CONGO FREE STATE

BY

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LIVERPOOL SCHOOL OF TROPICAL MEDICINE AND MEDICAL PARASITOLOGY

PREFACE

IN 1901 trypanosomes were discovered in the blood of a European by Dr. J. E. DUTTON, Walter Myers Fellow, while on an Expedition of the Liverpool School of Tropical Medicine to Gambia. In consequence of this observation an Expedition composed of Drs. DUTTON and TODD was sent in 1902 by the School to Senegambia to prosecute further researches in trypanosomiasis. The detailed report of the Expedition was published in 1903, and contained a study of the pathogenic trypanosomata of man and animals, several new species being described.

Prior to the return of this Expedition, the discovery of trypanosomes in the cerebro-spinal fluid of cases of Sleeping Sickness in Uganda by members of the Sleeping Sickness Commission of the Royal Society caused the subject of trypanosomiasis to assume great importance. At the same time it was brought to the notice of the Committee of the Liverpool School that in the Congo Free State the native population had from time to time suffered from very fatal epidemics of this disease. The Committee therefore decided to accept the invitation of His Majesty King LEOPOLD to send an Expedition to study Sleeping Sickness in that country. Drs. DUTTON and TODD were recalled from the Senegambia, and as soon as they had drawn up their reports they left for the Congo in September, 1903, and were soon after joined by Dr. CHRISTY, who had served previously on the Royal Society's Sleeping Sickness Commission in Uganda. On reaching the Congo the Expedition decided to make Leopoldville its headquarters. The authorities of the Free State at the same time attached Dr. INGE HEIBERG, an old pupil of the School, to the Expedition, and to him the members are greatly indebted for his aid in the work. A special hospital was erected by the State, in order that the observers might have the Sleeping Sickness cases under their care, and facilities were given for the study of a large number of patients. The results of these investigators are incorporated in the present volume, and illustrate the occurrence and distribution; describe the symptoms of trypanosomiasis in all its stages, both in Europeans and natives, and shew how Sleeping Sickness, so-called, is related to trypanosomiasis as a symptom of that disease.

At the same time the Committee resolved to continue the researches on trypanosomiasis in Liverpool, which had been started by Drs. Dutton and Todd in Senegambia; Dr. Thomas was appointed to conduct the work, and aided by Dr. Linton experiments were immediately commenced, a preliminary note of their work being embodied in this report. The two groups of observers have throughout worked together, and in order that comparable data might be obtained, selected cases of Sleeping Sickness were, by permission of the Congo Free State authorities, sent to the observers in Liverpool. A later report will be published on these cases. As far as the very numerous and detailed observations of these workers go, they shew that the parasite identified with Sleeping Sickness in Uganda and the Congo does not differ from that described by Dutton in the Gambia. This view is also held by Laveran and Mesnil in France, and Bruce in this country. The question of a curative agent has for a considerable time engaged the attention of the members of the research, and experiments are now in progress to find a remedial agent which would have the same effect in trypanosomiasis that quinine has in malaria. A variety of drugs have been used with more or less success; up-to-date, arsenic and trypan red, an aniline dye introduced by Ehrlich and Shiga, appear to be the most useful; the parasite disappears for a time from the blood, and the life of the animal is prolonged, but with neither of the drugs is an absolute cure attained. A combination of the two appears to offer better results; a large number of animals infected with different trypanosomes are under treatment. The present report also embodies an important note on the Tsetse-flies, by Mr. E. E. Austen, to whom the School is much indebted for describing and identifying the Diptera obtained during the Expedition.

Much important work remains to be done; a further study of the disease from a clinical aspect, extended experiments on the transmission of trypanosomic diseases by biting flies, and researches on the lines of Schaudinn's work, together with therapeutical observations in patients and large animals naturally infected with trypanosomes, are urgently needed.

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HUMAN TRYPANOSOMIASIS ON THE CONGO

HUMAN TRYPANOSOMIASIS ON THE CONGO

(Being the First Progress Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903) *

BY

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AT the request of His Majesty King Leopold II, King of the Belgians, this expedition was sent in September last to the Congo Free State to report upon the sanitation of the larger towns, and to continue the School's work on human trypanosomiasis. Through the kindness of the Governor-General of the Congo, and of Drs. VOURLOUD and NEILSENG, government physicians at Boma, the hospital for natives at Boma was opened to us. It contained about sixty-five patients, and we saw there eighteen patients who had been admitted as cases of sleeping sickness.

Whether admitted to hospital by the medical officers, or pointed out to us by the missionaries as cases of sleeping sickness, with three or four exceptions, the cases which we have as yet seen have been, in our opinion, very unlike what has hitherto been described as sleeping sickness. Continued sleep or even abnormal sleep has been almost absent from many of the cases. It has been absent even in those who were believed to be in an advanced stage of the disease and who ultimately died. In only three or four of the cases observed by us has somnolence been a marked feature, and only in these few cases have the symptoms in any way coincided with those observed by one of us during the Uganda epidemic of sleeping sickness.[1]

From November 4 to November 29 two of us were occupied in travelling through the cataract region, in order to ascertain for ourselves the exact conditions existing there. Reports sent to the Congo Free State officials, and handed on to us, as well as correspondence received by ourselves, led us to believe that in this district we should find, not only an epidemic of sleeping sickness, but that the whole population was being 'decimated' by the disease. Although, in the course of our

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journey, we visited many villages and made tiresome expeditions to visit those especially mentioned to us, not a single case of illness did we see in which sleep was a marked feature.

We stayed for some time at the Baptist Missionary Society's station at Wathen, in the Lutete district, where we received hospitality and assistance at the hands of those in charge of the mission. From here excursions were made into the surrounding district, and a large number of persons brought to us as cases of sleeping sickness were examined.

These consisted of a heterogeneous collection of men, women, and children, many of whom were found to be suffering from heart, lung, and other more or less common ailments. Amongst the boys it seemed that a diagnosis of 'worms' was sufficient in many cases to account for the symptoms. Cases of apparent starvation and neglect were also common, and it appeared from what we were told that, owing to there being a general belief in the contagiousness of 'manimba'—the native name for what is believed to be sleeping sickness—children and even adults were, as soon as the slightest symptoms developed, liable to be isolated and shunned by everyone, causing, eventually, a state of emaciation and filth which ended sooner or later in death. Apart from these, however, and eliminating the many common ailments, there still remains in the cataract region a class of cases which, undoubtedly, terminate fatally within a year or two. These cases, of which most villages visited by us contained one to three examples, have few very evident symptoms of illness beyond emaciation, and, in some cases, weakness, headache, enlargement of lymphatic glands, and dirty, dry, scurvy skin. In a proportion of these cases trypanosomes were found in the peripheral blood, and we think it probable that if a systematic examination were possible, the parasites would be found in a much larger number.

Trypanosomes have been found in the finger blood both of those cases in which the diagnosis of sleeping sickness was certain, and of those in which the case picture was atypical. In addition, trypanosomes have been frequently seen in the peripheral blood of apparently healthy individuals. The routine method adopted for the detection of the parasites in the peripheral blood of unsuspected cases was the simple examination of a rather thick, freshly-made, cover-slip preparation. All of the following persons were examined in this way:—

Place and Class of Native	Number Examined	Number Infected with Trypanosomes in Peripheral Blood	Number of Cases Admitted to Hospital or shown to us as Cases of Sleeping Sickness	
			With Trypanosomes	Without Trypanosomes
Boma				
1. Hospital at Boma. Native soldiers coming from all parts of the Congo	72	11	9 *	7
2. Prisoners in Boma gaol coming from all parts of the Congo	181	17	0	0
3. Children of native soldiers at Boma	19	0	0	0
4. Colony school. Native boys from all parts of the Congo	50	1	0	0
5. Native labourers and children from native quarter	34	0	0	0
Matadi				
1. Natives collected for examination by Dr. Sims	78	1	0	0
2. Children of native soldiers up to 8 years of age	10	0	0	0
3. Patients at the native hospital	22	3	2	2
4. Children at the Sansel, native quarters, up to 10 years of age	28	0	0	0
Cataract Region				
1. Carriers collected from Tumbar District ...	20	2	0	0
2. Carriers from Lutete District	23	0	0	0
3. Boys at Wathen Mission, ages up to 15 ...	35	1	0†	0
4. Natives examined indiscriminately at two small villages near Lutete	42	2	0	2
5. Natives coming to the mission for treatment, or sick natives seen in village within a twenty mile radius of Lutete	79	11	10	47
6. Cases collected for us as sleeping sickness cases by Chef de Post at Kusu from neighbouring villages	14	0	0	14

* Lumbar puncture was done in six of the sleeping sickness cases. In four trypanosomes were seen in the cerebro-spinal fluid. One of the four never showed trypanosomes in the peripheral blood.

† This boy had been suffering for twenty-four days previous to our arrival at the mission from a fever which was not amenable to quinine.

Case VI

Sleeping Sickness (September 30, 1903).—N'Bela, male, aged 24, agricultural labourer. A Mongo man. Patient never saw sleeping sickness before coming to Boma. Had lived in Boma for nearly three years. Illness commenced in July of this year. Admitted to hospital, August 1, 1903.

When the patient was seen (September 30) somnolence was already a marked feature of his condition. This symptom steadily became more marked as emaciation increased. When we left Boma (October 27.) the patient was comatose, and death had been expected at any time during the preceding week.

General Condition.—Patient is thin and very weak. Questions are answered rationally, but only after a long interval. He displays a somnolent indifference to everything about him, and only by constant shaking can drowsiness be dispelled for a period long enough to permit him to speak.

Physical Examination.—Nervous system ; co-ordination imperfect. Sense of weight good. Knee-jerks and superficial reflexes were obtainable, and showed no abnormality. Eyes reacted to light and to accommodation. Thoracic and abdominal examination showed nothing worthy of note. Lymphatic glands were all enlarged, hard, and freely movable. There was no haemorrhage into mucous membranes. Slight icterus of the conjunctiva was seen.

The accompanying chart indicates the course of the temperature in this case, and shows the results of the examinations for parasites. Trypanosomes were seen in both cerebro-spinal fluid and peripheral blood.

On October 9, 35 c.cm. of slightly clouded, colourless cerebro-spinal fluid were taken by lumbar puncture. No red cells were seen in the fairly profuse deposit formed by centrifuging. This precipitate contained a fair number of trypanosomes, many monuclear cells of large size, and numerous polymorphonuclear leucocytes.

Experimental Inoculation

The following animals have been inoculated from this case. The material inoculated was in each case demonstrated to contain living trypanosomes.

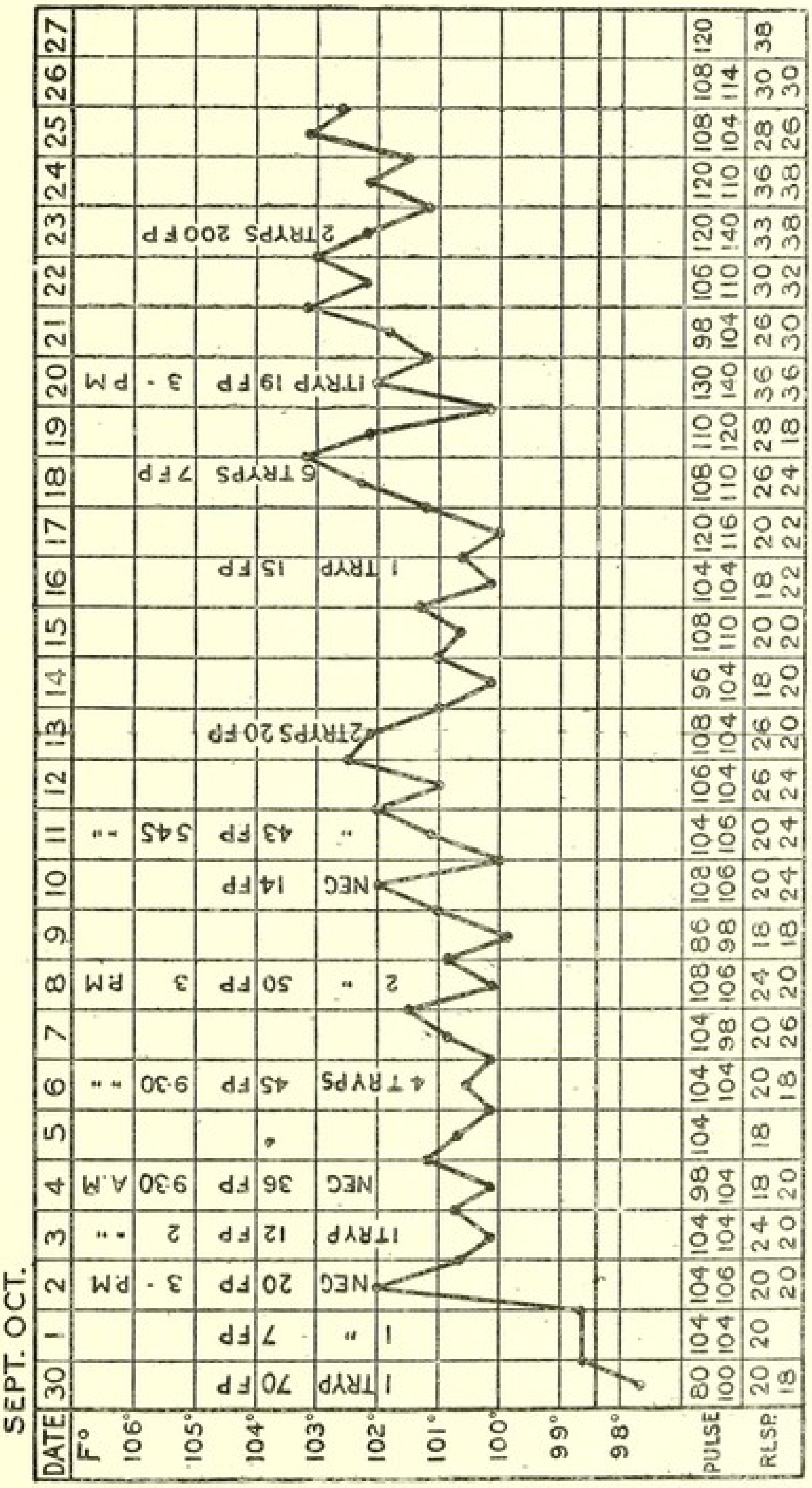
Animals Inoculated from Case 6

October 7. White mouse (Experiment 16) inoculated subcutaneously with 1 c.cm. cerebro-spinal fluid ; infected October 25.

October 7. White mouse (Experiment 17) inoculated subcutaneously with 1 c.cm. cerebro-spinal fluid ; never infected.

September 30. White rat (Experiment 5) inoculated subcutaneously with 5 c.cm. blood ; never infected.

September 30. White rat (Experiment 6) inoculated intraperitoneally with 1 c.cm. blood ; never infected.



TEMPERATURE CHART, CASE VI

Tryp. = Trypanosome. F. P. = Filaria perstans

October 9. White rat (Experiment 21) inoculated intraperitoneally with 4 c.cm. blood ; never infected.

October 9. White rat (Experiment 22) inoculated subcutaneously with 8 c.cm. blood ; infected October 23.

October 9. White rat (Experiment 23) inoculated intraperitoneally with 5 c.cm. blood ; infected October 23.

Case IV

Simple Trypanosomiasis (‘*Maladie de Dutton*’)[2], September 22.—J. P., male, aged twenty-eight, native of Sierra Leone, where sleeping sickness is not endemic. Came to Boma six years ago as a Free State soldier. Has always been in lower river districts. Entered hospital September 22 with gunshot wound. Had gonorrhoea in 1902, otherwise has not been ill during his stay in the Congo.

Patient is a strong, healthy man, well nourished, skin moist and clean ; slight oedema over both shins ; patient does not complain of feeling ill.

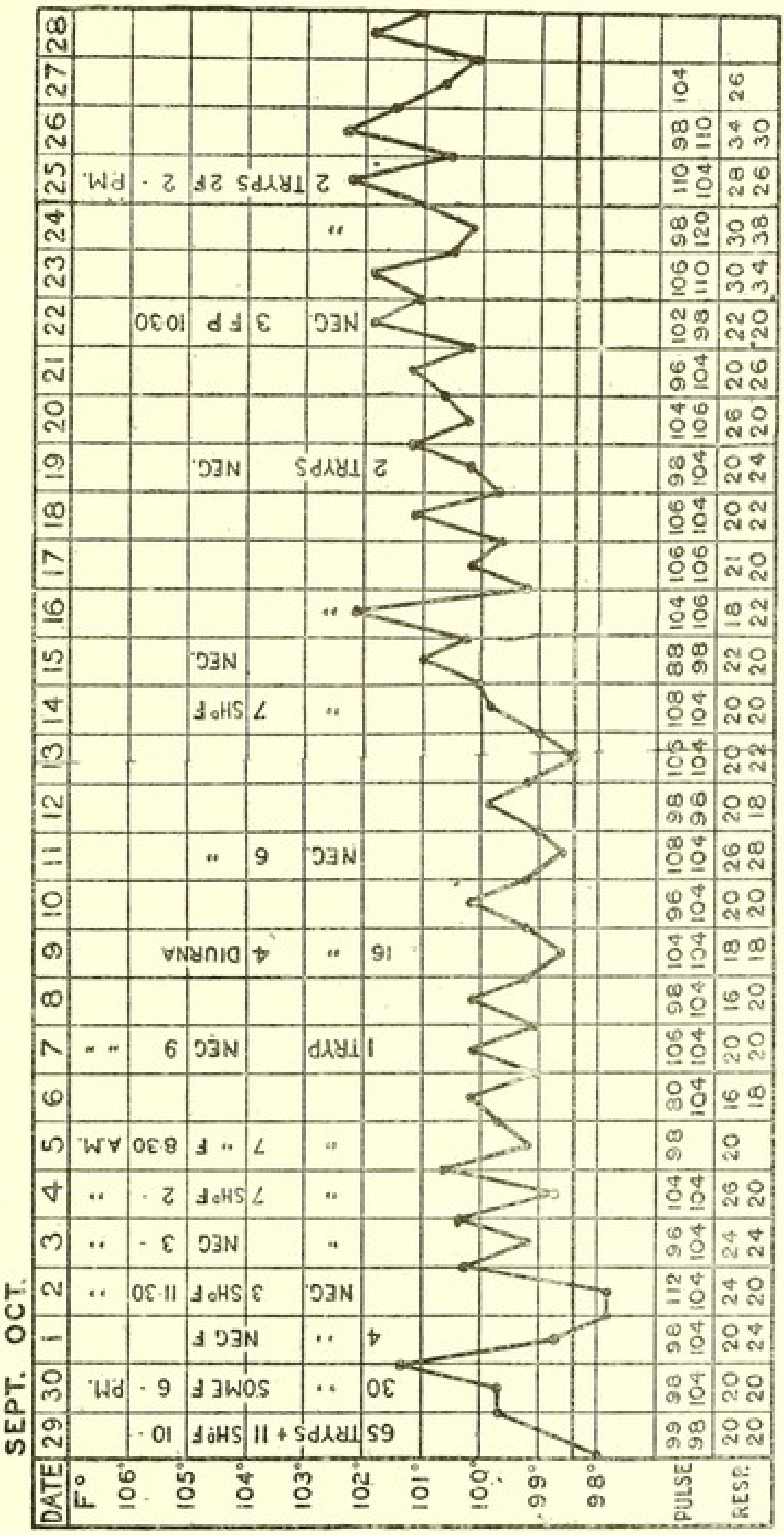
Glands are easily palpable, but are not markedly enlarged or hard. He is a bright, intelligent man, slightly deaf, but answers questions quickly and well. He is alert and interested in his surroundings. Mucous membranes are anaemic. There is a complete cataract of right eye. Heart and lungs are normal. Liver normal in size, but slightly tender. Spleen normal. Appetite good. Bowels constipated. Nervous system is normal.

Urine passed in twenty-four hours, 760 c.cm. ; specific gravity, 1,002, light straw colour, cloudy precipitate, acid ; small amount of albumen present, no sugar ; urea, 0·41 gram to 100 c.cm. of urine. Microscopically a few pus cells, probably due to a chronic gonorrhoea, were seen.

On October 26, 10 c.cm. of limpid cerebro-spinal fluid, as clear as distilled water, were withdrawn with some difficulty by lumbar puncture. The patient almost fainted before 8 c.cm. had been withdrawn. A very slight percipitate was obtained after long centrifuging. On examination it was found to contain a very few red cells, and still fewer small mononuclear white cells. No trypanosomes were seen during a long and careful search of the whole of the precipitate.

The cerebro-spinal fluid from this case presented a very different appearance, both macroscopically and microscopically, from that obtained from sleeping sickness cases. The fluid was clear, not clouded. None of the large mononuclear or smaller mononuclear and polymorphonuclear leucocytes seen in sleeping sickness cases were present.

The accompanying chart shows the course of the temperature in this case, and indicates the occasions on which trypanosomes were seen in the peripheral blood.



TEMPERATURE CHART, CASE IV

Tryp. = Trypanosome. F. P. = Filaria perstans. Shd. F. = Sheathed filaria.

Experimental Inoculations

The following animals were inoculated from this case :—

Animals Inoculated from Case 4

September 30. White rat (Experiment 5) inoculated subcutaneously with 5 c.cm. blood ; never infected.

September 30. White rat (Experiment 4) inoculated subcutaneously with 1 c.cm. blood ; infected October 8.

October 27. Guinea-pig (Experiment 27) inoculated subcutaneously with 4 c.cm. blood, infected November 7.

October 27. Guinea-pig (Experiment 28) inoculated subcutaneously with 5 c.cm. blood ; infected November 18.

October 27. Rabbit (Experiment 24) inoculated subcutaneously with 6 c.cm. blood ; never infected.

Necropsies were done at Boma on four cases which were admitted to the hospital for sleeping sickness. Two of these died before their blood or cerebro-spinal fluid could be examined. Repeated examinations of the blood (centrifuge used) of the third failed to demonstrate trypanosomes. Lumbar puncture was not done on this case. In spite of repeated and very careful examinations of the blood and cerebro-spinal fluid of the fourth case, trypanosomes were never seen.

A necropsy was also done on the body of a native admitted to the hospital as a case of encephalitis. This patient never showed the usual signs of sleeping sickness, and finally died of dysentry. Many trypanosomes were seen in his finger blood. Lumbar puncture was not done.

The *post-mortem* appearances in each of these cases were very similar to those described as occurring in sleeping sickness.[3] The usual increase of subarachnoid fluid, which had become cloudy, or occasionally almost purulent, was observed. The superficial and substantial vessels of the brain and spinal cord were turgid, and in two cases small sub-ependymal haemorrhages were noted.

In addition to these changes in each case, lymphatic glands were enlarged, several were congested or injected, not infrequently members of the various groups of glands were to the eye either partially or—especially the smallest glands—totally haemorrhagic. The naked-eye appearances of these glands were particularly interesting to us since we have observed very similar changes in animals infected by us with *Trypanosoma gambiense*.

Experimental Inoculations

The following experimental inoculations were made in white rats, white mice, rabbits, and guinea-pigs, with the results indicated :—

Twenty white rats were inoculated with cerebro-spinal fluid or blood taken either during life or *post-mortem* from patients admitted to hospital as cases of sleeping sickness and from cases of trypanosomiasis. Living trypanosomes in eleven instances were seen in the material inoculated. In seven of these the material inoculated was from cases of 'sleeping sickness,' in four from cases of simple trypanosomiasis. Of the former, three became infected; of the latter, two. None of the rats inoculated with material taken *post-mortem*, in which no living trypanosomes were seen, have ever become infected.

Four white mice were inoculated with cerebro-spinal fluid taken from two cases of sleeping sickness. Trypanosomes had been found in both cerebro-spinal fluid and blood of the first case, in the second trypanosomes were never seen. Two mice were inoculated with fluid containing many trypanosomes from the first case. One has become infected. Neither of the mice inoculated from the second case has ever shown parasites.

Two rabbits were inoculated with blood containing trypanosomes. The blood for one experiment came from a case of sleeping sickness, for the other from a case of simple trypanosomiasis. Neither animal has become infected. Four guinea-pigs were inoculated with blood containing trypanosomes, two from a case of sleeping sickness, and two from a case of trypanosomiasis. Both of the latter have become infected.

The very slight susceptibility of laboratory animals to infection with the trypanosomes found in man in the Congo, the great chronicity of the infection produced when inoculation has been successful, and the periodicity with which the parasite has appeared in the peripheral blood of the experimental animals, are points which greatly resemble the animal reactions of *Trypanosoma gambiense*.[6] The number of experiments done is not yet sufficiently large to permit the mention of incubation periods. During the eight or nine weeks which the infected animals have been under observation none of them have ever shown any gross sign of disease.

Conclusions

The examination of trypanosomes seen in stained specimens of blood from cases of trypanosomiasis, from cases of sleeping sickness (typical or doubtful), in the specimens of cerebro-spinal fluid of the latter cases, and in the blood of experimental animals, infected with either of three above-mentioned fluids, has led us to the following conclusions:—

1. The trypanosomes seen in the blood of man, whether symptoms of sleeping sickness were present or not, have always been the same. The number of cases in which trypanosomes from the spinal fluid have been examined is at present too small to permit of a definite description of morphologic characteristics. We have seen forms in the cerebro-spinal fluid similiar to those described by Bruce[3] and Castellani,[4, 5] and also longer forms similar to those seen in the finger blood of the same cases.

2. None of the human trypanosomes seen, whatever their source, have presented any morphologic appearance incompatible with *Trypanosoma gambiense*.

3. The parasites seen in rats inoculated with the cerebro-spinal fluid of cases admitted to the hospital for sleeping sickness are the same as those seen in rats inoculated with the blood of cases of either sleeping sickness or simple trypanosomiasis.

4. The organisms seen in the blood of rats inoculated with trypanosomes from any of the three indicated sources have up to the present shown no differences from those observed in animals infected with *Trypanosoma gambiense*.

We have observed the extraordinarily. long forms with prolonged flagella, and the stumpy forms with short flagella described as occuring in animals inoculated with the Gambian parasite.[6]

We have, therefore, no reason to suppose that the organisms seen by us in the Congo are other than *Trypanosoma gambiense*.

References

1. Christy, *The Epidemiology and Etiology of Sleeping Sickness in Equatorial East Africa*, with Clinical Observations, Royal Society Sleeping Sickness Commission, *Report III*, November, 1903.

2. Laveran and Mesnil, *Des Maladies à Trypanosomes, leur Réparition à la Surface du Globe*, Janus, August 15, 1903, pp. 395-402.

3. Bruce, Royal Society Sleeping Sickness Commission, *Report I*, August I, 1903.

4. Castellani, Royal Society Sleeping Sickness Commission, *Report I*, August, 1903.

5. Kruse, *Ueber das Trypanosoma Castellani den Erreger der Schlafkrankheit. Sitzungsberichten der Neiderrhein Gesellschatt f. Natur. u. Heilkunde zu Bonn*, May, 1903.

6. J. E. Dutton and J. L. Todd, *First Report of the Trypanosomiasis Expedition to Senegambia*, Liverpool School of Tropical Medicine. *Memoir IX*.

HUMAN TRYPANOSOMIASIS AND ITS RELATION TO CONGO SLEEPING SICKNESS

HUMAN TRYPANOSOMIASIS AND ITS RELATION TO CONGO SLEEPING SICKNESS

(*Being the Second Progress Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo,* 1903) *

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THE Expedition arrived at Leopoldville on November 21, 1903. Two of its members who had made a short tour through the Cataract Region arrived a week later. During their journey through this district, in which Congo Sleeping Sickness was said to be extremely prevalent, many cases, with very anomalous symptoms, but called sleeping sickness, were seen. As already stated in our *First Progress Report*[1] trypanosomes were found in the peripheral blood of some of these cases. It therefore became necessary to commence a clinical study of human trypanosomiasis in order to see what relation it bore to Congo Sleeping Sickness.

Leopoldville offered particular advantages for such a study, and the members of the expedition decided to remain there for a few months. A large bungalow was placed at their disposal by the Congo government, and through the kindness of Dr. Grenade, the State Medical Officer, and Dr. Broden, Director of the Leopoldville Bacteriological Institute, the patients at the native hospital, a good proportion of whom were infected with trypanosomes, were given to the expedition to study. In addition to this the presence of about two thousand state employees—labourers, soldiers, etc.—afforded an easily accessible, healthy, native population.

Later, the hospital for natives was found unsuited for a complete examination of the cases, and a new structure was built and supplied with the necessary appurtenances through the kindness of the local government. The members of the expedition have therefore for four months been in a position to keep patients under continued and careful observation.

* Received for publication, May 23, 1904. 1. *British Medical Journal*, January 23, 1904

The following table indicates the results of examinations of cover-slip preparations of finger blood taken from four hundred and sixty-five natives at Leopoldville. The results of similar examinations, made in the region lying between Stanley Pool and the sea, are appended in order to present a concise idea of the prevalence of human trypanosomiasis in the Congo :—

Class of Native	Number examined	Number with Trypanosomes in Finger Blood	Number of Cases with Trypanosomes previously diagnosed as sleeping sickness
Healthy labourers, prisoners, women, and children, all resident for varying periods in or near Leopoldville, but many of whom are natives of distant parts of the Free State	255	6	0
Outpatients visiting the clinic of the State Doctor at Leopoldville and chosen for examination because of their miserable appearance	53	3	2
Patients admitted by State Doctor to native hospital	157	45	34
Total for Leopoldville	465	54	36
Total of previous examinations at Boma, Matadi, and in the Cataract Region .	707	49	21
Totals	1,172	103	57

In the British Colony of the Gambia only six cases of human trypanosomiasis were found among 1,043 natives.[1] These cases presented no definite symptoms of illness and nothing abnormal was detected, with the possible exception of an occasional rise in temperature and increase of pulse frequency.

In the Congo we have also seen examples of the mild Gambian type, but the majority of our cases have shown marked symptoms of illness. From a close study of these cases it becomes evident that there is no well-defined line of demarcation between these two forms of the disease, though for descriptive purposes we propose to consider them under three main headings, A, B, and C :—

Type A. Cases with no definite symptoms of illness.

,, B. Cases with few symptoms.

,, C. Fatal cases showing well-marked symptoms, the most notable being fever, lassitude, weakness, and wasting.

1. Dutton, J. E., Todd, J. L., *First Report of the Trypanosomiasis Expedition to Senegambia* (1902), Liverpool School of Tropical Medicine, Memoir XI.

It is significant to note that a large percentage—thirty-six out of forty-four of those classed under types B and C—were believed by their friends to be suffering from 'sleeping sickness.'

We have seen cases coming under type C in which no sleep symptoms were ever present, as well as cases in which some of the diagnostic signs of classical sleeping sickness were noted.

We therefore subdivide type C into :—

1. Fatal cases showing no sleep symptoms.
2. Fatal cases showing sleep symptoms.

Here again no sharp division is possible between these two groups, still, we think it not inadvisable to separate them, since, from our experience here we believe that altogether too much prominence, as a diagnostic feature, has been given to what appears to us to be only a minor and inconstant feature of this disease, namely sleep. The prominence given to this symptom has tended to disguise the true nature of Congo Sickness which is, primarily at least, a trypanosome infection.

The following charts and abstracted clinical reports will illustrate the characteristics of the Congo disease.

TYPE 'A'

Cases with no Definite Symptoms of Illness

Case 79. Fariala. Male. Age thirty.

History.—Admitted to hospital for chronic ulcer of thigh, January 7. Is from Lukila, Kasai district ; has been for ten years in the neighbourhood of Leopoldville.

January 17. General condition. Is a well-nourished, sturdy man ; intelligence good, answers questions quickly and well, shows no unsteadiness of gait, and complains of nothing save the ulcer. Skin is dry and dirty ; there are several large scars and cicatrices on knees, ankles, and elbows, said to be due to injuries and burns. Face is pitted by smallpox. Slight oedema of right shin, probably due to old cicatrix.

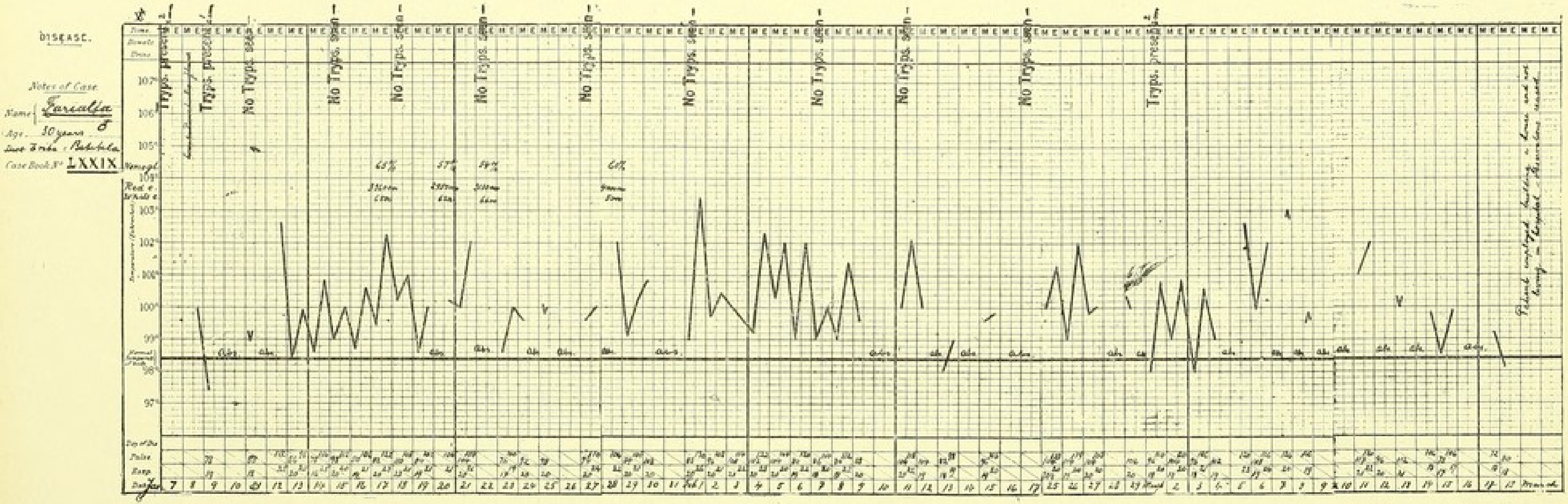
Lymphatic glands are all enlarged. Circulatory system : heart, position and dulness normal, loud mitral systolic bruit, aortic second sound accentuated. Respiratory system : normal. Alimentary system : tongue, teeth, and mouth normal ; bowels regular.

Liver and spleen not enlarged. Nervous system : co-ordination perfect, superficial and deep reflexes normal, pupils react to accommodation and light.

January 25. Complains of nothing, and, save for ulcer, seems quite well. Blood shows filaria diurna, filaria perstans, and trypanosomes.

March 31. Patient at work, and apparently in good health.

CASE LXXIX


DISEASE.
Notes of Case.
Name
Age
Case Book No. LXXIX
Trypanosomes present
No Tryps. seen
Tryps. present

Case 94. Kassongo. Male. Age twenty-three.

History.—A Batetela man. Has been for two years in Leopoldville as State labourer. Patient says that he never had fever.

February 23, 1904. General condition : Is a well-nourished, intelligent man, answers questions quickly and well. Has a stolid expression, but no dulness or vacancy whatever, actions not markedly slow. Oedema absent, no puffiness of face. Skin smooth and glossy. Lymphatic glands, all easily palpable, freely movable and hard ; parotids enlarged. Patient believes himself to be in perfect health. A careful physical examination reveals nothing abnormal in thorax or abdomen.

Nervous system. Co-ordination and sensation to touch and pain normal ; superficial and deep reflexes, normal ; pupils react to accommodation and light ; no tremors.

March 31. Physical examination repeated. With exception of a distinctly accentuated aortic second sound patient seems to be absolutely normal. He works willingly and well all day long.

TYPE 'B'

Cases, Intermediate Between Types 'A' and 'C,' showing very few signs of Illness, and not yet Definitely Believed by Their Friends to be Suffering From Sleeping Sickness.

Case 46. M'Pangila. Age seventeen. Male.

History.—Patient is a Lower Congo native. At age of thirteen he was admitted to the Baptist Mission Station at Wathen, Cataract Region. Here he was successively employed as garden boy, table boy, goat herd, and at the age of fifteen as cook. In December, 1902, he complained of fatigue while on the march, and was soon after dismissed because of untidy careless habits. His employers had at this time only a vague suspicion that these might be the prodromal symptoms of sleeping sickness. He had not since been seen until November 13, 1903, when, with another youth, he carried into the Mission a sick child from a village four-and-a-half hours distant. The only changes perceived in the lad were that much less care was taken of his personal appearance than formerly, and he was not so robust.

November 14, 1903. General condition. Patient is thin and has a certain, apathetic stolidity or dulness of expression. Oedema absent. Skin is soft and clean but dry. Lymphatic glands all considerably enlarged. Physical examination reveals nothing abnormal. Pulse, 96-110. Respiration, 20-24.

Temperature, with the exception of an evening rise to occasionally 99·5° F., is almost normal. Patient was sent to England, December 4, 1903. His condition since he has been under observation in Liverpool has not yet been ascertained.[1]

1. August, 1904, condition remains the same—parasites present in the blood.

Case 65. Mokoko. Male. Age twenty.

History.—Patient is a lower Congo native, and comes from a district in which sleeping sickness is present. He left his village a year ago, and has since been employed on a steamer plying on the Upper Congo. November 18, 1903, was admitted to hospital as a possible case of sleeping sickness. He says his illness commenced about the middle of September, with pain in his chest and knees, and a watery diarrhoea, no blood. These symptoms still continue.

December 12, 1903. General condition : Patient is very thin, muscles wasted. He is very weak and can only stand or walk with difficulty. He lies by the fire all day long without sleeping, and when spoken to insists that he has not 'sleeping sickness.' He complains of diarrhoea, and pain and tenderness in both hypochondria and epigastrium. There is no marked oedema. Skin is dry and dirty, slight 'craw-craw.' Lymphatic glands all slightly enlarged and hard. Respiratory system, slight bronchitis. Circulatory system, heart normal. Abdomen, distended and resonant. Liver, lower border not easily made out, apparently normal. Spleen, normal. Nervous system, co-ordination and sensation to touch and pain normal. Reflexes, superficial and deep, obtainable ; each muscle contracts to flicking ; pupils react to accommodation and light. Patient's condition seems to be wholly due to dysentery and bronchitis.

December 27. Functional murmur at pulmonary second sound.

January 5. Yesterday patient's blood showed over two hundred trypanosomes to the cover. His abdomen was distended and his feet oedematous, but there was little complaint. To-day the parasites are, perhaps, three times more numerous, the abdomen is more distended, and the feet oedematous. Patient complains of headache, pains in his joints, and of the abdominal distention. During these two days he has been more irritable, his breathing has been rapid and his skin moist. No murmurs.

January 6. No trypanosomes in blood, symptoms much alleviated. With the exception of the last two days patient has for some time been in much better condition than when he was admitted.

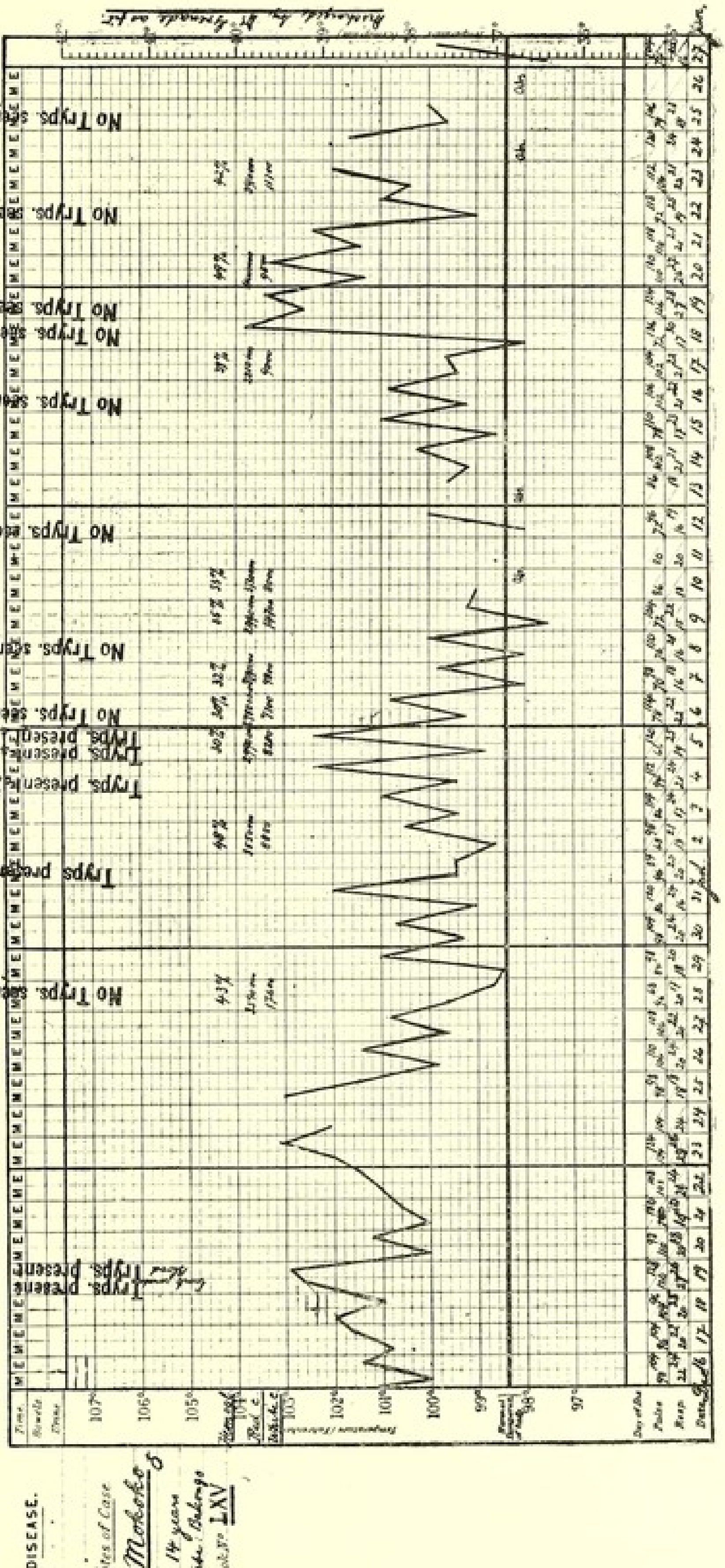
Faeces contain ova of *Anchylostoma duodenale*, *Ascaris*, and *Trichocephalus dispar*.

January 18. There is no oedema. Abdomen is distended and partially tympanitic. He complains of headache, but is otherwise comfortable. Is much stronger and strolls about.

January 28. Observations ceased, allowed to leave hospital.

February 13. Patient seen walking about with steady gait and with exception of abdominal distention and slight wasting, appeared to be well and expressed himself as such.

CASE LXV



TYPE 'C'

Cases Showing Well-Marked Symptoms.

The two following cases illustrate sub-group 'I' of this type. Fatal cases showing no sleep symptoms.

Case 82. Kimfuta. Female. Age eight.

History.—Patient is a Lower Congo native, and comes from a village four hours' march from Leopoldville. When brought to Leopoldville three months back she was an orphan and destitute, and a fortnight ago was sent to hospital, more through lack of friends to look after her than because of any suspicion of sleeping sickness.

December 29. General condition. Patient is miserably thin, and has the appearance of being half starved. She is very weak, her feet are full of chiggers, and she can only walk with difficulty. She has a dazed expression, and is constantly trembling. Tremors are increased on the slightest exertion.

Conjunctivae are congested and there is a slight purulent secretion. Intelligence is good, answers questions quickly and well. Skin, dry, imbricated, and filthy. Lymphatic glands, all easily palpable and hard, save femorals, which are much enlarged, soft, and matted together. The child complains of backache, and insists that she has sleeping sickness, but her condition is thought to be due mainly to starvation and ill-treatment. Circulatory system, normal. Respiratory system : slight bronchitis. Liver, normal. Spleen, just palpable. Alimentary system : tongue heavily coated, teeth tartrous, gums healthy, appetite excellent, abdomen flat and hard. Nervous system, reflexes all increased.

January 8. In spite of attention, cleanliness, and better food, patient is going down hill.

January 16. Greatly emaciated, tremors increased, patient can hardly stand and cannot walk, speech is thick but coherent. There is no drooping of lids, but eyes are fishy and vacant ; intelligence is now very dull ; she whines and complains on being disturbed ; eats little ; is seldom asleep, although she is always lying down, and passes faeces under her.

January 19. Emaciation extreme, is too weak to rise, lies with wide-open mouth and eyes, whines, moans, or attempts to speak if touched.

January 20. Spleen punctured, only a few parasites seen, although blood contained 100 to cover. Died during night.

January 21.

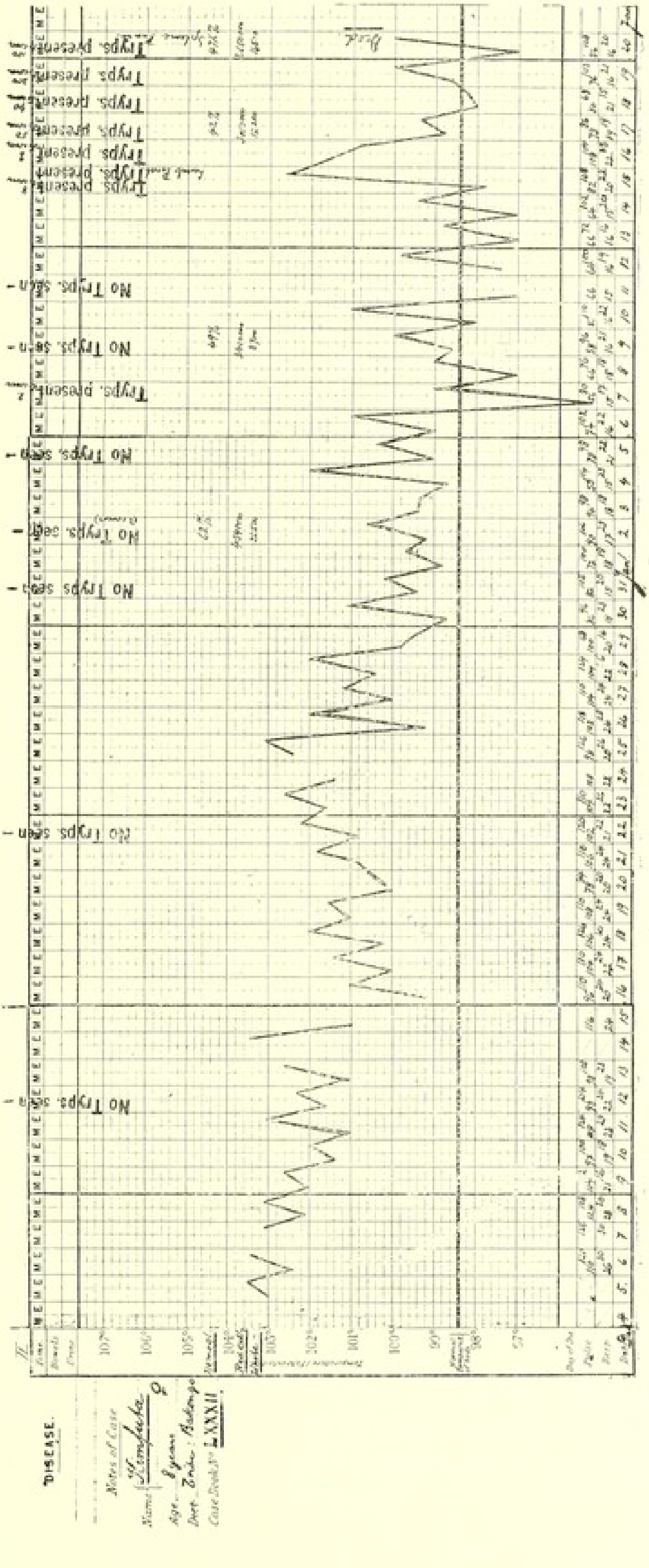
Necropsy commenced at 7 a.m., nine hours after death. Body much emaciated. No bed-sores, nor oedema. Ring-worm of scalp. Mouth foul, pyorrhoea alveolaris, teeth irregular, second dentition.

Thorax : Pleurae normal. Diaphragm : Right side, fourth space ; left side, fifth rib.

Lungs : Left lung normal ; right lung, old adhesions of upper and middle lobes.

Pericardium contained 5 c.cm. of turbid yellow fluid, in which no trypanosomes were found.

CASE LXXXII


No Tryps. seen
Tryps. present
DISEASE.
Notes of Case
Case Book No LXXXII

Heart dilated, both sides contained large, firm, white agonal clots. Valves normal. In left ventricle was small area of sub-endocardial petechial haemorrhage. Several pin-head calcareous nodules along cardiac veins.

Lungs : Weight, right, 227 grammes ; left, 151 grammes. Both show profuse sub-acute bronchitis ; bronchi full of mucous.

Abdomen : Omentum drawn up and wrapped around spleen, small clot of blood between it and outer surface of spleen due to puncture. Peritoneum contained no fluid. Old adhesions between transverse colon and gall bladder.

Liver : Weight, 682 grammes. Yellow, slight interlobular congestion. Gall-bladder full of dark-green semi-fluid bile.

Spleen : Weight, 228 grammes ; enlarged, anterior border very much notched ; substance very diffluent and dark red in colour. One small spleniculus.

Kidneys : Weight (together), 151 grammes ; normal. Bladder normal, filled with urine.

Genitals normal, save for left tube bound down in Douglas' pouch by firm fibrous adhesions. Child has menstruated, remnants only of hymen.

Intestines normal, few anchylostomes in ileum.

Bone marrow (tibia), reddish orange in colour.

Brain : Dura not adherent to calvarium or pia. Superficial brain vessels much congested, vessels of basal ganglia very much so. There was fair amount of colourless, slightly turbid, sub-dural and sub-arachnoid fluid. Similar fluid occurred in ventricles and escaped from vertebral canal. No trypanosomes were seen in these fluids.

Lymphatic glands : Generally much enlarged, often oedematous, usually greatly congested and, in the abdominal and thoracic groups, haemorrhagic, sometimes excessively so. There were numerous patchy areas of dark sub-capsular pigmentation in the femoral and axillary groups.

Case 64. Dysiki. Female. Age twenty-six.

History.—Patient is from Lusambo, in the Kasai district, where sleeping sickness is said to be prevalent. She has been in Leopoldville for two-and-a-half years. Her illness is said to have commenced one-and-a-half months ago. Entered hospital because ' feet were sick and had difficulty in walking.'

December 8. General condition. Patient is very thin, expression somewhat dull and vacant, intelligence good, answers questions fairly quickly, muscles are wasted, and great weakness is apparent in her unsteady walk ; speech clear, but weak ; eyes very prominent ; lips puffy, dry, and cracked. Skin is dry, dirty, and scurfy. There is distinct pitting of shins and dorsa of feet but not of face or forehead. Lymphatic glands, all enlarged. Physical examination of abdomen and thorax showed no abnormality. Nervous system, co-ordination and muscular sense good, reflexes only just obtainable. Alimentary system : tongue steady, slightly furred, teeth and gums normal, appetite good, bowels regular.

December 15 to 19. Patient is very weak, sits most of the day outside the hut. Sleeps but very little, likes to sit in the sun.

December 21. Extremely weak, passes faeces in blanket without changing position. Prominence of eyes (ocular tension increased) and puffiness of eyelids and lips persists.

December 24. Patient in same state, helpless but conscious. Died during the morning.

Necropsy commenced one-and-a-quarter hours after death. *Rigor mortis* just commencing. Body thin, muscles wasted, eyes prominent, both pupils dilated (especially right). Oedema of shins, feet, and forehead. Marked cutaneous thickening of eyelids. Many chiggers in feet. Tongue bitten through, clenched between teeth (no history of a fit). Body very warm; had been lying in sun, skin blistered. Panniculus scanty.

Thorax: Right pleura, few fibrous adhesions at base of lung. Left pleura, showed three small sub-pleural haemorrhages along vertebral column at level of fifth dorsal vertebra.

Pericardium contained 100 c.cm. clear yellow fluid.

Heart: Weight, 341 grammes; fat, oedematous, valves normal, muscle pale, patchy thickening of endocardium of left ventricle, vessels normal.

Lungs: Slight bronchitis, oedematous. Weight: Right lung, 226 grammes; left, 454 grammes.

Abdomen: Peritoneal cavity contained about 2 c.cm. clear fluid. Colon at level of umbilicus; all abdominal blood-vessels turgid; very extensive old fibrous pelvic adhesions; several small broad ligament cysts full of clear fluid; firm fibrous adhesions of liver and spleen to parietes.

Liver: Weight, 1,818 grammes: distinctly fatty, capsule over surface thickened. Gall bladder full of dark green fluid bile, ducts patent. Between liver and diaphragm was a layer, 5 c.cm. thick, of colourless gelatinous oedema.

Spleen: Enlarged and gorged with blood, substance soft and friable.

Kidneys, together, weighed 250 grammes, both showed cloudy change, capsules were adherent, and there was congestion of venae stellatae and around pyramids.

Pancreas and suprarenals normal.

Alimentary system: Mouth foul, gums soft, stomach normal, intestines normal, anchylostomes in jejunum.

Genitals: Vagina, slight mucous and cellular discharge, containing *Trichomonas vaginalis* and various bacteria; no acute inflammation. Uterus nonparous, sub-acute metritis. Left ovary partially fibroid. Right ovary normal; no signs of recent inflammation in tubes.

Bone marrow (femur): Very dark reddish orange.

Brain: Dura not adherent; superficial vessels congested, but not so much as in many of the cases; sub-arachnoid fluid not greatly increased and only slightly turbid; ventricles contained a few c.cm. of yellowish, slightly turbid fluid, ependymal vessels congested; no haemorrhages seen; spinal cord vessels turgid.

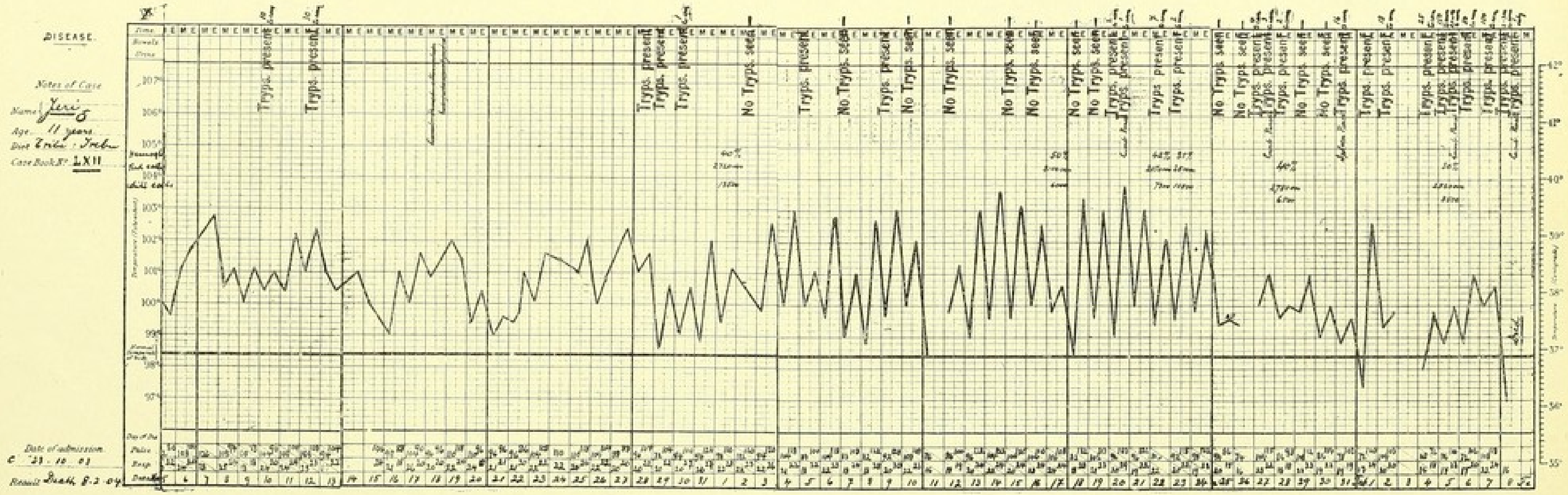
Lymphatic glands were nearly all enlarged, watery, and often congested. Some of pelvic and lumbar glands were chocolate colour and almost diffluent; a small gland size of pea in much the same condition, but not diffluent, was found lying on head of pancreas. No actual haemorrhages into gland substance were seen. Fluids from pericardium, glands, receptaculum chyli, and oedematous tissues were examined, but no trypanosomes were found.

The following cases illustrate sub-group '2' of Type 'C.' Fatal cases showing sleep symptoms.

Case 62. Jeri. Male. Age eleven.

History.—Is a native of Irebu, a town near Lake Tumba, where sleeping sickness is said to be present. Left his village two years ago and has since lived in or near Leopoldville. He has been in hospital for one-and-a-quarter months. Was 'boy' to a white man who sent him to hospital as a suspected case of sleeping sickness. When

CASE LXII


DISEASE.
Notes of Case
Name Jeri
Age 11 years
Case Book No. LXII
Date of admission 23. 10. 03
Result Death 8.2.04
Tryps. present
No Tryps. seen

first seen on November 23, patient was a thin, sharp-witted lad, and denied that he had sleeping sickness, but was said by his companions to sleep a great deal.

December 11, 1903. General condition. He is a weak emaciated boy; intelligence good; answers questions quickly; no thickness of speech; no unsteadiness of gait; is a mouth breather, and his 'adenoid look' gives him a certain vacancy of expression. Skin is dry and scurfy and covered with early 'craw-craw.' Muscles wasted; mucous membranes anaemic; lymphatic glands all enlarged. Circulatory system, normal. Respiratory system, slight bronchitis. Alimentary system, tongue steady, slightly coated, teeth and gums covered with tartar. Liver, 1 cm. below ribs. Spleen, 2·5 c.cm. below ribs, not tender nor painful. Nervous system, reflexes normal; pupils react to accommodation and light; co-ordination and muscular sense, normal.

December 28. Patient still answers questions quickly and well, has no pain nor headache, complains of a constant desire to sleep, but is seldom seen sleeping. Heart: reduplication of first apical sound. No oedema. Ocular tension is very distinctly increased, and the eyes are prominent. Knee jerks exaggerated, tendon reflexes not obtainable. He is able to go some distance from the hospital to collect firewood to cook his food. His inordinate appetite has become the joke of the hospital.

January 19. Patient now sleeps most of the day, or sits dozing over his fire with his head drawn back and his mouth wide open.

January 21. Is too weak to walk about, but lies in the hut complaining and talking of his weakness.

January 25. Sleeps much more than previously and is becoming, if possible, more emaciated. Is easily roused when touched.

February 2. Is vivacious and talkative again. When lying down or dozing over fire, head is drawn back and chin protruded to utmost as noted on January 19.

February 5. Is much worse again, apparently dying, lies curled up on his side, and is roused with difficulty.

February 8. Dying, almost pulseless, Cheyne-Stokes respiration, lies on back in an extreme state of opisthotonos, with legs extended and head drawn back to such an extent that two fists, one above the other, can be passed beneath him. Died at 7 p.m.

Necropsy commenced one-and-a-quarter hours after death. Body much emaciated, still warm. Slight oedema of forehead, shins, and dorsa of feet.

Thorax: Pleural cavities normal. Pericardium contains 100 c.cm. of clear yellow fluid in which were seen divisional forms of trypanosomes.

Heart: Weight, 226 grammes, normal.

Lungs normal.

Abdomen: No fluid, old firm fibrous adhesions of right lobe of liver to parietes.

Liver: Weight, 610 grammes, slightly congested, otherwise normal. Gall bladder full of dark thick bile. Ducts patent.

Kidneys: Right showed marked peri-pyramidal congestion.

Spleen: Weight, 266 grammes. Slightly enlarged, substance firm, not slatey.

Pancreas and suprarenals normal.

Intestines contained very many ascaris, anchylostomes, and a few *Trichocephalus dispar*.

Bladder showed two submucous haemorrhagic areas near meatus.

Genitals normal.

Lymphatic glands : Generally enlarged and watery, especially the abdominal groups, some of the latter were deeply congested ; one gland lying on the anterior surface of the pericardium had a distinctly haemorrhagic centre.

Brain : Slight congestion of superficial vessels and flattening of convolutions ; sub-arachnoid fluid in excess, 'ground-glass appearance' of arachnoid. *Cord* : vessels congested, great increase in cerebro-spinal fluid.

None of cranial bone cells were abnormal.

Living trypanosomes were seen in preparations made *post-mortem* from finger blood and pericardial fluid, but not in heart blood.

Case 84. Moidi. Female. Age twenty-four.

History.—Is a Kasai woman. Has been living for past two months near Leopoldville. Was sent to hospital, January 12, as a case of sleeping sickness.

January 21. Patient is a big well-made woman, no emaciation, her expression is dull, pained, and stupid, almost vacant. She is continually making grimaces. She cannot walk and lurches forward in a half drowsy condition during examination. Speech is thick and slow. Oedema of shins and feet, face and lips puffy. Indeed, the whole body is more or less puffy and presents an appearance of plumpness. Skin dry and dirty. There is a very extensive cicatrix, from a burn, implicating the right arm, side, and thigh. Lymphatic glands not enlarged. Circulatory and respiratory systems normal. Alimentary system, tongue coated and moist ; teeth and gums foul. Tip of tongue only, after much persuasion, protruded. Liver normal. Spleen slightly enlarged.

January 25. Patient usually sits dozing over a small fire. She is occasionally found lying at full length, naked, on the floor, or asleep in an uncomfortable attitude on the board bed. She can be easily aroused by a touch, and can, by shouting, be persuaded to speak.

February 5. Patient is almost lethargic, and is aroused only with some difficulty. She now eats nothing and is becoming emaciated. Sensation is dulled ; hardly flinched during lumbar puncture.

February 6. Died early this morning.

Necropsy six hours after death. The body of a massive but wasted woman. *Rigor mortis* present in masseters and extremities. Panniculus in fair amount.

Abdomen normal. Diaphragm : Right side, upper border fourth rib ; left side, fifth rib.

Thorax : Pleurae normal.

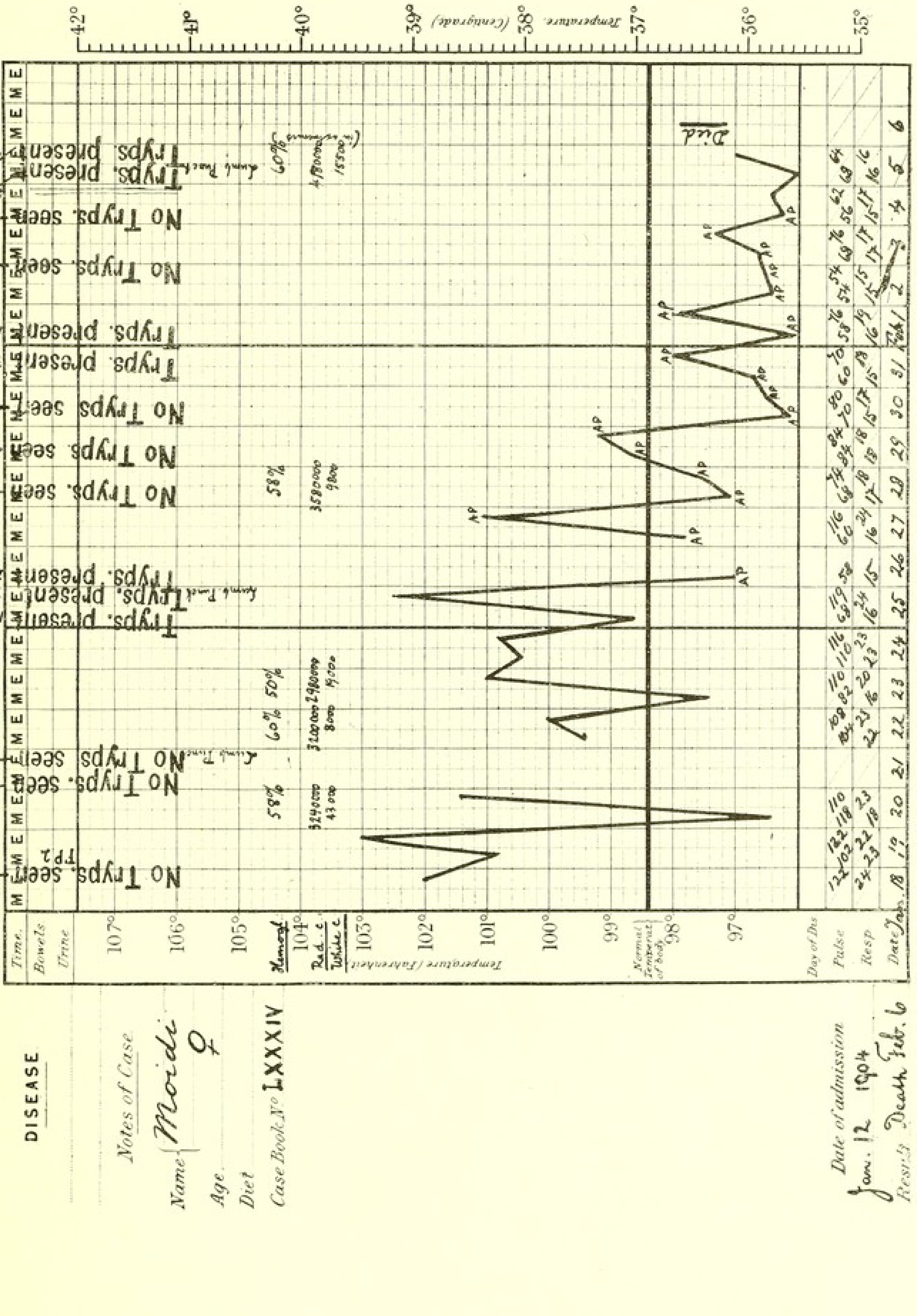
Pericardium contained a small amount of yellowish fluid.

Heart : Weight, 342 grammes ; contained firm white agonal clots.

Lungs : Weight, right, 454 grammes ; left, 335 grammes ; slight bronchitis and hypostatic congestion.

Liver : Weight, 1,591 grammes ; light in colour, central lobular congestion, soft and friable. Gall bladder full of dark, thick bile. Ducts patent.

CASE LXXXIV


DISEASE
Notes of Case
Name Moidi
Age ♀
Diet
Case Book No LXXXIV
Date of admission Jan. 12 1904
Result Death Feb. 6
Died
No Tryps. seen
Tryps. present
Temperature (Centigrade)
Temperature (Fahrenheit)

Spleen : Weight, 345 grammes ; measures 22 × 10 × 4·5 cm. ; substance firm, slightly fibroid.

Kidneys : Weight together, 338 grammes, normal.

Genitals, with exception of chronic vaginitis, normal. Mouth foul with sores. Intestines contained a few anchylostomes and *Trichocephalus dispar*. Alimentary canal otherwise normal.

Brain : Vessels all much congested, sub-arachnoid fluid increased and turbid. Microscopically cerebro-spinal fluid showed pus cells but no trypanosomes.

Lymphatic glands all much enlarged. Retro-sternal and mesenteric glands slightly injected. Decomposition had commenced in retro-peritoneal glands. Femoral and inguinal glands congested and in one or two of the latter pus formation had commenced.

The two following cases, not easily classable under the foregoing headings, are, we think, of interest, as they illustrate the extremely rapid course the disease occasionally takes after symptoms have once developed.

Case 69. Kabali. Female. Age twenty-six.

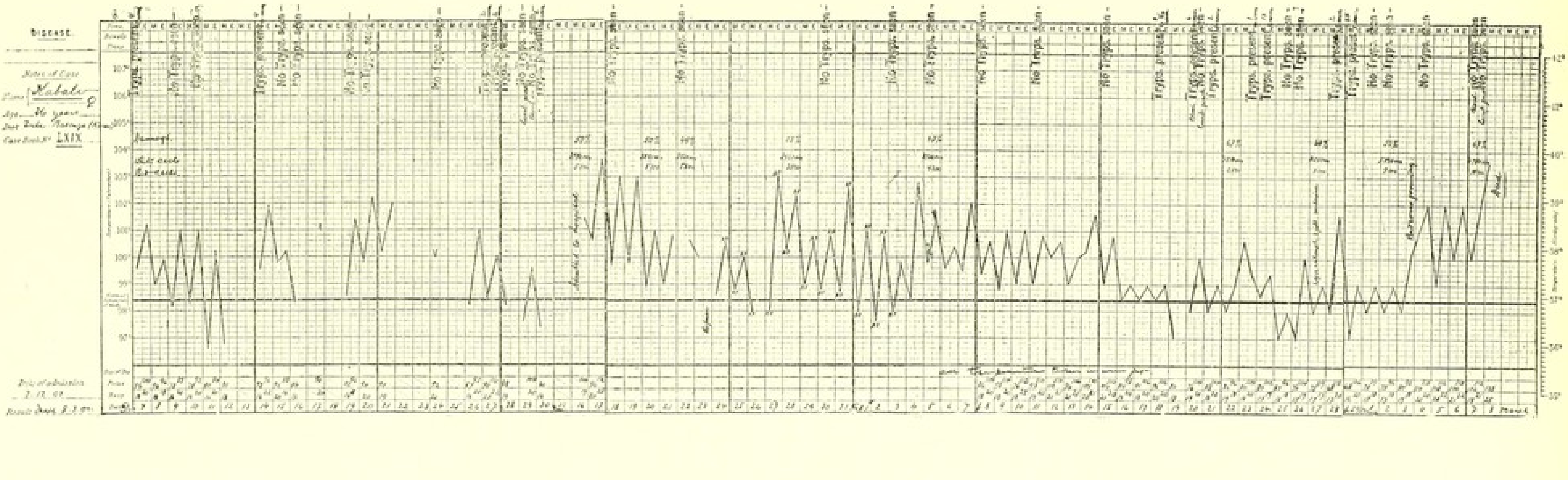
History.—Patient comes from the Kasai district, and left her native village, which is four days distant from Lusambo, ten years ago. Since then she has been in many places along the Upper Congo. Has lived in Leopoldville for the last two or three years.

When first seen on December 7, 1903, she stated that her illness had commenced four months previously, and began with rigor and fever ; the left side of her head swelled and was painful. There was no sore nor evacuation of pus. This condition lasted for six weeks. She says that she has since become thinner and weaker, particularly during the past two or three weeks. She has lost her appetite and has a tendency to diarrhoea.

December 25, 1903. General condition. Patient is a tall, well-developed woman, but thin, and her muscles are flabby. She is less active and vivacious than when first seen, and has a tired, listless gait. Her expression is rather dull, but she is intelligent and answers questions quickly and well. She speaks without hesitation or thickness. Complains of pain on pressure on shins. Skin is very abnormal. It is clean, though dry, and gives a rough feeling to the touch. This is most marked on shoulders, arms, and extensor surfaces of thighs and legs. In the parts most affected the skin has somewhat the appearance of an early exfoliative dermatitis, in which patches of glazed and thinned skin desquamate, slightly, at their edges along rectangular cracks and furrows. There is no itching nor discomfort, and the condition seems to be recent. At some spots are areas of crumpled tissue-paper-like wrinkles. No oedema. Lymphatic glands all enlarged. Tongue furred, moist, and steady. Circulatory system, pulmonary second sound is very much accentuated. Respiratory system normal. Liver normal. Spleen, considerably enlarged. Nervous system, co-ordination and muscular sense, normal ; reflexes, normal ; pupils react to accommodation and light, mental condition, alert.

January 18. Patient was admitted to hospital two days ago as a case of sleeping sickness. She is much thinner and weaker. Expression dull and sleepy. Skin

CASE LXIX



condition less marked ; tongue coated and dry but steady ; complains of sleepiness and dozed during examination.

January 25. Lies in bed all day, is drowsy but does not sleep much, is irritable and querulous.

February 2. Seldom asleep, and then at once aroused, is bright and intelligent ; complains of pains 'all over' and of insomnia at night ; staggers with weakness on attempting to walk.

February 12. Is much weaker, can hardly walk ; speech is thick, weak, and monosyllabic ; lips flabby and glued together ; sleeps a good deal but easily aroused.

February 16. Lies in a drowsy condition all day ; complains that she cannot walk. Food is brought to her, but unless assisted she does not eat.

February 24. Sleeps lightly all day ; is almost too weak to sit up alone ; calls for assistance to go to stool.

March 7. Pulse rapid and weak ; patient has not slept during night ; complains of pains all over ; cries out when touched, owing to bed-sores forming on sacrum and scapulae ; pupils equal and widely dilated ; axillary and femoral glands enlarged, but not nearly so large as when admitted to hospital ; cannot take her food, either milk or soup. Knee jerks increased ; arms persistently flexed at elbow ; hands tremulous. No oedema.

March 8. Died 4 p.m.

Necropsy commenced three-quarters of an hour after death. Body much emaciated ; bed-sores over sacrum and both scapulae ; skin clean, dry, and shows slightly on extremities the previously noted 'imbricated appearance.' No oedema ; pupils widely dilated, left slightly more.

Thorax : Left pleura contained 30 c.cm., very turbid fluid with floating flakes of lymph, right pleura contained 10 c.cm. of similar fluid. Pericardium contained 40 c.cm. slightly turbid yellow fluid.

Heart : Weight, 223 grammes ; normal ; full of firm clot.

Lungs, each weighed 231 grammes. Marked hypostatic congestion, with sub-acute bronchitis of both lungs. At posterior border of left lung, level of seventh dorsal vertebra, there was a recent deposit of fibrous lymph on pleura, with intense subjacent congestion.

Abdomen : Peritoneum dry, mesenteric vessels congested ; spleen and liver adherent to parietes and adjacent organs by fairly extensive, old, fibrous adhesions.

Liver : Weight, 1,585 grammes, large, nutmeg, with commencing fatty change.

Gall bladder filled with thick grumous bile.

Spleen : Weight, 335 grammes, $19 \times 11 \times 4.5$ c.cm. Anterior border deeply notched, substance dark, firm, but friable.

Kidneys weighed together 225 grammes, normal.

Pancreas and suprarenals : Normal.

Alimentary canal : Mouth, stomach, large intestine, and jejunum normal. A Peyer's patch about 60 cm. above ileocaecal valve was greatly congested. On either side of patch for some 10 cm. were numerous disseminated congested areas, varying in diameter from 1 to 4 mm. Ascaris and anchylostomes present.

Genitals : Uterus small, nonparous small myoma. All genital organs firmly bound together by old adhesions ; vagina normal.

Brain: dura easily detached, sub-arachnoid space filled anteriorly with thick-formed lymph, posteriorly sub-arachnoid fluid very cloudy and semi-purulent; all vessels moderately congested. About 50 c.cm. turbid yellowish cerebro-spinal fluid escaped on opening tentorium. Cranial bone sinuses normal.

Bone marrow (femur): Very dark and diffluent, like clotted blood.

Lymphatic glands: All retro-peritoneal and pelvic glands very deeply congested; on section, soft, with a good deal of bloody fluid. One or two omental glands in a similar condition.

Glands from the other parts of the body enlarged but otherwise normal. Trypanosomes were not found by coverslip preparations in any of the body fluids or blood.

Case 86. Yaiyai. Female. Age twenty.

History.—Patient was sent to us on January 7 by native dispenser at a settlement near Leopoldville. She was said to have recently come from a district in which sleeping sickness was present. She was supposed to be in the 'initial stage' of that disease. Patient was well dressed, clean, and neat. She seemed in good health. She had, however, a peculiar vacancy of expression, and answered questions in an excitable and voluble manner, making grimaces. She stated that she had sleeping sickness, but, as yet, not badly. Patient was kept under observation for two days, but nothing abnormal was noted, save her expression and some display of irritability.

On *January* 24, she was carried into hospital in a listless, dazed, and sleepy condition, unable to walk, and apparently unable to speak.

February 4. General condition: Is a well-nourished woman; expression dull and vacant; manner apathetic and listless. Is able to walk with slow shuffling steps. Intelligence much dulled. Tongue coated and moist, slight tremors. Skin normal. Glands all enlarged save posterior cervical. Considerable oedema of shins and insteps; lips and eyelids puffy. Appetite good. Patient munches her food in a slow way, peculiar to many advanced cases. She frowns continuously. Circulatory, respiratory, and alimentary systems normal.

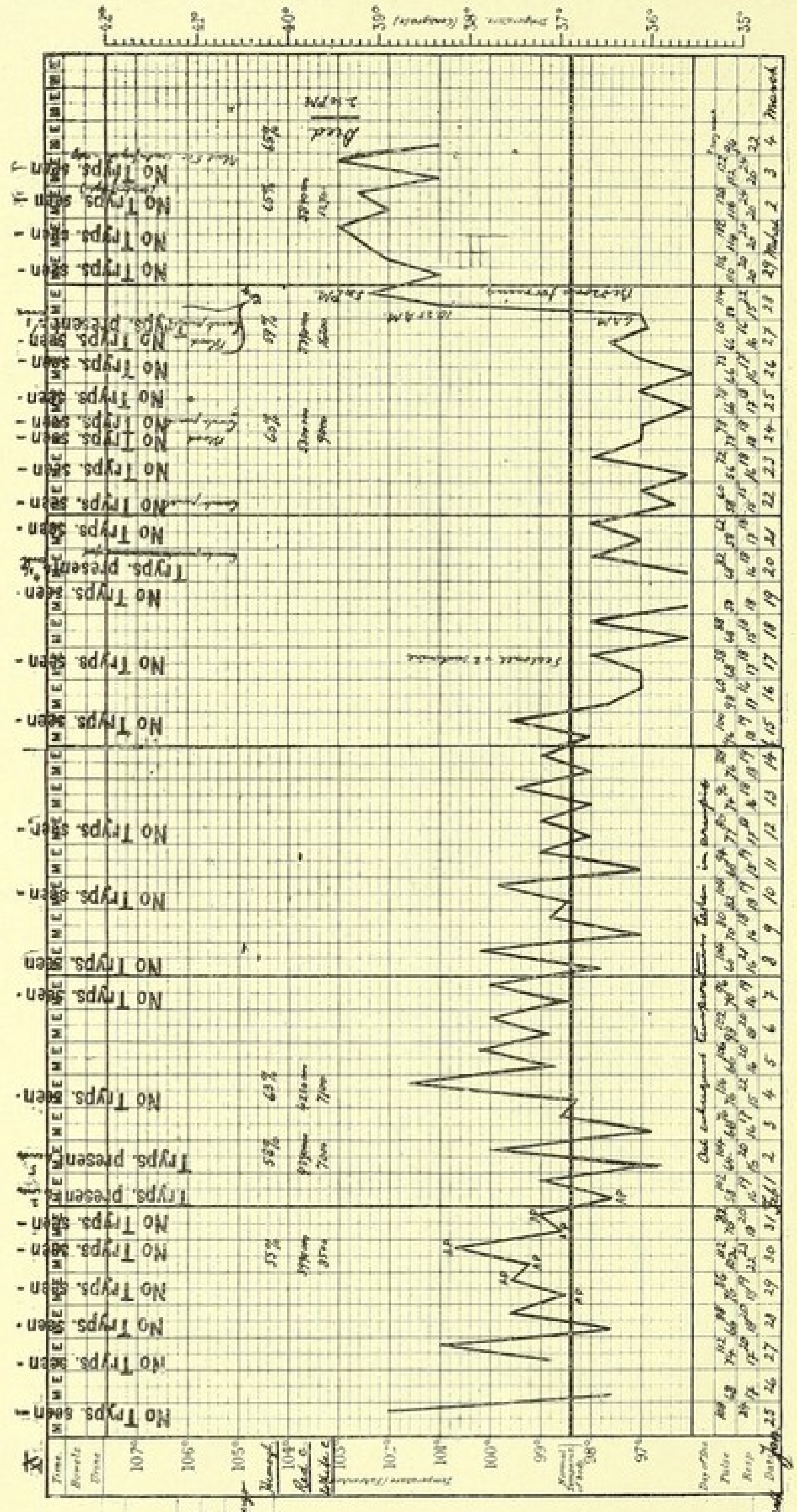
February 10. Sleeps a good deal but is much better than she was, is not so apathetic, and can talk and laugh while eating; appetite good.

February 16. Vacancy of face is again marked; patient is very weak and trembles all over; she speaks in weak voice only after much persuasion.

February 28. Since last note patient's condition has not altered. She has been unable to get off her bed; passes motions into bed; has only been able to take liquid food, and that only with assistance, is usually wide awake and conscious of all her surroundings, and, until now, has shown no very marked signs of wasting. To-day temperature, 102·4 F., profuse perspiration; crepitation and dullness at base of right lung.

March 3. Is now helpless, with sunken eyes and haggard face; body and limbs show marked wasting; oedema of shins and insteps and puffiness of face have disappeared; tremors, which were very marked, have ceased; she cannot take even soup; large bed-sores have formed on either side of sacrum.

CASE LXXXVI


DISEASE.
Notes of Case
Name
Age
Case Book No LXXXVI
Date of admission.
25.1.04
Result
No Tryps. seen
Tryps. present
Pulse
Resp.
Day of Dis.
Temperature Fahrenheit
Temperature Centigrade
Normal Temperature

March 4. Patient dying, but perfectly conscious, even acutely observant of all that goes on around her. Died at 2.30 p.m.

Necropsy commenced one-and-a-half hours after death.

Body warm, wasted though not distinctly thin. *Rigor mortis* just commencing, pupils evenly and widely dilated. Tissues dry, panniculus fairly abundant. Muscles normal.

Thorax : Pleurae normal.

Pericardium contained a few drops of fluid.

Heart : weight, 148 grammes, small, muscles pale and firm. Mitral valve showed distinct, reddish, gelatinoid thickening.

Lungs : Weight, right, 300 grammes ; left, 223 grammes. There was slight bronchitis of both lungs and marked hypostatic congestion, the latter condition marked in the right ; vessels contain firm, stratified clots.

Abdomen : Pelvic peritoneum congested and genitals firmly bound down by extensive fibrous adhesions.

Liver and spleen adherent slightly by old fibrous adhesions to adjoining organs and parietes.

Liver : Weight, 1, 582 grammes, slightly nutmeg. Gall bladder moderately filled with golden bile.

Spleen : Weight, 221 grammes, $17 \times 9 \times 5$ cm., upper lobe almost entirely divided by deep indentation from lower, substance dark, firm, friable.

Kidneys : Weight together, 218 grammes, normal.

Pancreas and suprarenals : Normal.

Alimentary Canal : Normal.

Bladder : Normal.

Genitals : Uterus small, non-parous, metritis with acute intense cervicitis ; fallopian tubes and ovaries bound down to uterus by old adhesions, acute vaginitis.

Bone marrow (femur) : Reddish brown.

Brain : Superficial vessels congested, particularly over posterior half of hemispheres (patient lying on back for several days before death). Relatively small amount, though increased, of sub-arachnoid fluid ; no ependymal haemorrhages ; about 30 c.cm. cerebro-spinal fluid escaped on cutting tentorium. Cranial bone sinuses normal.

Lymphatic glands : Retro-peritoneal and pelvic glands were enlarged ; the latter group being congested ; the remaining groups of glands were normal.

In this attempt to illustrate the course of sleeping sickness, as found in the Congo, we have tried, as far as possible, to exclude from the illustrative cases those in which obvious secondary lesions were demonstrated *post-mortem*. It will be seen that deep sleep, continued sleep and lethargy, symptoms described as characteristic of sleeping sickness, are not features of the Congo disease as observed by us up to the present.

Trypanosoma Gambiense as a Probable Cause of Congo (Sleeping) Sickness

(*A*) As already indicated, in nearly every case in which sleeping sickness was diagnosed, or suspected, trypanosomes have been found in either blood, cerebro-spinal fluid, or both.

(*B*) We have shown that there is a very evident clinical connexion between those cases which have only very slight symptoms ('Trypanosoma fever') and the advanced cases of 'sleeping sickness' seen in hospital.

(*C*) In Gambia there is an undoubted trypanosome disease in horses which is characterized, in its first stage, by the absence of obvious symptoms; and later, by fever, emaciation, and weakness. The course of this disease may be chronic and death delayed for a long period.

We have a horse, in good condition, under observation in Liverpool, which was first found to be naturally infected on October 30, 1902. A letter, dated January 18, 1904, from an officer in Gambia, says that his horse, found naturally infected in April, 1903, 'could not be better, and is in excellent condition.'

This Gambian horse disease seems to present a striking analogy to the human trypanosome disease seen in the Congo. The dull, listless expression, the weakness, the wasting and lack of energy, the irregular elevation of temperature, the frequent disappearance of the parasite from the peripheral blood (to ordinary examination), and the chronic course of the disease, are features characteristic of both infections. The similarity seems to us to be a point in favour of the casual relation of trypanosomes to Congo sleeping sickness.

(*D*) The sleeping sickness of the Congo is known to have a long latent period. Symptoms are said to have developed in some cases two to five years after leaving an infected locality.[1]

It is interesting to note that natives may be infected with trypanosomes for many months without showing signs of illness.

We have just heard that a Gambian native in whose blood trypanosomes were seen over a year ago is still in the very best of health.

Dr. Zerbini, State Physician at Boma, has just sent us a report on cases observed by us in Boma during October last. His report is based on either his own observations or on the statements of heads of departments in those instances in which the cases had passed from his care. The report on five cases is indistinct or vague. Five had been in perfect health during the whole six months. Three have had surgical troubles, but are now well. One has had persistent diarrhoea, but has quite recovered and has been sent to the Upper Congo. Two cases have died of pneumonia, and the remaining four, only one of whom was in perfect health when we saw them, show slight oedema, lack of energy, or some other ailment. In none is there any suspicion of sleeping sickness.

(*E*) Europeans[2,3,4] infected with *Trypanosoma gambiense* show symptoms which are quite comparable with those observed in uncomplicated trypanosome infections of Congo natives.

(*F*) In Gambia, where cases of sleeping sickness are rarely seen (Dr. M. Forde, Principal Medical Officer at Bathurst, stated that perhaps one case a year came under his care), only six out of one thousand odd natives were found to be infected,[5] by the examination of fresh cover-slip preparations. In an almost exactly equal number of a similar class of natives examined in the same way in the Congo, forty-six have been infected In Uganda, where the disease occurred in epidemic form, the percentage of infection among the general population was still higher.[6]

1. Guérin, *Archives de Médecine*, VIe séries, vol. 14, Paris, 1869.
2. Manson, *Brit. Med. Jour.*, March 28, May 30, 1903.
3. Dutton, Todd, Christy, *Brit. Med. Jour.*, January 23, 1904.
4. Broden, Les injections à Trypanosomes au Congo chez l'homme et les animaux. (*Extrait du Bulletin de la Soc. d'études Coloniales*, Févr., 1904).
5. Dutton, Todd, *Ibid.*
6. Reports of the Sleeping Sickness Commission, Royal Society.

We have not yet met with an epidemic of sleeping sickness in the Congo, although at least one has been recorded.[1] From the answers to inquiries, which we have received from state doctors and officials in different parts of the country, we do not think that the disease exists in any part of the Congo in a much more severe form than at Leopoldville, and certainly there is no epidemic comparable to that in Uganda.

It will be noted that the Congo type of case, as we have described it, bears a close resemblance to some of the cases described by Bruce and Nabarro on the Victoria Nyanza, at a time many months after the epidemic wave had passed eastward, and at a place Entebbe, situated at the extreme tail of the epidemic area. Moreover, one of us is able to recognize a similarity between many of the cases seen here, particularly those in which emaciation, lengthened period of illness, and absence of sleep, are the main features, and many of the cases seen by him on Buvuma Island, also situated in Victoria Nyanza, and towards the tail of the epidemic area.[2]

The Course of the Disease

Duration. It has been impossible to decide for how long a period a native may be infected with trypanosomes and still show no definite signs of disease. One man already mentioned, is known to have been infected for over a year and is still perfectly well. It would appear from one or two early cases which have been observed that the transition from this 'latent' stage to one in which symptoms are noticed may be very gradual. We have only observed eight fatal cases of Congo sickness in which the necropsies showed no obvious secondary infection. The duration of the disease, dating from the recognition, either by the friends of the patient or by ourselves, of obvious signs of ill-health, has been from two to four months.

Recovery. In our experience no native who has shown definite and constant signs of ill-health has recovered.

Since we have been in Leopoldville we have frequently seen a case of trypanosomiasis in a European, reported by Dr. Broden[3] and Sir Patrick Manson.[4]

Mrs. M., a missionary stationed at Leopoldville, states that her illness commenced on October 1, 1900, with a fever which lasted for three months and was not amenable to quinine. Since that time she had not been free from constantly recurring fever, except for two periods, in 1901 and 1902, each of three months duration, up to March 19, 1903. Since the last date she has been absolutely free from fever or other signs of trypanosoma infection up to the present (April, 1904). She is apparently in perfect health and has increased in weight. The trypanosomes were found by Dr. Broden on February 7, 1903, during an attack of fever which lasted for a few days. During the last year Dr. Broden has seen no parasites in the blood of this case.

Death. We do not think that we have sufficient evidence to state that death is produced by the trypanosomes alone.

1. Bergh St. Marie in the Portuguese Commission's Report.
2. Christy, Reports of the Sleeping Sickness Commission, Royal Society, No. III.
3. Broden, *Ibid.*
4. Manson, *Ibid.*

Secondary Infections and Complications

Secondary bacterial infections seem to determine the fatal issue of many cases of Congo sleeping sickness. Thirteen out of twenty-two necropsies performed at Leopoldville showed complications or obvious secondary infections.

They were as follows :—

Purulent meningitis	4
Purulent pleurisy and pneumonia	1
Pneumonia and localized tubercle of lung	1
Localized gangrene of lung	1
Enlarged caseating and breaking down glands in thorax and abdomen. No tuberculous lesions in organs (tubercle bacillus in glands seen in one case)	2
Dysenteric ulceration of large bowel (perforation in one case) ...	2
Universally adherent pericardium (recent)	1
Infiltration of pus in femoral, inguinal, and internal iliac glands (gonorrhoea)	1

According to the *Post-mortem* Reports of Colonel D. Bruce and Dr. Nebarro very similar lesions were observed in Uganda, where ten out of twenty autopsies on sleeping sickness patients showed obvious secondary infections and in three instances purulent meningitis.

It will be noted that purulent meningitis has been the most frequent complication both in Uganda and in the Congo. The brain in these cases (see case 69) presents a very abnormal appearance. The convolutions, especially on the upper surface, are covered and glued together by a thick layer of tenacious lymph, and the vessels of the pia arachnoid are intensely congested. It is evident that such morbid changes are explicable on bacteriological grounds, and we have found, microscopically, in all such cases an almost pure culture of a diplococcus occurring in small chains. These observations make us doubt whether the acute congestion of cerebral vessels accompanied by an increase of pia arachnoid fluid containing pus cells, seen by us here, and described by others as typical of sleeping sickness, can be attributed to the trypanosome alone.

The Portuguese Sleeping Sickness Commission,[1] Dr. Broden in Leopoldville,[2] and Dr. Castellani in Uganda,[3] have all described bacterial infections in a very large percentage of sleeping sickness cases examined before as well as after death.

It must be noted that such purulent changes have not been described in animals dying from other trypanosome infections.

1. Bettencourt, Koppe, de Rezende and Mendes, *La Maladie du Sommeil*, 1903.
2. Broden, *Ibid.*
3. Castellani, Report of the Sleeping Sickness Commission, Royal Society.

OBSERVATIONS ON THE PARASITE

Periodicity and Frequency of Occurrence in the Peripheral Blood

Frequent examinations of the finger blood of trypanosome cases have shown that the parasites may, to the ordinary methods of examination, be absent from the peripheral blood for varying periods. This periodicity is illustrated by the two following cases :—

Case 101. Oporanga. Regular observations were made about every third day, commencing on January 3, 1904, when no parasites were seen. The periods of presence or absence of the parasite from that date until death were as follows :—

22	days	absent	...	11	observations.	
3	,,	present	...	3	,,	
7	,,	absent	...	4	,,	
3	,,	present	...	3	,,	
33	,,	absent	...	14	,,	
4	,,	present	...	4	,,	
6	,,	absent	...	3	,,	Died.

This case shows comparatively long periods of absence.

Unless especially stated the routine method of examination employed for the detection of the trypanosomes was the examination of a freshly made three-quarter inch square, cover-slip preparation of finger blood ringed with vaseline.

Case 90. Bongwendie. Routine examinations commenced on January 19, when trypanosomes were found to be present. They had not been seen for four days previously.

3	days	present	...	3	observations.	
9	,,	absent	...	4	,,	
6	,,	present	...	4	,,	
6	,,	absent	...	4	,,	
1	,,	present	...	1	,,	
2	,,	absent	...	1	,,	
1	,,	present	...	1	,,	
5	,,	absent	..	4	,,	
2	,,	present	...	1	,,	
3	,,	absent	...	1	,,	
6	,,	present	...	5	,,	
10	,,	absent	...	7	,,	Died.

This case shows shorter periods of absence.

In some cases parasites have been almost constantly present in the blood (Case 85); in others, as is shown by the two following cases, they have been rarely found.

Case 77. Ejoli. Under observation for twenty-one days before death. Parasites seen only twice on two consecutive days; sixteen observations.

Case 103. Belamo. Still under observation. Parasites not seen for thirty-eight days; seventeen observations. They have been seen in the blood of this case only by centrifugalizing.

The frequency with which the parasite is obviously present in the peripheral blood bears no relation to the severity of the symptoms.

Number of Parasites Appearing in the Blood

The number of parasites seen in ordinary fresh cover-slip preparations is generally small, but in some patients, very large numbers have been recorded. In two cases a large increase has occurred during the few days immediately preceding death.

Case 87. Patesa. Admitted to hospital for acute dysentery; under observation for four days preceding death. Parasites increased from two to a cover on the first day to twenty to a field on the day of death. There was no accompanying rise of temperature.

Necropsy showed very extensive dysenteric ulceration of the large intestine.

Case 88. Boyo. Parasites increased during the four days preceding death from two to one hundred to a cover. They had not been previously seen in such large numbers. At the necropsy on this case very general enlargement and caseation of abdominal and thoracic glands was noted. There were no tubercular lesions in the lungs or other organs.

A similar increase of parasites occurred just before death in Cases 62 and 82 (see charts); but in the two following cases they were absent for some days before death:—

Case 89. Kapinga. Parasites not seen for ten days preceding death; six observations.

Case 77. Ejoli. Parasites not seen for nineteen days before death; fourteen observations.

Sudden Disappearance of the Parasite from the Finger Blood

The following are examples of cases in which the parasites have gradually increased from small to fairly large numbers (twenty to cover-slip or more) and then suddenly disappeared on the day after their acme was reached.

Case 65. Mokoko. See chart.

Case 99. Mozao. At the end of the first examination on March 5 seven trypanosomes were seen to a field. On March 6, 7, and 8 none were seen.

Case 102. Kondolo. On February 24, seven parasites were seen to a cover; on February 25, seventy to cover; on February 26 and eight following days, none were seen, although observations were made every other day.

A second similar acme and sudden disappearance was recorded in this case. On March 10, six parasites were seen to cover; on March 11, two hundred and fifty; but on March 12, none were found.

Case 90. Bugwendi. On February 26, 27, 29, and March 1, parasites were seen in the following numbers respectively, eight, five, five, and one to a cover. On March 2, twenty-four were seen; but from March 3 to date of death (March 21) they were absent.

Case 101. Oporanga. On March 1, 2, 3, parasites were seen in numbers six, forty-eight, thirty-one, respectively, to the cover-slip. On March 4, one hundred and twelve were noted; but on March 6, 7, and 8, not one was to be found. (No examination on March 5).

Case 66. Tenda. On February 23, 24, and 25, the number of parasites recorded per cover was four, five, and seven, respectively,. On the 26th, seventy to a cover; but on the 27th, and for fifteen subsequent days, none were found.

Case 85. Banja (see below). Illustrates a somewhat opposite condition. The parasites increased in this case to an acme which lasted for two or three days, and then a marked diminution in number was observed. This patient, who is still under observation, illustrates the constancy with which parasites are seen in the peripheral blood of some cases. It will be noted that his general health has latterly improved.

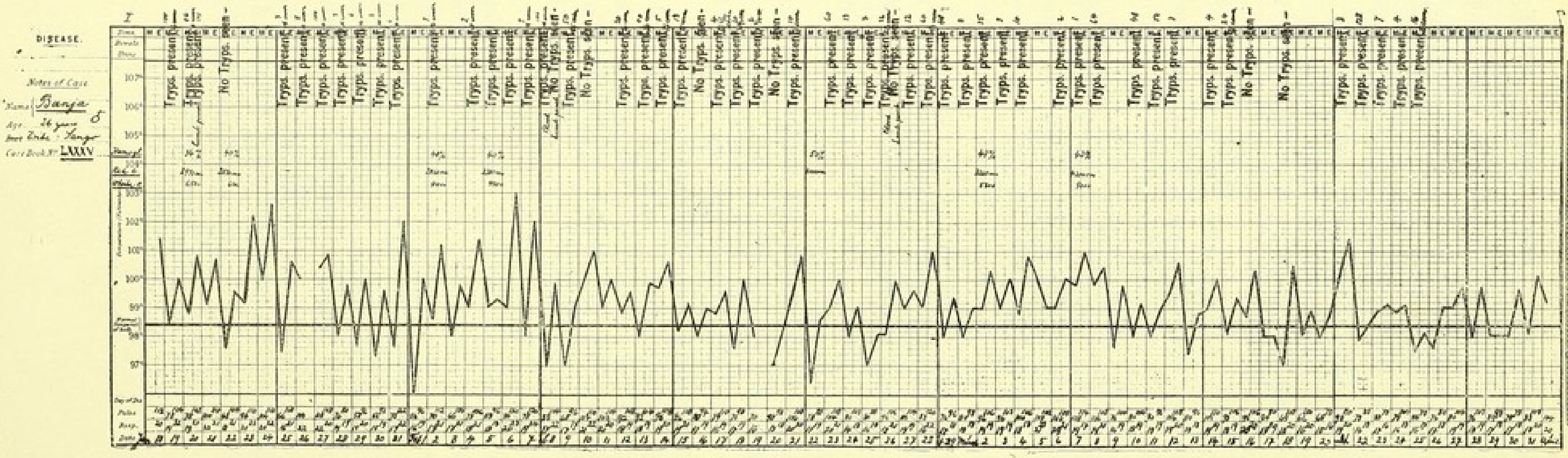
Case 85. Banja. Male. Age twenty-six.

History.—Patient comes from the Sango district of the Bangala country, where Congo Sickness, so far as we know, is not present. He has been employed for some years on steamers plying on the upper river. A month before being sent to hospital was imprisoned on a charge of cannibalism. No history of illness before going to prison.

January 20, 1904. General condition: Somewhat emaciated; expression pained and anxious; intelligence fair, answers questions slowly but correctly; breathing laboured—is apparently very ill. His skin is dry and filthy, no 'craw-craw.' Slight oedema of forehead, considerable of shins and feet; lymphatic glands all enlarged, especially femoral and inguinal; tongue coated, moist, and steady.

Circulatory system, heart sounds booming at apex; pulmonary second sound accentuated and dicrotic. Respiratory system, dullness at base of right lung, loss of breath sounds, pleuritic rub and moist rales. Liver enlarged and painful. Spleen not enlarged. Nervous system, patellar and cremasteric reflexes not obtainable, epigastric increased; pupils equal and react to light.

CASE LXXXV


DISEASE.
Notes of Case
Name Banja
Age 26 years
Tryps. present
No Tryps. seen

February 2. Is in better condition, and is brighter than when admitted; abdomen distended; oedema of loins marked.

February 16. Shows no signs of sleep, walks, now without any unsteadiness. Appetite large.

February 24. Seems quite well; slight oedema of shins, but none elsewhere; no puffiness of face; can walk about with ease.

March 18. Gait normal, expression contented, no dulness, is quite intelligent, answers questions quickly and well; glands all enlarged, but femorals and inguinals apparently smaller than when admitted to hospital; slight oedema of shins; liver still enlarged, but not tender; heart and lungs, normal; knee jerks, normal; epigastric and cremasteric reflexes obtainable; appetite good; no drowsiness; patient works willingly around the hospital.

April 1. Has certainly put on flesh lately and increased in general robustness.

Symptoms Associated with the Presence of the Parasites in the Blood

The only patient in whom a large increase of parasites was associated with a rise in temperature and the presence of symptoms which might be attributed to the parasite was Mokoko (Case 65), whose case is given above.

From our observations we cannot make out any definite relation between the temperature and pulse and the appearance of the parasites in the peripheral circulation. A rise of temperature is not necessarily associated with an increase of parasites in the blood.

It appears, therefore, that the number or constant presence of the parasites in the peripheral blood bears no relation to the severity of the disease.

Occurrence of Parasites in Serous Fluids

On two occasions 10 c.cm. of fluid was drawn from a flabby hydrocele (in Case 104) and centrifugalized. Parasites were seen each time, although they were absent from the blood to ordinary examination, and probably had been absent for some days previous to the second tapping. The cerebro-spinal fluid of this case was also examined on the same date as the first tapping, but no parasites were seen, although the deposit of the centrifugalized hydrocele fluid showed fourteen to a cover. In another case (number 92), in which the penis and scrotum were very oedematous and there was a small right hydrocele, no parasites were seen in either oedema or hydrocele fluids, although the blood showed thirty to a cover. We have not found parasites in the urine (centrifugalized) in the few cases examined in which the blood showed many parasites.

The Occurrence of the Parasites in Tissues and Fluids after Death

Our examination of film preparations of tissues and fluids taken at autopsies are not completed, but it is interesting to note here the frequency with which the parasites have been seen in the pericardial, pleural, and peritoneal fluids when examined fresh. In three cases (62, see chart, 64, 76) parasites were seen, without centrifugalizing, in the pericardial or peritoneal fluid; one-and-a-half, two, two-and-a-half hours, respectively, after death. In two of these cases numerous longitudinal divisional forms were seen in the pericardial fluid. In three other cases actively motile trypanosomes were seen in the pericardial fluid after centrifugalizing, fourteen, fifteen-and-a-half, twenty-and-a-half hours after death. In all these cases parasites were seen either the day before or a few days previous to death. In only one case has a trypanosome been seen in fluid from a lymphatic gland (omental); but in this case parasites were easily detected in the blood, *post-mortem*, and were very numerous in the pericardial and peritoneal fluids.

Occurrence of Parasites in the Cerebro-Spinal Fluid

During the stay of the expedition at Leopoldville, lumbar puncture was performed on forty-nine natives coming from many parts of the Upper and Lower Congo. Of these thirty-eight were proved to be suffering from trypanosomiasis, the parasites being found in the blood. In the remaining eleven cases no trypanosomes were seen in either the blood or cerebro-spinal fluid, and in some of them a diagnosis of some other disease, *e.g.*, tubercle, dysentery, etc., was established either during life or *post-mortem*.

In twenty-five of the thirty-eight trypanosomiasis cases the parasites were found in the cerebro-spinal fluid, but in thirteen no parasites were seen, although in one case (No. 101) the fluid was examined on five occasions.

If, however, those punctures in which the cerebro-spinal fluid was mixed with the blood in greater proportion than from three to four red cells to a field (Zeiss 1/6 objective, No. 4 eye-piece, diaphragm removed), and in which the parasites were found by coverslip examination to be present in the peripheral blood on the same day as the puncture, be excluded, then we find that the above result is very different, namely, thirty-two cases, in sixteen of which the parasites were found in the cerebro-spinal fluid, and in sixteen they were not. The amount of cerebro-spinal fluid drawn off and centrifugalized at each operation varied from 10 to 30 or even 40 c.cm. This, if necessary, was not only centrifugalized a second or third time, but from one to six coverslip preparations of the resulting deposit were examined before a negative result was recorded.

If the cerebro-spinal fluid is mixed with blood it has a slight yellowish tinge, and is opalescent or clouded according to the amount of blood it contains. If normal cellular elements are much increased the fluid has also an opalescent or cloudy appearance, but there is no yellowish tinge. It is doubtful whether the presence of the parasite in the cerebro-spinal fluid has any influence upon the increase of its cellular elements. It would seem, from a study of our cases, that the fluid as a rule, whether the parasites be present or not, is perfectly clear and limpid as in health. Only in a few instances, in both positive and negative cases, have the cellular elements shown an apparent increase, consisting mainly of small mononuclear cells, together with some mononuclear large cells. In Case 93, the only one in which a large number of parasites—fifty to a cover—were found in the cerebro-spinal fluid, a great increase of small mononuclear cells was noted at the same time. A month later the cerebro-spinal fluid was again examined, but only one parasite could be found, and the cellular elements were scanty. This case, up to the present date, nearly two months after the discovery of large numbers of trypanosomes in the cerebro-spinal fluid, has shown no tendency to sleep during the daytime, no wasting, nor any of the more noticeable symptoms associated with the later stages of many of our cases of trypanosomiasis.

As a rule, we have found that the parasites occur in extremely scanty numbers in the cerebro-spinal fluid, seldom more than one to three or four, very occasionally from ten to twenty to the cover-glass preparation of the sediment left after centrifugalizing.

As already stated, neither at Leopoldville, nor anywhere on the Lower Congo, up to the present time, have we met with a case of Congo sickness in which sleep has had a prominent place among the clinical symptoms, and in those few cases in which it has been noted a few days before death, or at irregular intervals during the course of the disease, it has not been describable as deep or continuous sleep, but merely a drowsy or somnolent condition from which the patient was at once aroused by being touched or, perhaps, by being spoken to. On comparing the cases in which parasites were found in cerebro-spinal fluid with those in which they were not found, we see that most of the few cases in which drowsiness was a feature, together with cases in which head symptoms, *e.g.*, mild mania, epileptic attacks, flexure contractions, and convulsive seizures, were conspicuous are upon the positive side. On the negative side similar cases are also found, but it is noticeable that there are many of those cases which showed hardly any symptoms, and which, if no fatal complications intervened, lived on month after month in an advanced state of emaciation, retaining their faculties, speech, appetite, etc., almost to the moment of their death.

It is, therefore, not improbable that the presence of the parasites in the cerebro-spinal fluid at a late stage in the disease may tend to increase the gravity of the case by predisposing to one or other of many complications, or, in other ways, hasten a fatal termination ; but that this is not invariably so is proved by at least two of our cases, one of which (Case 93) is now one of the most sturdy patients under observation.

Animal Experiments

We have infected rats, mice, guinea-pigs, rabbits, and monkeys with human trypanosomes taken from cases of Congo Sleeping Sickness, both in its early and its latest phases. As was stated in our first Progress Report the course of the infection in these animals has given us no reason to suppose that we are dealing with more than one species of trypanosomes, or that the parasite is other than *Trypanosoma gambiense*.

All our inoculations have been made with small or medium doses (1 to 5 c.cm.) of infective material, either cerebro-spinal fluid or blood—diluted or no—in which, in almost every case, living trypanosomes, sometimes in enormous numbers, were demonstrated. About 50 per cent. of such inoculations have failed to infect. These failures seem to bear no relation either to the source of the material inoculated, to the site of inoculation—subcutaneous or intraperitoneal—or to the approximate number of parasites injected.

Once more, no animals inoculated with material in which trypanosomes were seen, taken *post-mortem* from cases of trypanosomiasis, have ever become infected. Parasites have been seen in the peripheral blood of infected animals only at more or less irregular intervals. Guinea-pigs have, perhaps, shown themselves the most satisfactory of ordinary laboratory animals, since, as a rule, when once infected, parasites are constantly present in large numbers.

Death, in the small number of our infected animals which have died, can in no instance be certainly said to have been due to the trypanosome alone. These are all points in which the Congo trypanosome resembles *Trypanosoma gambiense*. In addition, the 'incubation period,' that is, the period intervening between the inoculation of small or medium doses of infective material and the detection of the parasite in the peripheral blood of the experimental animal, is much the same for both parasites.

	Congo trypanosome	Trypanosoma gambiense
Rats	5—20	7—20
Mice	5—16	6—7
Rabbits	17—27	21
Guinea-pigs ...	11—25	12—21

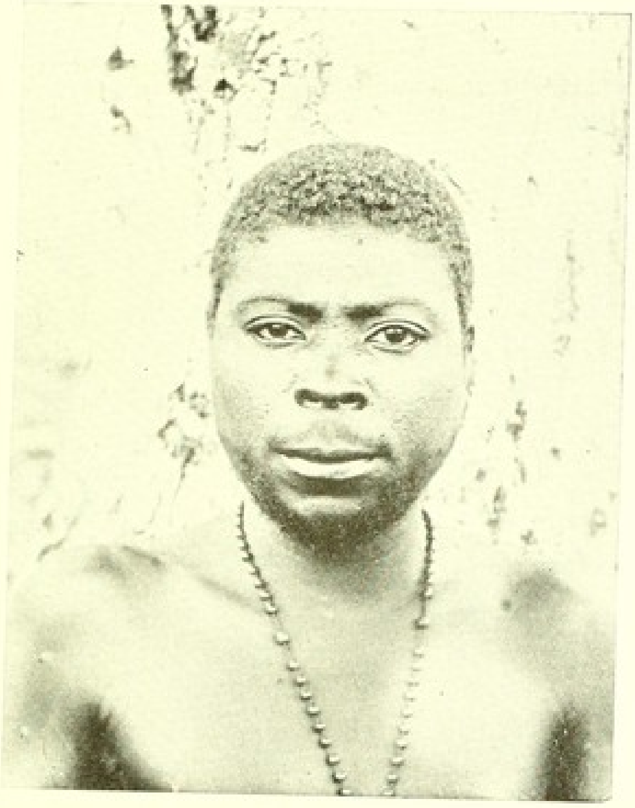
Monkeys of two different varieties, both belonging to the sub-family *Cercopithecus*, have been infected. Only one has shown slight symptoms of ill-health. On two occasions a slight rise of temperature and loss of vivacity has accompanied one of the irregularly appearing intervals during which parasites have been seen in the peripheral blood. This monkey has been infected for nearly three months.

We have again failed, even with large doses of blood containing huge numbers of trypanosomes, to infect two dog-face monkeys (*Cynocephalus*).

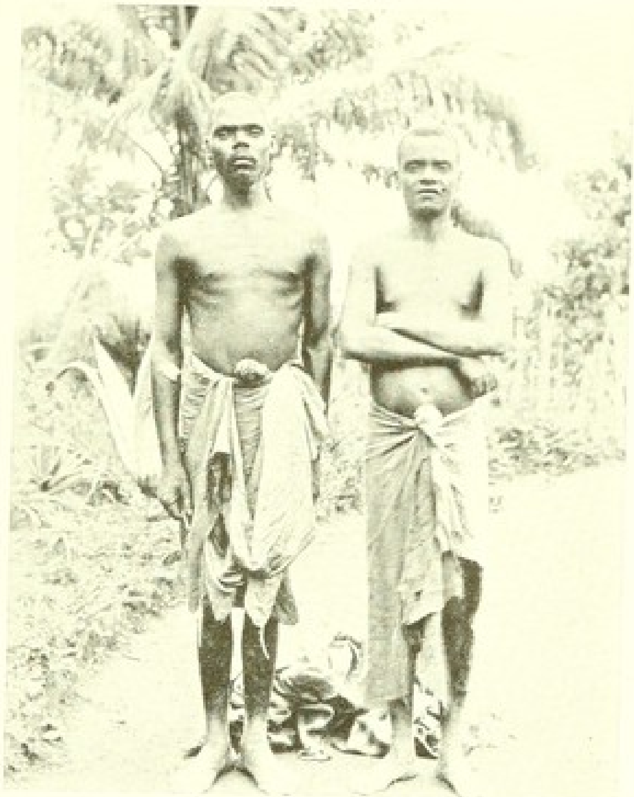
Transmission Experiments

We have attempted to repeat the transmission experiments made by Bruce, in Uganda, with the tse-tse fly. These flies are rather numerous in the bush along the river banks on either side of Leopoldville, and a fair number are daily brought to the laboratory by a gang of boys supplied for the purpose by the local authorities. Practically all the flies brought in by them have been *Glossina palpalis* (native name, 'mavekwa'). Unfortunately, we have had the greatest difficulty in obtaining monkeys and have only been able to use two for these experiments. Both in the Congo and in the Gambia, experiments have shown that the guinea-pig is, perhaps, the laboratory animal most susceptible to *Trypanosoma gambiense*. We, therefore, determined to employ it, lacking monkeys, in our transmission experiments. At the time of writing both experiments with monkeys remain unsuccessful, and only one, a direct transmission experiment with guinea-pigs, in which the flies were made to feed alternately on an infected and an uninfected animal, has given a positive result.

In conclusion, we wish to thank Dr. Inge Heiberg, who has been attached to the expedition by the Government of the Congo Free State, for his untiring kindness and the help he has given us in our work.



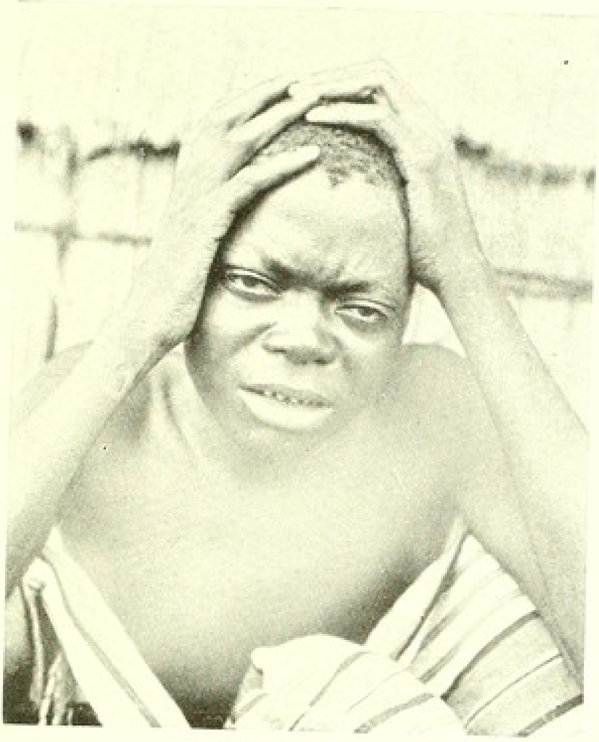
Fariala (Case LXXIX). Illustrating an early stage with general absence of symptoms except rise of temperature.



Two cases from Cataract Region of Congo, showing practically no symptoms. Carried heavy loads for many days without complaint.

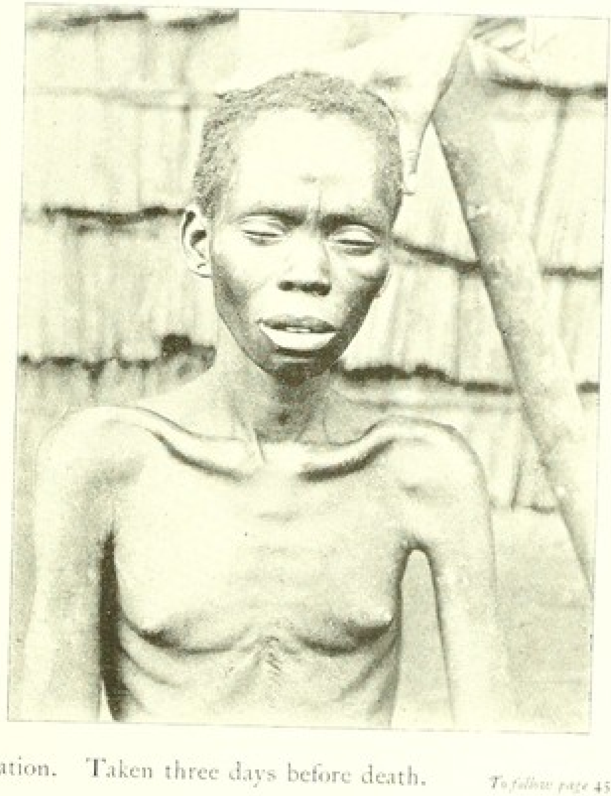
Trypanosomiasis cases in the hospital for blacks at Leopoldville, Upper Congo, waiting for their daily ration of 'Kwanga' (Casava bread) to be served out to them.

To follow page 45



Kondolo (Case CII). Main symptoms severe and continued headache. No sleep.

Boyo Mitchel (Case XCI). Showing puffy face and lips, and drowsy dull expression. Taken six weeks before death.



Oparanga (Case CI). Showing extreme emaciation. Taken three days before death.

To follow page 45

THE CONGO FLOOR MAGGOT

THE CONGO FLOOR MAGGOT

A BLOOD-SUCKING DIPTEROUS LARVA FOUND IN THE CONGO FREE STATE

(*The First Interim Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo*, 1903. *Received January*, 1904)

BY

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AND

CUTHBERT CHRISTY, M.B., Edin.

IN correspondence, during our stay at Boma, with the Rev. Holman Bentley and Mr. Sutton Smith, both of the Baptist Missionary Society Corporation, we learned of the existence in the Lower Congo of what were called 'floor maggots,' which they described as 'keen blood-suckers.'

It was not, however, until camped at a place called Nkanga, on our way from Tumba to Lutete, in the cataract region of the Congo, that we had an opportunity of seeing specimens of these maggots. Here, the head man of a neighbouring village, after being questioned on the subject of native pests, collected for us during the night, a number of what appeared to us—at first sight—to be ordinary blow-fly maggots. On a closer inspection many of them were seen to contain bright red blood.

A day or two afterwards, when visiting a native village, we had the opportunity of seeing the natives collect these blood-suckers by digging with the point of a knife or scraping with a sharpened stick in the dust-filled cracks and crevices of the mud floors of their huts. We were soon able to find them ourselves as easily as the natives, and unearthed many larvae which contained bright red blood. In collecting them the natives selected those huts in which the occupants slept on floor mats, saying that where people slept on beds or raised platforms the maggots were not so numerous. They informed us, however, that those who slept in beds which were not raised more than eighteen inches from the ground were also bitten, and credited the maggot with the power of jumping to that height. In some of the huts we collected, in a short space of time, as many as twenty from only a small proportion of the floor crevices. Many were turned up from a depth of three inches. In some of the cracks, and in moist, soft earth, they were found at greater depths. There is no doubt that these maggots feed only at night. Mr. Bentley told us that as many as fifty could sometimes be found beneath a single mattress, and that he had known boys to be so pestered by them that they had preferred to sit all night outside a house to sleeping within it.

In one village, Nzungu, we visited a hut, measuring eight feet by ten feet, in which seven boys were sleeping on a small mat, and in the dust beneath a bed-platform on which slept a man and a woman. In the corner of the hut was the usual small fire and a sleeping pye-dog. Although we did not see the maggots actually feeding, we collected from beneath the mats and from amongst the boys' legs some half-dozen which were filled with recently sucked blood. The natives said that the maggots dropped off at once if the limb on which they were feeding was moved. There were specimens of all sizes, ranging in length from 2 to 15 mm. amongst those brought to us, and so far we have obtained them in every village we have visited. When ready to pupate, the larva lies dormant upon the surface, changes in colour to a pinky-brown, and later becomes a dark-reddish or brownish-black, chitinous, segmented, and oblong puparium.

We have never been able to substantiate the assertion, made to us on several occasions, that the maggot is able to jump to a height of eighteen inches. We think it more probable that they reach the raised beds by crawling up either the supports or the grass wall against which the bed is usually placed. We have, however, satisfied ourselves that it feeds mainly or entirely at night, and that it probably feeds nightly since blood in varying stages of digestion, and ranging in colour from bright red to black, can often be seen in its alimentary canal.

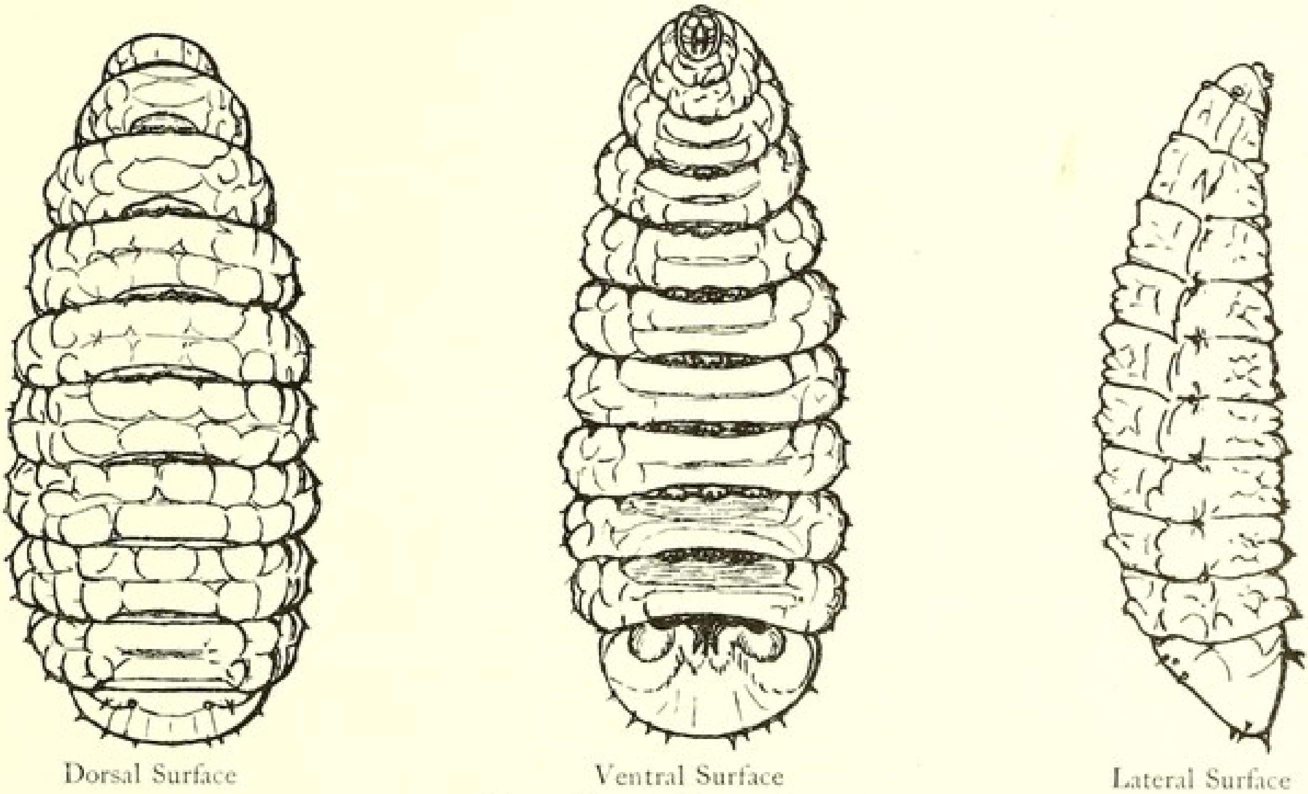
The distribution of this larva seems to be very extensive. We have collected it all over the Lutete and surrounding districts, and at Leopoldville. We have heard of it as being common at San Salvador, in Portuguese territory, on the Congo at Matadi in the cataract region, and at Tchumbiri one hundred and fifty miles above Stanley Pool.

Some of the native names for the maggot are as follows :—

At Tchumbiri, north of Leopoldville, the Bateke, according to Mrs. E. Billington of the Royal British Nurses' Association, call it 'Mabinzu.' At Leopoldville the Bateke call it 'Nchichi.' At Wathen (Lutete), in the cataract region, Mr. Bentley states that all maggots are called 'Ntunga,' and that there was no other special name for this one. At Matadi the native name is probably 'Mvidi.' In the Bangala district it is called 'Kiso.'

This larva maggot is semitranslucent, of a dirty white colour, acephalous, and amphipneustic. It resembles, when adult, the larvae of the bot-flies, and consists of eleven very distinct segments. The first or anterior one is divisible, by a slight constriction, into two portions, the foremost of which is small, bears the mouth parts, and is capable of protrusion and retraction to a considerable extent.

The larva is broadest at the ninth and tenth segments, is roughly ovoid in transverse section, and has, distinctly, dorsal and ventral surfaces. At the junction of the two surfaces is a row of irregular protuberances, two or more being placed on each segment. On each protuberance is a small posteriorly directed spine and a small pit. The central part of the ventral surface is flattened, and at the posterior margin of each segment is a set of three foot-pads, transversely arranged, each covered with small spines directed backwards. These aid the larva in its movements, which are fairly rapid and peculiar in that the mouth parts are protruded to the utmost and the tentacula fixed, as a purchase, first on one side then on the other, while a wave of contraction runs along the body as each segment is contracted and brought forward.



Dorsal Surface Ventral Surface Lateral Surface

Congo Floor Maggot (× 4·5)

The last segment is larger than any of the others. Its upper surface is flattened, and looks backwards and upwards at an angle of about forty-five degrees with the longitudinal axis of the larva. This surface is roughly hexagonal and bears anteriorly, one on either side, the posterior spiracles which are seen with a pocket magnifying glass as three transverse, parallel, brown lines. Around this flattened surface, towards its border, are placed groups of rather prominent spines. The ventral surface of this segment is also flattened, and is thrown into folds by muscular contractions. The anus is situated in the anterior portion of this segment in the middle line, and is seen as a longitudinal slit, surrounded by a low ridge. Posterior to it, and on either side, is a large conspicuous spine. The anterior segment is roughly conical, and bears the mouth parts in front. Posteriorly, on the dorsal surface, almost covered by the second segment, two spiracles, on either side, are seen with a low power as small brown spots. Two black hooks or tentacula protrude from the apex of this segment. They are curved towards the ventral surface of the maggot. The apex of each hook is blunt, and its base surrounded by a fleshy ring. Between them is the oral orifice. The tentacular processes are continued for some distance into the body of the maggot as black chitinous structures with expanded bases. There is probably, as in *Oestrus ovis* (Linn.), an articulation between the external and internal chitinous structures, since the arrangement of the mouth parts seems to be the same as in the maggot of that fly. Paired groups of minute spicular teeth are placed around the two tentacula so as to form a sort of cupping instrument. The arrangement of these teeth is as follows :—A rather large tubercle is situated on either side of and above the tentacula ; each is mounted by two or more groups of very small chitinous teeth. Just above each tentaculum is another small group of teeth. On either side of these black tentacula two irregular rows of small teeth are placed one above the other. The two latter groups are not placed upon tubercles. The integument of the larva is thick and difficult to tear. The larva is able to withstand a good deal of pressure without injury.

The following gross internal anatomical structures have at present been made out—intestinal canal, salivary gland, nervous system, and fat body. The intestinal canal commences as a short oesophagus, which ends in a proventriculus. A remarkable dorsal diverticulum, corresponding to the food reservoir of the muscid larvae, opens into the oesophagus near its anterior end. After the maggot has fed, the diverticulum is a very conspicuous object, since it is seen through the semi-transparent body wall as a bright red area when full of blood, extending from the head to about the fifth segment. The caeca, behind the proventriculus, have not as yet been well made out. The mid-intestine or chyle stomach is short, when compared with the hind intestine, and extends from the proventriculus to the junction of the urinary tubules with the gut. It lies in one or two coils. The hind intestine is very much coiled, and occupies the greatest part of the body cavity.

The urinary tubules are four in number, two on either side of the intestine. Each lateral pair combines to form a broad plate, from which is given off a single process for attachment to the gut.

Each salivary gland of the larvae consists of one very long acinus made up of large granular cells. The gland ends in a chitinous ringed duct, which joins its fellow of the opposite side to form a common duct, opening near the base of the free portion of the tentacula. The body of the maggot is lined by a white, loosely reticulated fat body. The minute anatomy of the mouth parts and sucking apparatus has not been studied.

The time required for the maturation of the larva is not yet known. The puparium is a dark-brown or black, cylindrical, segmented body, measuring 9-10·5 mm.

in length and 4-5 mm. in width. The anterior end is roughly conical, the posterior is rounded. All the external structures seen in the larva can be made out on the external surface of the puparium. The cuticle shows annular ridges.

The duration of the puparial stage is from a fortnight to three weeks.

During our stay at Wathen, Mr. Bentley showed us, among his collection of insects, a large light-brown fly which he believed to be developed from the floor maggots. Specimens caught in the boys' dormitory at the Wathen Mission were soon after brought in by one of our collectors, and later, while searching a native hut infested with 'floor maggots,' we saw one of these flies resting on the grass wall. Many others were subsequently found in the same building, sitting motionless amongst the beams and cob-webs of walls and roof. Because of their colour, which corresponded exactly with the smoke-stained straw and rafters of the huts, they were difficult to see, and in the dark interiors more difficult to catch.

This fly, seldom one of any other species, has since been found in many huts infested with maggots. We were told that the fly deposited its eggs on the ground of a hut, particularly in spots where urine had been voided. As a rule the fly is silent, but on one occasion we observed it buzzing loudly, fly in at the door and go directly beneath some bed mats which were raised by a low platform, some eight centimetres from the floor.

Both Mr. Bentley and the natives state that this fly never bites men.

The native name at Wathen for all flies is 'Nwanzi' or 'Mbwanzi.' The name for the fly which we describe is 'Nkulu Mwanzi.' The fly is thick set, and is of about the size and build of a 'blue bottle.' It is about 10-12 mm. in length, and once seen can be easily recognized. Its general colouring is tawny, but the small black hairs covering its body give it a smoky appearance. The head is large, as broad as the thorax, and protrudes in front of the eyes, which are when fresh a reddish brown in colour. The eyes are separated from each other, below, by a considerable interval and appear small in comparison with the size of the head. The proboscis is folded beneath the head in a deep groove, and is inconspicuous while in this position.

The palpi are club-shaped and covered, more particularly at their apices, with conspicuous black bristles. The third joint of the antenna is long, yellow, flattened from side to side, and rounded at its apex. It bears an arista which, thickened at its base (probably jointed), tapers to a fine point. The arista bears fine black hairs along its upper and lower borders ; long at its base, the hairs become short and slanting at its apex. The dorsum of the thorax is flattened, and marked by longitudinal black and brown stripes, the transverse suture is well marked. The thorax is covered with fine black hairs and studded with rows of black bristles, which are particularly long on the sides. The squamae are very large, yellow in colour, and completely cover the yellowish-white halteres. The abdomen apparently consists of five segments. It is covered with long black hairs, and bears a few long bristles on the last two segments. The second segment is the longest, and here the width of the abdomen is greatest, the upper surface of this segment is characteristically marked. A dark-brown or black line runs down the centre of the segment to meet at right angles a similar line which borders its posterior edge. There are no other marks on this segment, it is transparent, and its general colour is that of the rest of the body. The third segment is, except for a narrow yellow streak along its anterior border, very dark brown in colour, more marked laterally. The fourth segment is of the same dark colour, and is bordered posteriorly by a narrow lighter brown band. The fifth segment is small, and contains the genital apparatus. The wings are of a smoky brown colour, and show a well-marked venation. The legs are of the same buff as the rest of the body, and are covered with black hair and bristles. A noticeable feature of the legs is the jet-black fifth tarsal joint, which stands out prominently against the large cream-white pulvilus.

We have been able to allow a number of these maggots to feed on rats and guinea-pigs. We purpose carrying out a series of experiments with the object of determining whether they are able to play a part in the transmission of the human trypanosome. In none of the entomological works, which we can at present command, are we able to find any reference to habits or morphology by which we can identify this fly.

Specimens of the flies and larvae were submitted for identification to Mr. E. E. Austen, the dipterologist to the British Museum, together with a copy of the above report, and he has been kind enough to write as follows :—'I have read the report on the "Blood-Sucking Floor Maggot" with the greatest possible interest. Whether this maggot prove to be in any way concerned in the dissemination of trypanosomiasis or no, Messrs. Dutton, Todd, and Christy have come across an entirely novel and most interesting fact in the biology of diptera, and they are heartily to be congratulated on being the first to bring it to notice.

The flies are specimens of *Auchmeromyia luteola*, Fabr. (a species of the family Muscidae), which is widely distributed in tropical and subtropical Africa. Before reading the report, I was under the impression that the larvae of this fly were well known subcutaneous parasites of human beings and dogs, but I have now no doubt that *A. luteola* has been confused with another fly, very similar to it in appearance, but belonging to a different genus, the larvae of which are unquestionably subcutaneous parasites in man, dogs, and monkeys. Nevertheless,' says Mr. Austen, 'I have evidence, apparently reliable, which seems to show that the larvae of *A. luteola* may, perhaps, under exceptional circumstances, live subcutaneously in man. The fly itself, so far as I am aware, is otherwise harmless, and is incapable of sucking blood. Specimens in the national collection show that it ranges from Northern Nigeria to Natal ; it is therefore somewhat surprising that the habits of the larva have not been reported before.'

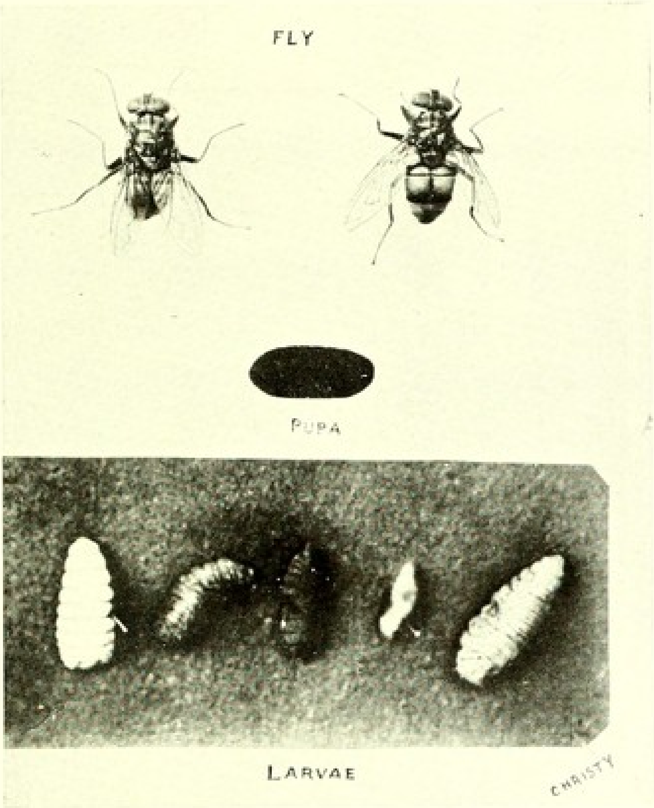


Fig. 1

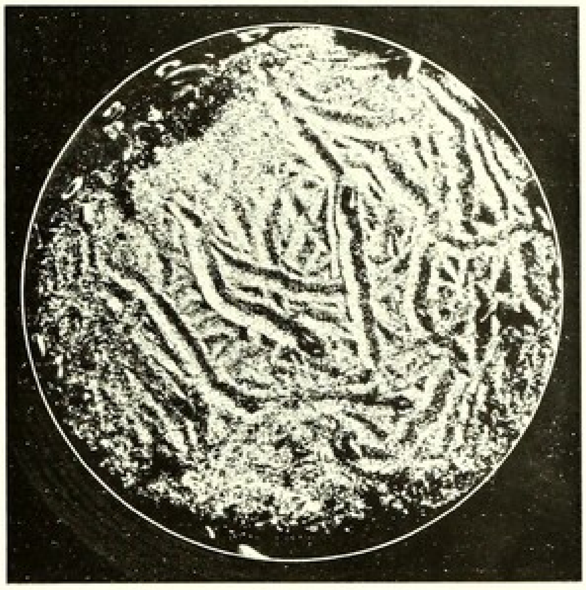


Fig. 2

Fig. 3

CONGO FLOOR MAGGOT AND FLY

Fig. 1. Flies, pupa and larvae (nat. size). Fig. 2. Markings in the sand, produced by larvae.
Fig 3. Larvae immediately after, and some hours after, feeding. (× twice).

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THE CEREBRO-SPINAL FLUID IN SLEEPING SICKNESS (TRYPANOSOMIASIS)

THE CEREBRO-SPINAL FLUID IN SLEEPING SICKNESS (TRYPANOSOMIASIS)

104 LUMBAR PUNCTURES

Second Interim Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903

BY

CUTHBERT CHRISTY, M.B., C.M., Edin.

THE majority of the punctures recorded in the accompanying tables were performed whilst working with Drs. J. E. Dutton and J. L. Todd, in the Congo Free State. All, with the exception of three, were performed by myself either at Boma, Leopoldville, posts further up the Congo, or since returning to England. Some conclusions drawn from a number of them are published in our last conjoint report.[1]

Out of a total of sixty-four natives operated upon, the fifty-four in Table I were proved to be cases of sleeping sickness by the discovery of trypanosomes in the blood or cerebro-spinal fluid, or in hydrocele fluid ; while in the remaining ten in Table II, parasites were never found, although the majority of them were more or less suspicious cases, and all were in hospital at Leopoldville.

In thirty-four of the fifty-four sleeping sickness cases the parasites were found sooner or later in the cerebro-spinal fluid, whereas in twenty of them no parasites could be found, although in one (Case 17) the fluid was examined on five occasions.

If, however, those punctures in which the cerebro-spinal fluid was mixed with blood, and in which the parasites were found by coverslip examination to be present in the peripheral circulation on the same day as the puncture, be excluded, then we find that the result is very different, namely, forty-nine cases only, in twenty-five of which trypanosomes were found in the cerebro-spinal fluid, and twenty-four in which they were not found.

A reference to Cases 19, 20, 21, will show how important it is to exclude from all statistics those punctures in which the fluid contains trypanosomes with blood cells when the parasites are known to be in the blood stream. Cases 20 and 21 show clearly that when the fluid is mixed with blood the number of parasites appearing in it is closely in proportion, not only to the number in the blood, but to the amount of blood admitted by unskilful puncture. I therefore in this analysis will exclude from consideration all punctures in which the cerebro-spinal fluid and the blood both show trypanosomes when blood is admitted into the fluid. In the Tables these are marked with an asterisk in the name column.

1. *Second Progress Report.*

TABLE I.—SLEEPING SICKNESS CASES

+ Indicates trypanosomes present. − Indicates trypanosomes absent. C.Cms. stands for cubic centimetres.

Those marked with an asterisk are excluded from statistics owing to blood appearing in the C.S.F. when trypanosomes are known to be present in the circulation. Centrif. stands for centrifugalisation.

No.	Name		Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms drawn off	Days before death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Case, Prominence of Sleep, or other Symptoms, etc., and Mode of Death
1	Elombo		17-12-03	♂	40	− 1 cover examined.	18	11	− 4 covers examined.	Clear.	..	None.	28-12-03	Duration about five months. Extreme emaciation. No symptoms of sleep. Comatose from sun exposure when punctured. Complete revival after withdrawal of fluid.
2	Lisasi	*	16-12-03	♂	20	+ 5 to cover.	10	0	+ 7 to cover.	Cloudy.	..	Many.	16-12-03	Always slightly drowsy, increased before death.
3	Salamo	*1	18-12-03	♀	24	+ 3 to cover.	15	2	+ 4 to cover.	Slightly cloudy.	Increased.	A few.	20-12-03	Duration about three months. Seldom seen dozing till a few days before death. Many division forms of trypanosomes in C.S.F., pericardial fluid, and bone marrow one-and-a-half hours *P.-M.*
		2	20-12-03			+ 13 to cover.	40	*P.-M.*	+ many.	Cloudy.	Increased.	None.	..	
4	Mokoko ..	*	19-12-03	♂	21	+	17	..	+ 3 to cover.	Cloudy.	Increased.	Many.	..	Few symptoms. After being two months in hospital was discharged by medical officer as fit for duty. On January 5 his blood showed 1000 trypanosomes to the cover.
5	Dysiki		19-12-03	♀	26	− 2 covers examined.	18	2	+ 1 in 4 covers.	Clear.	Increased.	A few.	21-12-03	Emaciation but no sleep symptoms till day before death.
6	Bamliki		19-12-03	♂	16	− 2 covers.	6	6	− 1st centrif. 5 covers.	..	..	..	..	Extreme emaciation; slept a good deal, and was semi-comatose for three days before death. Bed-sores.
									+ 2nd centrif. 3 to cover.	Cloudy.	Scanty.	Many.	25-12-03	
7	Polulu ..	*1	21-12-03	♂	21	+ 1 in 2 covers.	20	21	+ 1 in 2 covers.	Cloudy.	Scanty.	Many.	..	December 19 had severe left hemiplegic seizure. No sleep symptoms at any time. *P.-M.*—Extensive purulent meningitis. Cysticercus in triangularis.
		2	31-12-03			+ 3 to cover.		11	− 1st centrif. 2 covers.	Slightly cloudy.	Scanty.	None.	11-1-04	
									+ 2nd centrif.					
8	Tenda	1	23-12-03	♂	30	− 2 covers.	30	103	− 4 covers. 2 centrif.	Clear and limpid.	Very scanty.	None.	..	Duration about five months. Progressive emaciation. Frequently found dozing during January, but subsequently marked absence of nearly all symptoms. Retained faculties and was able to walk till hour of death. Pericardial and peritoneal fluids both showed active division forms twenty-and-a-half hours after death.
		*2	16-1-04			+ 6 to cover.	3	79	+ 1 in 2 covers.	Cloudy.	Increased.	A few.	..	
		3	27-2-04			− 2 covers.	25	37	− 4 covers. 2 centrif.	Clear and limpid.	Very scanty.	None.	..	
		4	31-3-04			− 2 covers.	16	4	+ 1 in 2 covers.	Clear.	Scanty.	A few.	4-4-04	
		5	5-4-04			− 2 covers before death.	47	*P.-M.*	− 5 covers. 13 hours *P.-M.*	Slightly cloudy.	Increased.	None.	..	

TABLE I.—*Continued*

No.	Name		Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms drawn off	Days before death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Case, Prominence of Sleep, or other Symptoms, etc., and Mode of Death
9	Manteka ..	1	24-12-03	♂	19	−	30	21	− 4 covers.	Clear.	Scanty.	A few.	..	Duration about three months. Rapid emaciation. Irritable and troublesome. Helpless, dazed, semi-comatose condition for two days before death.
		2	5-1-04			+	16	9	+	Clear and limpid.	Scanty.	None.	14-1-04	
10	Manga	*	26-12-03	♂	22	+	30	9	+	Slightly cloudy.	Increased.	A few.	4-1-04	Duration about five months. Marked absence of symptoms till ten days before death when sudden fit, followed by semi-comatose condition, great salivation, abolished reflexes, and erection of penis. Improved somewhat before death.
11	Kalenga ..	*1	26-12-03	♂	24	+ 1 in 2 covers.	18	45	+ 2 to cover.	Cloudy.	Scanty.	Many.	9-2-04	Marked sleep symptoms, no emaciation. Death due to sun exposure; temperature 107. Blood showed 100 trypanosomes to cover five hours before death.
		2	9-2-04			− 2 covers 1½ hours *P.-M.*	24	*P.-M.* 1½ hrs.	− 4 covers. 2 centrif.	Cloudy.	Much increased.	None.	..	
12	Maiadina ..	*1	29-12-03	♂	18	+ 2 to cover.	14	28	+ 36 to cover.	Cloudy.	Scanty.	Many.	..	Duration about four months. Had epileptic attacks, few sleep symptoms, simple-minded condition. Six days before death, tremors of limbs, opisthotonos and semi-coma. *P.-M.* Pneumonia and purulent meningitis.
		2	22-1-04			− 2 covers.	18	4	− 3 covers. 2 centrif.	Clear and limpid.	Scanty.	None.	26-1-04	
13	Kabali	1	29-12-03	♀	27	− 2 covers.	5	70	− 8 covers. 2 centrif.	Cloudy.	Increased.	A few.	..	Duration about five months. Progressive weakness, drowsiness, and emaciation from the first. No marked nervous symptoms. Bed-sores.
		2	20-2-04			+ 6 to cover.	32	17	− 5 covers. 2 centrif.	Clear.	Scanty.	A few.	..	
		3	7-3-04			− 2 covers.	15	1	− 5 covers. 2 centrif.	Clear.	Scanty.	None.	8-3-04	
14	Molumba ..	1	7-1-04	♂	32	− 2 covers.	14	..	− 5 covers. 2 centrif.	Cloudy.	Increased.	Many.	..	No marked symptoms, no drowsiness or dulness. Recurring attacks of dysentery.
		2	5-2-04			− 1 in 2 covers.	22	..	− 3 covers. 2 centrif.	Clear and limpid.	Scanty.	None.	..	
15	Kondolo ..	1	8-1-04	♂	32	− 2 covers.	20	80	− 5 covers. 3 centrif.	Clear and limpid.	Very scanty.	None.	..	Three months in hospital. Marked absence of symptoms except headache. Ten days before death headache severe. Suicide by drowning.
		2	14-3-04			− 2 covers.	22	14	− 2 covers. 2 centrif.	Clear and limpid.	Very scanty.	None.	28-3-04	
16	Ejoli	..	7-1-04	♂	28	− 2 covers.	8	19	− 3 covers. 3 centrif.	Clear.	Increased.	None.	..	Drowsiness. Great emaciation. Few symptoms. Conscious till hour of death.

TABLE I.—*Continued*

No.	Name		Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms drawn off	Days before death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Case, Prominence of Sleep or other Symptoms, etc., and Mode of Death
17	Oparanga ..	1	7-1-04	♂	18	− 2 covers.	16	62	− 3 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	Duration five or six months. Progressive weakness and emaciation from the beginning. Extreme emaciation at death. No dulness or marked symptom at any time, except drowsiness during January, but less subsequently. Could walk, and retained faculties till hour of death. Trypanosomes in blood scanty and seldom seen.
		2	27-1-04			+ 3 to cover.	20	42	− 7 covers. 3 centrif.	Clear and limp.	Scanty.	A few.	..	
		3	11-2-04			− 2 covers.	20	27	− 2 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	
		4	23-2-04			− 2 covers.	14	15	− 3 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	
		5	2-3-04			+ 48 to cover.	10	7	− 6 covers. 2 centrif.	Clear and limp.	Scanty.	None.	9-3-04	
18	Kimfuta ..	..	15-1-04	♀	9	+ 8 to cover.	16	5	+ many.	Clear and limp.	Very scanty.	None.	20-1-04	Duration about two months only. Rapid emaciation, weakness, tremors, and vacancy. Sleep symptoms only present towards the end.
19	Banja ..	*1	20-1-04	♂	26	+ 80 to cover.	8	..	+ many.	..	..	Much blood.	..	Was admitted January 5 from prison, chained to two other prisoners, and charged with cannibalism. Emaciation due to starvation. By end of February quite well and putting on flesh. At end of April started for England, arriving apparently in robust health. Now fat and well, and is employed in Johnston Laboratory, Liverpool.
		2	8-2-04			+ 100 to cover.	50	..	− 4 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	
		3	26-2-04			+ 32 to cover.	20	..	− 4 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	
20	Ieri ..	1	20-1-04	♂	11	+ 2 to cover.	20	19	+ 1 in 2 covers.	Clear and limp.	Very scanty.	None.	..	Duration about four months. Progressive weakening and wasting interrupted by periods of partial recovery. Somnolence marked towards the close. Appetite voracious to within three days of death. Marked retraction of head and opisthotonos for several days before death. *P.-M.*—No signs of purulent meningitis.
		2	27-1-04			+ 4 to cover.	10	12	+ 4 to cover.	Clear and limp.	Very scanty.	None.	..	
		*3	5-2-04			+ 150 to cover.	10	3	+ 40 to cover.	Cloudy.	Scanty.	Many.	..	
		*4	8-2-04			+ 250 to cover.	15	0	+ 1 in 2 covers.	Clear.	Scanty.	A few.	8-2-04	
21	Moidi ..	1	21-1-04	♀	24	− 2 covers.	6	16	− 3 covers. 2 centrif.	Clear.	Scanty.	A few.	..	Duration about three months. Drowsiness a marked symptom latterly. Very little wasting. Sensations much dulled. Lumbar puncture without cocaine.
		*2	25-1-04			+ 13 to cover.	35	12	+ 3 in 4 covers.	Clear.	Scanty.	A few.	..	
		*3	5-2-04			+ 100 to cover.	15	1	+ 20 to cover.	Slightly cloudy.	Scanty.	Many.	6-2-04	
22	Kapinga ..	..	23-1-04	♀	24	+ 1 in 2 covers.	20	12	+ 1 in 3 covers.	Slightly cloudy.	Much increased.	None.	4-2-04	No drowsiness at any time. Progressive weakness, vacancy, and emaciation.

TABLE I.—*Continued*

No.	Name		Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid							Remarks on Duration of Cases, Prominence of Sleep and other Symptoms, etc., and Mode of Death
							C.Cms drawn off	Days before Death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	
23	Patesa		3-2-04	♀	12	+ thousands, 15 to field.	10	0	– 6 covers. 2 centrif.	Clear.	Scanty.	A few.	3-2-04	Only four days under observation. Admitted for dysentery. Emaciation extreme. No drowsiness or vacancy. L.P. four hours before death. Spleen punctured at same time showed 80 trypanosomes to field.
24	Boyo		9-2-04	♂	19	– 2 covers.	32	0	– 3 covers. 2 centrif.	Slightly cloudy.	Increased.	None.	9-2-04	Duration three to four months. L.P. soon after convulsive seizure, with high temperature and unconsciousness, due to sun exposure. Six hours before puncture, finger blood showed 100 trypanosomes to the cover.
25	Benjamin		9-2-04	♂	28	+ 2 to cover.	13	1	+ 9 to cover.	Slightly cloudy.	Greatly increased. Early pus.	None.	10-2-04	Duration about three months. Progressive weakness and emaciation. Seldom drowsy. Tremors almost amounting to rigors before death, which was hastened by sun exposure. *P.M.*—Intense cerebral congestion.
26	Boyo Mitchel	1	11-2-04	♂	16	– 1 cover.	18	103	+ 3 to cover.	Cloudy.	Increased.	Many.	..	Duration about five months. Drowsiness very marked. Extreme emaciation during last month on voyage to England. Died on the way to Liverpool.
		2	27-2-04			– 2 covers.	16	99	– 4 covers. 2 centrif.	Clear.	Increased.	None.	..	
		3	31-3-04			– 2 covers.	25	54	+ 1 in 2nd centrif.	Slightly cloudy.	Increased.	Many.	..	
		4	23-5-04			+ 5 to cover.	35	1	+ 1 in 5 covers.	Clear and limp.	Scanty.	None.	24-5-04	
		5	24-5-04			– 1 cover.	30	*P.-M.*	–	Cloudy.	Increased.	None.	..	
27	Kabongo		13-2-04	♂	35	+ 4 to cover.	4	..	– 4 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	Very few symptoms. No drowsiness. Still under observation. On March 21, hydrocele fluid negative, three covers examined; blood positive, 12 to cover.
28	Kikoffi	1	20-2-04	♂	19	+ 10 to cover.	30	..	+ 60 to cover.	Slightly cloudy.	Much increased.	None.	..	Still under observation. Nervous tremors and exaggerated reflexes on admission, but improved subsequently.
		2	25-3-04			– 2 covers.	26	..	+ 1 in 1 cover.	Clear and limp.	Scanty.	None.	..	
29	Yaiyai	1	24-2-04	♀	20	– 2 covers.	42	9	– 3 covers. 2 centrif.	Slightly cloudy.	Increased.	A few.	..	Duration two months only. Rapid progressive weakness and wasting. Symptoms of drowsiness not marked. Extensive bed-sores. Conscious till hour of death.
		2	28-2-04			– 4 covers.	10	7	+ 1 in 3 covers.	Clear.	Increased.	None.	..	
		3	4-3-04			– 2 covers.	15	0	– 4 covers.	Clear and limp.	Scanty.	None.	4-3-04	

TABLE I.—*Continued*

No.	Name	Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms drawn off	Days before Death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Cases, Prominence of Sleep and other Symptoms, etc., and Mode of Death
30	Plekai	26-2-04	♂	27	− 1 cover.	22	9	− 5 covers.	Clear and limp.	Scanty.	None.	4-3-04	Admitted February 2 for dysentery. No drowsiness. Great emaciation.
31	Bugwendi	2-3-04	♂	16	+ 48 to cover.	25	19	− 5 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	Duration about three months. Irritable, hysterical, and troublesome. March 16, wasting and incoordination of movements. March 20, suddenly drank his urine from pot. Then developed incoherent jabber, spasmodic contraction of arms, with athetosic movements of fingers, and picking at blanket. *P.-M.*—Lymph round cord, ventricles of brain distended, etc.
		21-3-04			− 2 covers.	15	0	− 3 covers. 2 centrif.	Slightly cloudy. Straw colour.	Scanty.	Many.	21-3-04	
32	Belambo .. 1	27-2-04	♂	26	− 4 covers.	24	46	+ 1 to 4 covers.	Cloudy.	Greatly increased.	Many.	..	Duration about three months. Drowsiness at no time very marked, but nervous symptoms, tremors, and increased reflexes from day of admission. On March 19 developed spasmodic flexion of arms with convulsive movements of face and many muscles of body. No wasting. Appetite good, and conscious till hour of death. Reflexes nearly absent at death.
	2	9-3-04			..	18	35	+ 1 in 4 covers.	Clear.	Increased.	None.	..	
	3	30-3-04			− 2 covers.	20	14	+ 80 to cover.	Cloudy.	Increased.	Many.	..	
	4	13-4-04			− 2 covers.	40	0	+ 1 in 6 covers.	Clear and limp.	Scanty.	None.	13-4-04	
33	Litali	29-2-04	♂	26	− 5 covers.	18	2	+ 3 to cover.	Slightly cloudy.	Greatly increased.	None.	2-3-04	Admitted to hospital as a jabbering lunatic. Not suspected of sleeping sickness. Under observation for two months. Trypanosomes never found in blood. Slept a good deal latterly.
34	Mozao 1	11-3-04	♂	16	+ 3 to cover.	18	7	− 5 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	No very marked symptoms, but extreme emaciation.
	2	18-3-04			− 2 covers.	4	0	− 3 covers.	Clear.	Increased.	None.	18-3-04	
35	Batanga	14-3-04	♂	27	− 2 covers.	24	24	+ 2 to cover.	Clear.	Slightly increased.	None.	7-4-04	Duration about three months. Marked sleep symptoms. Epileptic attack March 17. At L.P. pressure of fluid considerable. Improvement in symptoms after puncture.
36	Bandela .. 1	16-3-04	♂	10	− 2 covers.	22	30	− 4 covers. 2 centrif.	Clear.	Increased.	None.	16-4-04	Duration five months. March 12, had appearance of bloated cretin, with marked sleep symptoms, which disappeared for several days after L.P. Salivation, no wasting. *P.-M.*—Large quantity ventricular and subarachnoid fluid.
	2	16-4-04			− 1 cover from heart.	50	*P.-M.*	− 3 covers. 8 hours' *P.-M.*	Cloudy.	Much increased.	None.	..	

TABLE I.—*Continued*

No.	Name	Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms drawn off	Days before Death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Cases, Prominence of Sleep and other Symptoms, etc., and Mode of Death
37	Mengo..	10-3-04	♂	24	− 2 covers.	26	..	− 6 covers. 2 centrif.	Clear.	Scanty.	A few.	..	Admitted March 2 with very marked nervous symptoms; childish and irritable. One flick with finger on patella caused uncontrollable clonic movements of legs, and a light tap caused violent extension of whole body and legs, so powerful as to throw him off a chair yet able to walk about and do light work. Observations up to April 29, 1904. * Refers to hydrocele fluid only.
	Hydrocele fluid	10-3-04			− 2 covers.	..	..	+ 14 to cover.	Cloudy.	Large quantity.	None.	*	
	" "	25-3-04			− 2 covers.	..	..	+ 2 in half deposit.	Cloudy.	Large quantity.	None.	*	
38	Tumba .. 1	26-3-04	♂	21	− 2 covers.	35	4	+ 20 to cover.	Slightly cloudy.	Scanty.	Many.	..	Duration about three months. Marked dulness and sleep symptoms. March 22, developed tremors and flexions of arms, which increased after L.P. on 26th. Conscious up to time of death.
	2	30-3-04			− 2 covers.	34	0	− 4 covers. 2 centrif.	Clear and limp.	Scanty.	None.	30-3-04	
39	Molar	26-3-04	♂	14	− 2 covers.	15	..	+ 2 covers.	Clear.	Scanty.	A few.	..	Mission boy, only under observation for a few days.
40	Mokindi	2-4-04	♂	18	+ 4 to cover.	20	..	− 5 covers. 2 centrif.	Clear and limp.	Very scanty.	None.	..	An early case. Did not admit that he was sick. Marked dulness, but no sleep. Distension of belly.
41	Nakunyi	4-4-04	♂	17	+ 16 to cover.	18	4	− 4 covers. 2 centrif.	Clear and limp.	Very scanty	None.	8-4-04	Admitted a month before death for dysentery. Great emaciation and weakness, otherwise few symptoms, and none of sleep.
42	Pania	6-4-04	♂	18	+ 4 to cover.	18	..	− 5 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	An early case. Few marked symptoms and none of sleep.
43	Kitambala	7-4-04	♂	13	− 4 covers.	18	..	− 4 covers.	Clear and limp.	Scanty.	None.	..	An early case. Marked dulness, but no sleep.
44	Katambue	14-4-04	♂	24	− 2 covers.	26	..	+ 300 to cover.	Slightly cloudy.	Increased.	A few.	..	An advanced case. Only under observation for one day. Was doing duty up to February 27, 1904.
45	Kabela	14-4-04	♂	26	− 2 covers.	20	..	* + 16 to cover.	Slightly cloudy.	Scanty.	A few.	..	An advanced case. Only under observation for one day. Was doing duty up to February 17, 1904.
46	Ekongo	18-4-04	♂	21	− 2 covers.	22	..	+ 6 to cover.	Slightly cloudy.	Increased.	A few.	..	Advanced case seen on the march, and punctured under difficulties in the grass.
47	Mbeka..	18-4-04	♂	19	+ 2 to cover.	20	..	− 4 covers. 2 centrif.	Clear and limp.	Scanty.	None.	..	An early case, with no symptoms.

TABLE I.—*Continued*

No.	Name	Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms. drawn off	Days before death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Cases, Prominence of Sleep, or other Symptoms, etc., and Mode of Death
48	Kitambue	23-5-04	♂	24	+ 4 to cover.	18	17	+ 1 in 4 covers.	Slightly cloudy.	Much increased.	None.	9-6-04	Admitted to hospital beginning of March. Started for England April 29. Weakness increased during voyage and sleep a marked symptom. Admitted Royal Infirmary, Liverpool, May 24. Slept almost continuously before death.
49	Tomi	23-5-04	♂	17	+ 5 to cover.	4	25	− 3 covers. 2 centrif.	Clear and limp.	Slightly increased.	None.	..	Boy from Kinshassa Mission, Leopoldville. Duration of case about five months. No sleep symptoms. Progressive wasting and weakness.
		15-6-04			+	30	1	+ many. 5 to field.	Clear.	Increased.	None.	17-6-04	
		17-6-04			+	45	*P.-M.*	− 2 covers.	Slightly cloudy.	Much increased.	None.	..	
50	Nbela	9-10-03	♂	24	..	35	23	+ many.	Slightly cloudy.	Much increased.	None.	1-11-04	An advanced case seen at Boma. Marked somnolence. Admitted August 1.
51	John Paka	26-10-03	♂	28	+ 2 to cover.	10	..	− 6 covers.	Clear and limpid.	Very scanty.	A few.	..	An early case. A Sierre Leone boy seen at Boma. No symptoms and no complaint.
52	Louis	16-10-03	♂	16	+ 11 to cover.	15	..	+	Slightly cloudy.	Increased.	A few.	Died.	An advanced case in hospital at Boma.
53	Somi	13-10-03	♀	22	+ 6 to cover.	20	..	+ many.	Slightly cloudy.	Increased.	None.	Died.	An advanced case seen in hospital at Boma.
54	Bulumbu	29-10-03	♀	16	− 1 cover.	10	..	+	..	..	..	Died.	An advanced case seen at Boma.

TABLE II.—DOUBTFUL CASES NOT PROVED TO BE SLEEPING SICKNESS

No.	Name	Date	Sex	Age	Trypanosomes in Finger Blood	Cerebro-Spinal Fluid: C.Cms. drawn off	Days before death	Trypanosomes	Clear or Cloudy	White Cells	Red Cells	Date of Death	Remarks on Duration of Case, Prominence of Sleep, or other Symptoms, etc., and Mode of Death
1	Mwandu	22-12-03	♂	21	– 2 covers.	20	8	– 6 covers.	Clear.	Scanty.	A few.	31-12-03	Apparently a case of miliary tubercle. No symptoms of sleeping sickness.
2	Lembi	24-12-03	♂	23	–	5	9	– 5 covers.	Clear.	Scanty.	A few.	2-1-04	Probably a sleeping sickness case. Extreme emaciation.
3	Salabantu	30-12-03	♂	19	–	15	..	– 4 covers.	Clear and limpid.	Scanty.	None.	..	Discharged as fit. No symptoms of sleeping sickness.
4	Saoka	7-1-04	♂	17	–	10	..	– 3 covers. 2 centrif.	Clear and limpid.	Very scanty.	None.	..	A doubtful case, with symptoms of dulness and childishness, admitted December 26 and discharged as fit March 23, 1904.
5	Luisi	10-1-04	♀	24	–	14	0	– 5 covers.	Clear and limpid.	Scanty.	None.	10-1-04	A doubtful case, with marked emaciation and some sleep symptoms.
6	Kanyinki	22-1-04	♂	24	–	18	33	– 3 covers. 3 centrif.	Clear and limpid.	Scanty.	None.	25-2-04	A doubtful case, admitted for severe dysentery. Extreme emaciation but no dulness or drowsiness.
7	Sungula	5-2-04	♂	30	–	40	0	– 4 covers. 2 centrif.	Milky.	Large deposit of pus.	None.	5-2-04	Doubtful history of sleeping sickness; no emaciation. Retraction of head and convulsive movements of arms. Died a few hours after admission. *P.-M.*—Purulent meningitis and ethmoidal sinuses full of pus.
8	Fatiala	8-2-04	♀	20	– 2 covers.	22	4	– 3 covers. 2 centrif.	Clear.	Increased.	A few.	12-2-04	A septic case, with large collection of pus in arm when admitted.
9	Pongoe	10-2-04	♂	24	– 3 covers.	15	0	– 1 cover.	Greenish-yellow cloudy fluid.	Pus.	None.	10-2-04	Semi-comatose when admitted. Somewhat similar case to No. 8. Excessive continuous rigors, and pus oozing from nostrils. Violent spasmodic contraction of limbs.
10	Kabinda	27-2-04	♂	18	– 1 cover.	25	..	– 2 covers. 2 centrif.	Clear and limpid.	Very scanty, almost none.	None.	..	Only in hospital half-an-hour asking for treatment for craw-craw.

In studying the column in Table I, in which is enumerated the number of days intervening between the puncture and the date of death, it will be seen that the probability of trypanosomes being found in the cerebro-spinal fluid tends to increase as one nears the fatal termination. This is shown by the following two Tables compiled from the forty-nine cases under analysis.

Table III

Thirty-five cases known to have proved fatal at the date of compilation of Table I

Days before Death	Number of Punctures	Trypanosomes present	Trypanosomes absent
Within ten days	27	14	13
Between ten and thirty	19	8	11
Between thirty and one hundred and ten ...	11	4	7
Totals	57	26	31

Table IV

Fourteen cases not known to be fatal at the time of compilation of Table I

Days before Death	No. of Punctures	Trypanosomes present	Trypanosomes absent
The majority are comparatively early cases, and presumably many days from death	17	6	11

A larger series of lumbar punctures in the earlier stages would be of the greatest interest.

In the Congo disease, as we have seen it, mainly at Leopoldville, there is an endless variety of types. In most cases sleep is absent, in some dulness and apathy are prominent, in others nervous symptoms and mania are conspicuous, while a proportion of cases have only progressive emaciation and fever. In classifying these symptoms it does not seem possible to definitely connect them with the appearance or non-appearance of trypanosomes in the cerebro-spinal fluid.

Cases 8 and 17, each of them punctured several times with negative results, except in one instance, were conspicuous for general absence of all symptoms except fever and emaciation. They each were able to walk and retain their faculties up to the time of death. Case 13 is in many respects similar to the foregoing two, but developed increased drowsiness some time before death, although showing no parasites in the cerebro-spinal fluid.

On the other hand we have Cases 20, 26, and 32 all showing trypanosomes repeatedly in the cerebro-spinal fluid, and all conspicuous for sleep or other head symptoms, more marked in the later days.

Examples of long-continued mild mania are not infrequent, of which class Case 33 is a good example. This man's blood was examined on many occasions, but no trypanosomes were found until the lumbar puncture revealed them in his cerebro-spinal fluid.

On the whole one cannot say more than that the presence of the parasites in the cerebro-spinal fluid apparently tends to increase the gravity of the case, and predisposes to the more severe head symptoms and other complications likely to bring about a fatal termination. Only in such cases as 8 and 17 do I think the parasite can be said to be solely accountable for the death. In the vast majority of cases death is the result of complications, mainly bacterial.

As in the blood, where the appearance of a large number of parasites is frequently coincident with an unusually high rise of temperature, if the patient is not too far advanced in the disease to be irresponsive, so also the rare discovery of large numbers of parasites in the cerebro-spinal fluid is, I have found in several instances, coincident with an unusual rise in the temperature curve. This no doubt accounts for the occasional unexplained rises of temperature and aggravation of symptoms occurring where few or no parasites can be found in the circulation. An access of temperature is probably in these cases always coincident with the collection or the development of a crop of parasites in one or other of the organs or fluids of the body.

All cases punctured, whether with or without parasites in the cerebro-spinal fluid, had well-marked fever, characterized by an afternoon rise and a morning fall to near the normal, showing that no connexion can be traced between the commencement of the fever and the entry of the parasites into the cerebro-spinal fluid from the blood. Some of the cases in Table I died without ever having trypanosomes in their cerebro-spinal fluid, but showed nevertheless the characteristic temperature curve.

It would appear from Cases 26, 28, and 38, that just as in the blood, the parasites may come and go in the cerebro-spinal fluid irrespective of their presence or absence elsewhere in the system.

Case 23 shows that they may be in enormous numbers in the blood without appearing in the cerebro-spinal fluid, where, however, they do occur occasionally in large numbers as is seen in Cases 28, 38, 44, and 49, but in this fluid they are most frequently very scanty.

The amount of fluid drawn off is no indication of the total amount present. Occasionally the pressure is considerable, and in these cases very marked temporary benefit is often derived from the puncture.

Cerebro-spinal fluid with no admixture of blood or increase of white cells is as clear and limpid as distilled water. According to the amount of mixture with red or white cells, or both, I have here described it as clear, slightly cloudy, or cloudy. If with blood only the cloudiness has a pink tinge, but if with white cells only it has no pink tinge. It is invariably clouded almost immediately after death by excess of white cells. The colour and extent of the cloudiness is best gauged by looking down and not through the centrifuge tube.

The fluid, as soon as drawn, should be centrifugalized gently for fully five minutes. It can then be poured off to the last drop into another tube, leaving only the resulting small deposit, which can then be picked up with a fine pipette, placed on a slide and systematically examined under a coverglass well ringed with vaseline, with a one-eighth or one-sixth objective, and a No. 4 eyepiece. If centrifugalized violently for a length of time the activity of the trypanosomes may be much decreased, and, consequently, the labour of searching for them more difficult, and if there is much deposit they may even be mutilated by the pressure of the cells. I have found it far better to centrifugalize the fluid a second time after the deposit from the first centrifugalization has been examined, for, owing to degeneration changes, which commence in the cells almost as soon as the fluid is drawn, it is best to examine it and fix some films without delay. It is imperative that the fluid should be centrifugalized a second or even a third time if possible, for, on two occasions at least, I have found trypanosomes in the second deposit and not in the first. If there is no deposit in the tube the lowest fluid should be pipetted without pouring off, for the parasites are easily poured away with the fluid.

With regard to the white cell elements, I have described them as very scanty, scanty, increased, and much increased, and I have assumed that very scanty is the normal condition. The difference between these various degrees is difficult to make out, and is apt to depend upon the amount of fluid allowed to remain with the deposit.

TABLE V

L.P.	Very Scanty	Scanty	Increased	Much Increased	Totals
Tryps. present	3	10	11	7	31
Tryps. absent	7	25	10	1	43
Total ...	10	35	21	8	74

The majority of the punctures come under the headings of scanty or increased, viz., forty-six per cent. under the former, and twenty-six per cent. under the latter, leaving about thirteen per cent. for both very scanty and much increased.

One might conjecture that where the cellular elements are increased the examination would be positive for parasites, but the following table shows that this is not so evident as might be expected.

Case 32 shows that, although a large number of parasites were found at each puncture, there was an apparent decrease of cells in the fluid. In Case 17, no parasites were ever found in the cerebro-spinal fluid, and the cells were invariably scanty; and in the ten cases not proved to be sleeping sickness it will be seen that the cell elements of the fluid are almost invariably scanty. In the majority of the early Cases, 19, 39, 40, 42, 43, 47, 51, whether positive or negative, the cells are scanty or very scanty.

In Case 28 the cells seem to have disappeared from the fluid in much the same proportion as the parasites. In Cases 44 and 49 a very large number of parasites was accompanied only by a comparatively small increase of cells.

For those who are not familiar with the operation of lumbar puncture, I will describe the method I have found best.

The patient is placed on his right side, on a table if possible, with his knees drawn up to his face. After thoroughly cleansing his back with soap and water and again with alcohol or ether, cocaine is injected, with a short strong needle if the patient is a black man, both subcutaneously and deep into the muscles over the interspace above the last lumbar vertebra. This interspace is on a straight line drawn between the two iliac crests, and the needle should be passed half an inch to the left of the middle line, not midway between the two interspinous processes, but slightly nearer to the upper one. The next lower space between the sacrum and the last lumbar vertebra can be selected if for any reason it is desirable, but owing to the flattening of the canal in this situation the operation is not quite so easy to perform without drawing blood.

After waiting a few minutes the knees are adjusted so as to be exactly opposite each other, and while the assistant secures the position of extreme flexion, the tips of the fingers of the left hand are placed firmly upon the left iliac crest, leaving the thumb to indicate not only the interspace but the exact spot and direction as well.

The puncture needle is then passed through the skin, the precise direction again gauged, and the needle then passed on slightly upwards and towards the middle line, or downwards and to the right, with reference to the table. If the spot and direction have been well chosen, no bone is encountered, the passage of the needle point into the canal can easily be felt, and the clear fluid at once appears drop by drop. The syringe is then adjusted, and sufficient for examination is slowly drawn off. With a little practice and a docile patient no operation is easier, and I have performed it on the floor in native huts, in the open bush, in my tent, and in a canoe. Having learnt the exact spot and direction, the only difficulty is to gauge the depth to which the needle should be passed, for if the point is allowed to prick the cord or the membranes opposite, blood immediately appears and the results of the operation are valueless for statistical purposes.

With regard to anaesthetics, cocaine is the best. Cases of excitement or mania necessitate chloroform, but it is inadvisable to give chloroform if it can be avoided, for, in two cases, the struggle and subsequent exhaustion have I believe hastened a fatal issue.

The needle selected should be as fine as possible, consistent with sufficient strength to withstand the grip of the powerful back muscles, if in the early stages of the disease the patient is restless or insufficiently cocainised. In length it should be from two to three inches. It is important that the diagonal surface at the point should be as short as possible, and the actual point not too sharp. In no case should the syringe be used as a handle for the needle, but into the base of the needle should be screwed a metal handle, which, when the needle has been passed into position, can be substituted for a glass 10 c.c. serum syringe with a short rubber connexion. The careful sterilization of all instruments is of course necessary. Although the skin may be cleansed as thoroughly as possible, it cannot be sterilized, but, in my cases, no introduction of septic matter has resulted from the operation. It would, however, probably be wisest, after the cocaine has been injected, to cauterize the site of the puncture with some small cautery made for the purpose.

In the cases of septic meningitis, pus is frequently found in the ethmoidal or other sinuses, and the infection cannot be traced to the lumbar puncture. In Cases 7 and 9, in Table II, and others in Table I, symptoms of meningitis were apparent before the puncture was made, and in other cases death occurred from the same cause without lumbar puncture. The discovery of purulent lymph round the cord in Case 31 might possibly point to infection introduced with the needle, but in this case the symptoms did not commence till a fortnight after the puncture.

These notes are the outcome solely of work done in connexion with the Congo disease.

The duration of the cases in Tables I and II is gauged chiefly by the date of the commencement of symptoms, that is in many cases the date at which the patient finds himself unable to work, the actual duration probably being much longer. The disease can frequently be diagnosed by the intimate friends or fellow workmen of the patient long before he himself realizes it.

The total number of cases here recorded is too few to permit of any very definite statements, but I think it is sufficient to allow of the following provisional conclusions.

1. That in many cases the trypanosomes never find their way into the cerebro-spinal fluid, and in those cases in which they do they are more likely to be found towards the termination of the disease.

2. That the commencement of the fever or other symptoms is in no way co-related to the entrance of the parasites to the cerebro-spinal fluid.

3. That a large number of trypanosomes in the cerebro-spinal fluid is rare, but when it does occur there is usually an access of temperature.

4. That the parasites may come and go in the cerebro-spinal fluid as in the blood.

5. That enormous numbers may appear in the blood without appearing in the cerebro-spinal fluid, and, to some extent, *vice versâ*.

6. That when trypanosomes are present in the cerebro-spinal fluid its white cell elements are apt to be increased.

7. That in cases where the parasites gain access to the cerebro-spinal fluid early in the disease, mania and other head symptoms are more likely to be prominent.

A description of the various developmental forms of trypanosomes to be found in sleeping sickness cases in the cerebro-spinal fluid ; of the various cells of the fluid, in particular a peculiar large mulberry-shaped cell ; of its chemistry ; of certain large organisms with actively dancing particles, met with occasionally ; of the occurrence of nematode larvae and ova resembling those of *Ankylostoma duodenale* in connexion with the fluid in many cases, and of other matters of interest, must be left for a future publication.

A COMPARISON OF THE ANIMAL REACTIONS OF THE TRYPANOSOMES OF UGANDA AND CONGO FREE STATE SLEEPING SICKNESS WITH THOSE OF TRYPANOSOMA GAMBIENSE

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A PRELIMINARY REPORT[1]

BY

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THE strains we have used in our work are as follows:—Three strains of *Trypanosoma gambiense* from Gambia. (See below). Two strains from Uganda: (1) from the cerebro-spinal fluid of a case of sleeping-sickness; and (2) from the blood of a case of trypanosome fever. We take this opportunity of thanking Colonel D. Bruce, R.A.M.C., F.R.S., to whom we are indebted for these two strains. Four strains from the Congo Free State: (1)[2] from the cerebro-spinal fluid of a case of sleeping sickness; (2)[2] from the blood of a case of trypanosome fever; and (3) and (4) from the blood of two natives at present under observation in Liverpool.

Trypanosoma gambiense (Dutton).—Three strains of *Trypanosoma gambiense* were brought home by Dr. J. E. Dutton and Dr. J. L. Todd, from their Senegambia expedition[3]; of these three, which are called 'Gunjur,' 'Lammin,' and 'Q' strains, we have worked almost entirely with the 'Gunjur' strain, which was derived from the boy at Gunjur, case 4.[4] Since that time the strain has been passed through a great number of animals under varying conditions; the direct strain is that passed from rat to rat, to ascertain whether increased virulence or attenuation of the trypanosomes could be produced. It is not our purpose to present here the results, but

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1. In the forthcoming Thompson Yates and Johnston Laboratories Reports a fuller report will be published, together with serum and agglutination experiments, and the results of therapeutic experiments.

2. Sent to us by our expedition to the Congo Free State.

3. J. E. Dutton and J. L. Todd, *First Report of the Trypanosomiasis Expedition to Senegambia* (1902), Liverpool School of Tropical Medicine. Memoir XI.

4. *Ibid.*

we believe that a definite increase of virulence, as well as an attenuation, can be achieved, the former by the passing of the trypanosomes through a large series of animals of the same species, and the latter by constantly changing the species of animal employed.

Rats.—Young rats, thirty experiments, shortest incubation two days, longest thirty-five, average from four-and-a-half to seven-and-a-half days. Usual duration from twenty to forty-one days. Some have survived one hundred and thirty-two days. Adult rats, thirty-three experiments, incubation from four to forty-seven days, average eight-and-a-half days. Duration from forty-five to three hundred and eighty-eight days. Some rats inoculated in Senegambia in November, 1902, still survive, but their blood is negative microscopically, and non-infective. The parasites are present in the blood of both young and adult rats in fair quantities, though in many of the animals they are not constantly present, being at one time numerous in the blood, and a few days later absent altogether, or only demonstrated after a most careful search.

Mice.—Twenty-five experiments. Incubation period from one to thirty-seven days; average from four to seven days. Usual duration from eleven to fourteen days. In some cases the parasites have been very numerous, and continually present in the blood, but very often the animal shows only a few parasites, or there may be a marked irregularity as to the appearance and disappearance of the organism.

Guinea-pigs.—Ten experiments. Three guinea-pigs have become infected after twelve, fifty-three, and seventy-three days, respectively, and have lived three, four, and eight months. One, Experiment 114,[1] inoculated May 13 and positive twelve days later, never showed parasites again in its peripheral blood until September 11. On November 1 thirty to a field[2] were observed. The trypanosomes continued to increase in numbers, and on December 3 reached eighty to one hundred to a field. On December 20 the numbers decreased and death ensued on January 4. A guinea-pig, Experiment 133,[3] inoculated on July 20 from a rat, was positive on September 11, parasites became very numerous on November 1 (twenty to field), and continued so to the end on November 20. Rupture of the spleen was the cause of death. Four guinea-pigs, inoculated one hundred and twenty-four days ago with large quantities of blood containing numerous trypanosomes, have remained negative up to the present time, despite re-inoculations. Their controls—*i.e.*, rats and rabbits—became infected in the usual time. Three guinea-pigs, inoculated on March 7 from rat 279A with large doses of blood containing countless trypanosomes, showed parasites in their blood in twelve hours in two cases, and in three days in the other. The

1. J. E. Dutton and J. L. Todd, *First Report of the Trypanosomiasis Expedition to Senegambia* (1902), Liverpool School of Tropical Medicine. Memoir XI.

2. We have, throughout, used three-quarter inch square cover-slips, and examined with one-sixth inch objective, and No. II eye piece.

3. Dutton and Todd, *loc. cit.*

parasites were seen in their blood for a few days (about twenty-four to a cover). Since March 20 these animals have been negative.

Rabbits.—Incubation period from five to fifteen days ; average from seven to nine days. Duration from fifty to one hundred and twenty-eight days. In some cases the organisms have been fairly constant in the peripheral blood, in others they appear and disappear at irregular intervals, and the numbers vary from a few to twenty to a field. In these animals loss of weight and diminution of red cells and haemoglobin are constant features of the disease. In only one rabbit, which lived one hundred and twenty-eight days, have we noticed a purulent discharge from the nose, eyes, etc., with loss of hair, and then only in the last six weeks of its existence.

Cats.—Two experiments, both inoculated intravenously. Experiment 422, inoculated March 12 from a mouse. Trypanosomes were observed on March 19. Parasites were constantly present, the numbers usually being small. The temperature rose on March 20 to 104·4° F. and on the 22nd to 104·6°. Some loss of weight and anaemia have been observed. Experiment 447, inoculated March 22 from a rat ; positive on March 26. Parasites were constantly present and in fair numbers—often one to each field. No rise of temperature was observed.

Puppies (from three to seven months).—Three experiments. Incubation periods, five days after intravenous and ten days after intraperitoneal and subcutaneous inoculation. Duration from thirty-three to forty-three days. In two cases the parasites were to be found almost constantly and in fair numbers which increased in the later stages of the disease ; before death the blood became negative again. In the remaining experiment trypanosomes were only to be found at intervals and in small numbers. Loss of weight occurred in all three, and in two cases there was a marked diminution in the number of red corpuscles with a corresponding decrease in the percentage of haemoglobin. Subnormal temperature was recorded in one case before death.

Goat.—Small female, Experiment 518. Inoculated intraperitoneally on April 14 from a rat showing numerous trypanosomes. Strain 'Lammin.' Parasites appeared in the blood on April 21, but have not been found since. No rise of temperature nor other symptoms have yet been observed.

Donkey.—Inoculated subcutaneously on February 23 from a rat. Positive on March 9. Parasites were found on rare occasions, and then only in very small numbers. There was no definite rise of temperature. Some diminution in the percentage of haemoglobin and the number of red cells has been observed.

Monkeys.—Macacus rhesus, Experiment 311. This monkey had been infected by Dr. H. E. ANNETT with blood from the European Case H. K.[1] Parasites were found only at intervals and in small numbers, though the animal appeared to be very

1. H. E. Annett, *First Report of the Trypanosomiasis Expedition to Senegambia*, 1902, Liverpool School of Tropical Medicine, Memoir XI, p. 4.

ill and emaciated ; at the end of nine months it had quite recovered. In January, 1904, rats inoculated from it during the preceding four months not having become infected we decided to attempt to reinfect the animal. On January 29, thirteen months after its original infection, it was inoculated with blood from a rabbit ('Gunjur' strain). On February 6 parasites were found in the blood ; they were almost always present, though not in great numbers, up to March 24, from which date until death, on April 3, the blood remained negative. Very marked oedema of both upper and lower eyelids, intraorbital space, and eyebrows occurred on March 27 ; this persisted for three days ; no parasites were to be found in the oedema fluid. No other symptoms other than loss of weight and anaemia were observed.

Macacus rhesus, Experiment 517. Inoculated intraperitoneally on April 14 from a rat showing numerous trypanosomes. Strain 'Lammin.' Parasites appeared in the blood on April 16. Death occurred on April 18 from purulent and haemorrhagic peritonitis caused by a parasite found in the intestinal walls and not yet identified.

A chimpanzee, Experiment 134,[1] inoculated by Dutton and Todd in July, 1903. Parasites were rarely seen in the blood, and only in small numbers. After the third week in September trypanosomes were found only once in the blood, on January 27, when one was seen. On this date the temperature rose from its usual level of between 99° and 100° to 103·6° F., falling again next day. Parasites were not seen again before death, which occurred from broncho-pneumonia on February 10.

Sub-inoculations.—Two mice and a rat inoculated on November 20 did not become infected. Of the two mice and a rat inoculated on November 27 the mice did not become infected, while the rat was positive once, January 7, when one trypanosome was found in its blood. Two mice and a rat inoculated with large doses of heart blood immedately after death never became infected.

Symptoms.—There were occasional rises of temperature to 102° to 103° F. with no apparent cause. One of these occasions (November 27) one trypanosome was found in the blood. There were temporary loss of weight and appetite and falling off in condition towards the end of December, 1903. The animal subsequently improved and regained appetite. A blood count in July, 1903, showed haemoglobin 85 per cent. and red cells 8,360,000 per cubic millimetre. One made on February 6, 1904, showed haemoglobin 60 per cent. and red cells 4,540,000 per cubic millimetre.

Horse.—Experiment 87. The small bay stallion[2] inoculated in West Africa by Dutton and Todd in February, 1903, and brought to England in July, 1903, is alive and in good condition, and seems to have recovered. Trypanosomes have not been seen in its blood since it was brought to England. Two rats inoculated from it at the end of July became infected. Rats and mice inoculated on October 2 and

1. Dutton and Todd, *loc. cit.*

2. Dutton and Todd, *loc. cit.*

November 6 have not become infected; and one large rat and two small ones inoculated on April 22 have not, so far, become infected. On October 9, 1903, the weight of the horse was 513 pounds. On April 26, 1904, it was 506 pounds. The animal shows no symptoms, its temperature is regular (from 99° to 101° F.), and its appetite is good. There is no oedema, and its coat is in good condition.

Strain Derived from Cerebro-spinal Fluid of Uganda Cases of Sleeping Sickness[1]

Rats.—1. Young rats: Twelve experiments. Incubation period from four to thirteen days; average length, nine days. Parasites were fairly constantly present, but usually rather in small numbers. Duration from fourteen to forty-one days. 2. Adult rats: Twelve experiments. Incubation period from four to twenty days; average length, thirteen days. Parasites were fairly constantly present in small numbers in the early stages of infection, later they became rare. Duration from sixteen to one hundred and forty-nine days.

Mice.—Incubation period from five to six days. Parasites were rarely present in the blood after the first appearance. Duration was from nineteen to forty-seven days.

Guinea-pigs.—Four experiments. None yet infected. Five weeks have elapsed since inoculation. Sub-inoculations into mice and rats so far have been unsuccessful. No symptoms have yet been observed.

Rabbits.—Incubation period from seven to nine days. Parasites are constantly present, tending to become more numerous as the disease advances. Marked and fairly rapid loss of weight is observed. The rabbits are still living. Anaemia is a noticeable symptom.

Cats.—One experiment. A large grey cat was inoculated intravenously from a rat. Incubation was six days. The temperature rose on the evening of the sixth day to 105° F.

Dogs.—One experiment. Inoculated intravenously from a rat showing fairly numerous parasites. Trypanosomes appeared in the blood on the seventh day. The temperature has remained normal. The animal has, so far, shown no symptoms.

Puppy.—One experiment. Age four-and-a-half months. Inoculated on March 20 from a rat. Trypanosomes appeared in the blood on March 27 and have since been constantly present, although not more numerous than from two to five to a field. The temperature has varied between 101° and 103° F. There was no rise with the appearance of parasites in the blood. Diminution in haemoglobin and red cells has been observed. The animal has lost strength considerably.

1. This was sent to us in a rat which had been inoculated from a monkey infected from the cerebro-spinal fluid of a case of sleeping sickness; it was, therefore, only in its second passage.

Goat.—One experiment, a female. Incubation period, nine days. Parasites were fairly constant in the blood during the first week of infection, but afterwards were found only rarely. There was no rise of temperature with the appearance of parasites in the blood, but five days later, when eight trypanosomes were seen to the cover, the temperature rose to 104° F. No other symptoms have as yet been observed.

Donkey.—Inoculated on March 28 subcutaneously from a rat. On April 7 the temperature rose to 102·7° F., and on the 9th to 103·2°. A rat inoculated from the donkey on April 8 showed parasites on the 26th. The incubation period in the donkey was therefore ten days. Parasites were seen for the first time in its blood on April 18, and again on the 22nd.

Monkeys.—1. *Cercopithecus callitrichus.* Inoculated intraperitoneally on April 2 from a rat. Trypanosomes appeared in the blood on the 6th, and were constantly present for a week, when they became rare, occasionally being absent altogether. On the 7th the temperature rose to 105·5° F., and has since been irregular (with occasional rises to 104° to 105°, and over). No other symptoms have so far been observed, the appetite is preserved, and the animal is in good condition. 2. *Cercopithecus callitrichus.* Inoculated intraperitoneally on March 6 from a rat showing very few parasites. Trypanosomes did not appear in the blood before death, which took place from dysentery on the 10th. A monkey (*Macacus rhesus*), a rabbit, and one out of four rats inoculated with large doses of its heart blood became infected. Two guinea-pigs inoculated at the same time are still negative. Two mice inoculated with its blood died without becoming infected. 3. *Macacus rhesus.* Inoculated on March 10 intraperitoneally and subcutaneously with the heart blood of preceding monkey. Parasites were found in the blood on March 18, and were constantly present, although never very numerous, until April 6, when the animal died. On March 18 the temperature rose to 104·6°, with the appearance of parasites in the blood. During the last two days of life the temperature was subnormal (from 95° to 96°). Diminution of red cells and haemoglobin was observed. *Post-mortem*, purulent peritonitis was found due to a parasite found in the intestinal walls, and not yet identified. 4. *Macacus rhesus.* Inoculated on March 14 intraperitoneally with the heart blood of a rat. Trypanosomes appeared in the blood on the 18th, and were fairly numerous for four days; on the 31st there were from thirteen to eighteen to a field. They became rarer again before death, which occurred on April 1. The temperature rose on the 18th, and on the 19th reached 105·8°, there being six parasites to a field at the time. The red cells decreased from 4,000,000 to 2,500,000 per cubic millimetre, and haemoglobin from fifty to twenty-seven per cent. 5. *Macacus rhesus.* Inoculated subcutaneously on April 22 with blood from a rabbit showing many trypanosomes. This monkey is not yet infected (April 27).

Strain derived from Cerebro-Spinal Fluid of Sleeping Sickness, Case 6,[1] in the Congo Free State.[2]

Rats.—Twenty-three experiments. Incubation period: young rats from three to nine days; adult rats from four to ten days. Duration from seventeen to one hundred and seventy-six days. Some of the animals have shown parasites fairly constantly, and in moderate numbers; in others the organisms have disappeared for some time or have been present in small numbers. We have rats which have lived as long as one hundred and seventy-six days, but in the blood of such animals the parasites are either found only in rare instances or not at all.

Mice.—Incubation from four to eleven days. Duration over ninety-two days. Parasites usually rare.

Guinea-pigs inoculated more than fifty days ago have not shown parasites as yet.

Rabbits.—Incubation after intravenous inoculation from three to four days. There was a slight rise of temperature on the day of infection and the following day.

Cats.—Two experiments. 1. Intravenous inoculation from a rat. Incubation period, eight days. Parasites were constantly present. On the twelfth day there were five to a field. 2. Intraperitoneal inoculation from a rat. Incubation period, eight days. No symptoms have as yet been observed.

Dogs.—Two experiments. 1. An adult dog inoculated intravenously from a rat. Parasites were seen on the fifth day. They were not numerous at first, but are increasing and constantly present. 2. A puppy, four months old, inoculated intraperitoneally from a monkey. Incubation period, eight days. No symptoms have as yet been observed.

Goat.—An adult, inoculated intraperitoneally from a monkey. The temperature rose on the evening of the fifth day to 106·5° F.; next day the temperature was 104·2°; a rat inoculated on this day is not yet positive. Parasites have not yet been seen in the blood of this goat.

Monkeys.—1. *Macacus rhesus.* Experiment 497. Inoculated intraperitoneally from a rat. Incubation period six days. Parasites have been constantly present in the blood and have steadily increased in numbers. On the day of the appearance of the parasites the temperature rose to 106° F. 2. *Cercopithecus callitrichus.* Inoculated February 15 intraperitoneally from a rat. Parasites appeared in the blood on February 20. The temperature on the 21st was 103·8° F. Trypanosomes were constantly present in fair numbers until April 5. Since then they have been rarely found, and in only small numbers. No symptoms were observed. The animal was in good condition. There was slight diminution of haemoglobin and red cells.

1. Dutton, Todd, and Christy, *Human Trypanosomiasis on the Congo, etc.*, *Brit. Med. Journ.*, Jan. 23, 1904, pp. 186-188.

2. This strain was sent to us in a rat inoculated with cerebro-spinal fluid from a case of sleeping sickness.

Strains derived from the Blood of Case 4[1,2] and from Two Congo Natives at Present under Observation

Rats.—Incubation period from four to eleven days, average about seven days ; duration, some of the animals have survived after eighty-seven days. In these animals trypanosomes have been scanty in the blood, with periods of some days to even weeks when none were to be found. This perhaps may be accounted for by the fact that the majority of the animals have been direct inoculations from the natives, whereas the sleeping sickness and *Trypanosoma gambiense* strains have been passed through a series of animals.

Mice.—Parasites were always very rare and the duration was indefinite in direct inoculations. In mice inoculated from one of the guinea-pigs sent to us from the Congo Free State (see below), the incubation period was three days and parasites were more frequently present.

Guinea-Pigs.—Two guinea pigs inoculated by us directly from the natives, and two young guinea-pigs inoculated from monkeys have been negative for a period of one hundred and forty-six days. Two adult guinea pigs inoculated from Case 4[2] on the same day by the members of the Congo expedition, and sent home while still negative, have shown parasites for the first time in their blood on the seventy-ninth and one hundred and thirty-fourth days after inoculation. No symptoms have as yet been observed. They are still living one hundred and fifty-two days after inoculation.

Rabbits.—Incubation, direct inoculations nine and eleven days ; sub-inoculation from rat ten days. Duration from twenty-one to eighty-seven days. Parasites have been fairly constantly present but only in small numbers. Loss of weight, slight rise of temperature, and anaemia have been the only symptoms observable.

Monkeys.—*Macacus rhesus.* Two have been inoculated intraperitoneally directly from the natives. Experiment 331. Inoculated on February 9. Parasites appeared in the blood on the fifth day. On the next day the temperature rose to 104·9° F., the following day it registered 105·8° ; at the same time the parasites were observed to increase in numbers. Trypanosomes were constantly present at first. On March 5, there were from twenty-five to thirty to a field. About the middle of March the trypanosomes became scanty and were not found at all after March 17. Death occurred on March 25. Rises of temperature were observed in this monkey coinciding with temporary increase of numbers of parasites in the blood. Experiment 316. Inoculated on February 6. Parasites appeared on the 13th, and at the same time the temperature began to rise, and on the 19th it registered 104°, up to the end of March parasites were constantly present in its blood, since that date they have been scanty and sometimes absent. On March 27, marked oedema of the upper and lower eyelids, especially the left, was observed. This persisted for three days ; the puffiness was confined entirely to the eyelids ; no parasites were found in the oedema fluid. At

1. Received in a rat inoculated directly, and therefore in its first passage. 2. Dutton, Todd, and Christy, *loc. cit.*

this time the appetite was poor, and the animal seemed to be failing. From April 15 to 22 parasites were present in fair numbers again, but are now once more scanty. No rise of temperature was associated with this temporary increase. Slight diminution of haemoglobin and red cells has been observed. The animal is now in better condition than it was a month ago.

Strain derived from the Blood of Trypanosome Fever Cases in Uganda

Rats.—Incubation from twenty-four to thirty-one days. Duration from one to four months. This strain was an attentuated one and has died out. Parasites were rarely present, and only in very small numbers.

Comparison of Symptoms in Animals inoculated with the above different Strains

It will be seen that our results have been practically the same whatever the strain used. In rats and mice the same chronic disease, periodicity in appearance of parasites, and absence of symptoms are in all cases observed as were described by Dutton and Todd. M. Brumpt and M. Wurtz have described[1] very marked symptoms in mice and rats inoculated from Congo sleeping sickness cases—*e.g.*, progressive emaciation, intermittent paralysis of the posterior quarters, oedema of the perineum, and sometimes acute nervous affections. We have observed none of these symptoms; occasionally we have noted slight oedema *post-mortem*, but never in sufficient degree to be detected before death. In guinea-pigs there is with all strains the same lengthy incubation period. In those infected up to the present (with Gunjur and Congo blood strains) there is the same more or less chronic disease, characterized by loss of weight and constant presence of parasites in the blood. In rabbits we have produced with all strains the same chronic disease with fairly constant presence of parasites, loss of weight and anaemia. In cats the disease is the same with all strains, with rise of temperature on appearance of parasites, fairly constant presence of parasites, and absence of other symptoms so far as we have yet observed. In dogs and puppies there are no differences to be noted. Incubation periods are the same, and whatever strain be used there is the same constant presence of parasites in the blood, with loss of weight and anaemia. In goats and donkeys no differences have been observed between the strains used. In monkeys infection is readily produced with all strains, even with very small doses, and parasites are fairly constantly present in the blood, often in considerable numbers. Similar symptoms are observed with the different strains—*viz.*, slight loss of weight, anaemia, rise of temperature, especially with the first appearance of parasites in the blood, and occasionally localized oedema. We have observed no marked tendency to sleep in our monkeys; when a

1. Brumpt et Wurtz: *Maladie du Sommeil Expérimentale, etc.*, *Comptes Rendus de la Société de Biologie*, tome lvi, 1904, No. 12, Avril ler pp. 567-73.

monkey is ill it sits on its haunches with its head between its knees ; this position, which has been termed the typical sleeping sickness position, is not characteristic of trypanosomiasis or 'sleeping sickness' ; it is the position assumed by any sick monkey from whatever disease it be suffering. We have noted no nervous symptoms at all.

In stained specimens we have not observed any differences between the trypanosomes of Uganda and Congo sleeping sickness cases on the one hand and *Trypanosoma gambiense* (DUTTON) on the other. In the same species of animals and at corresponding stages of the infection the size and appearance of the former trypanosomes are precisely the same as those of the latter as described by DUTTON and TODD and since observed by us. In rats inoculated either directly or from monkeys inoculated directly they present the same stumpy and long forms, the former being more numerous in the early stages than in the later. After passage through some generations of rats the stumpy forms show the same tendency to disappear. In rabbits trypanosomes of all strains show the same preponderance of short stumpy forms as compared with rats, mice, and guinea-pig, while in guinea-pigs, so far as we have yet observed, there is the same greater tendency to length in most of the forms met with. In no animals infected with either the Uganda or Congo sleeping sickness trypanosome have we ever seen any form differing in measurements or appearance from *Trypanosoma gambiense.*

Pathological lesions.—In none of our animals have we found anything differing from the lesions described by DUTTON and TODD. Enlargement of the spleen is a feature in all the animals, more especially in rats and mice. In a guinea-pig, Experiment 133 (Gunjur strain), which died forty-two days after infection, rupture of the spleen was found, the rupture extending directly across the organ on its upper surface and near the posterior end for about one and a quarter inches. A profuse haemorrhage occurred and the animal bled to death. No history of an injury is known. Another guinea-pig inoculated with *Trypanosoma dimorphum* (DUTTON and TODD)[1] has died from rupture of the spleen. This case will be published in a forthcoming report on *Trypanosoma dimorphum.* The glands are very little, if at all, enlarged, and there are no haemorrhagic glands to be met with as in animals infected with *Trypanosoma dimorphum.* Petechial haemorrhages are rarely seen. In monkeys the mesenteric glands are enlarged, but this is without significance, as all our monkeys were infected with intestinal parasites. No macroscopical changes in the nervous system have been noted. In none of our animals, whether allowed to die or killed for special purposes, have we been able to find trypanosomes in the cerebro-spinal fluid, although the blood may have contained many trypanosomes, nor have any of the animals inoculated with this fluid ever become infected.

1 Laveran et Mesnil, *Comptes Rendus de l'Académie des Sciences*, tome cxxxviii, 1904, p. 732.

In the majority of animals which have died we are unable to say definitely that trypanosomiasis was the sole cause of death. Very frequently an intercurrent affection has occurred which, the animal's vitality having become impaired, has caused death. We would instance in rats broncho-pneumonia, caseous lung disease, and enteritis. In rats which have survived a few to many months it is exceedingly rare to find a single parasite,[1] nor has the negative blood appeared to be infective. Experiments are being conducted along these lines. In the majority of cases those rats which have been negative for months die without the presence of trypanosomes being again recognized. In some cases, however, rats which have been negative for months have at death once more shown parasites. As instances of this the following experiments are given.

Rat 95a[2] ('Q' strain) was inoculated on March 17, 1903, from horse Experiment 87; incubation period, eight days; parasites were found at irregular intervals and in small numbers. On September 13, 1903, a single parasite to a whole cover-slip preparation was seen, and the animal continued negative until its death on March 24, 1904, three hundred and sixty-five days after infection. At the necropsy a few parasites were found in the heart. Animals inoculated from it have not yet shown the infection.

Rat, Experiment 89[3] ('Lammin' strain). Inoculated February 26, 1903, from rat 26; incubation, eighteen days. Trypanosomes were present in its blood until April 21. From that time parasites were never seen except on the following dates, July 27, September 7, and November 1, 1903, until its death on March 15, 1904, three hundred and sixty-six days after infection. At the necropsy complete red hepatization of the whole of the left lung was found. The left pleural cavity contained over five cubic centimetres of slightly yellowish clear exudate containing one parasite to three fields. Animals inoculated with this exudate became infected, and from these sub-inoculations we have been able to infect a goat Experiment 518, and a monkey, Experiment 517.

We have observed that animals with extraordinary numbers of trypanosomes in their blood usually exhibit some lesion which tends to impair their vitality. The following experiment is a good example of this. A rat, 279a ('Gunjur' strain), inoculated on December 30, 1903, from a guinea-pig became positive on January 7, 1904. From that time until it was killed on March 22 the parasites were constantly present in increasing numbers in its blood. At the necropsy caseous lung disease was very far advanced, involving both lungs. Its blood on examination showed trypanosomes in countless numbers. Two rats, two mice, three guinea-pigs, one rabbit, and a puppy were all inoculated intraperitoneally with heart-blood. Twelve hours later the mice and rats, the rabbit and two guinea-pigs were found to be positive, the rats and mice having as many as three to eleven to a field, the rabbit two hundred and forty to the cover-slip preparation, and the two guinea-pigs eight to the cover. The puppy did not show parasites in its blood until five days later.

Very little, if any, immunity is conferred by infection with *Trypanosoma gambiense*. The two following experiments are of interest in this connexion.

1. A piebald rat was inoculated directly from Mr. Q. by Dutton and Todd on November 3, 1902, Parasites were found in its blood on November 12, and again on February 27, 1903. After this the blood was always negative. On November 23, 1903, it was reinoculated intraperitoneally from a rat ('Gunjur' strain) showing very numerous trypanosomes. It became infected, and on December 9 its blood was swarming with trypanosomes. Death took place on December 26.

2. A monkey (*Macacus rhesus*) infected by Annett from H. K. (Dutton's original case) in 1902 recovered, its blood being non-infective to rats. On January 29, 1904, it was reinoculated (Experiment 311) from a rabbit ('Gunjur' strain), and became infected (see above).

As one would expect, there is no transmission of immunity to offspring. Several of the young rats which we have infected have been born from parents which either were infected at the time or had

1. This is also the case in other animals. See chimpanzee experiment.

2. Dutton and Todd, *loc. cit.*

3. *Ibid.*

recovered from an infection. And one guinea-pig (Experiment 216) which we infected with 'Gunjur' strain was born from a guinea-pig infected at the time (also with 'Gunjur' strain). There is a certain amount of natural immunity or resistance to the human trypanosome to be met with in individual rats and other animals. Every now and then we have come across animals which have exhibited this feature. For example, of two rats A and B of the same size, inoculated at the same time with equal amounts of virulent blood from an infected animal, A will become infected while B remains uninfected or shows a prolonged incubation period. Again, A receives a larger dose than B; it frequently happens that B will show the infection earlier than A. Guinea-pigs show considerable resistance to infection. As instances of this we would mention those inoculated from Rat 279A (see above). Baboons (*Cynocephalus sphinx*) have up to the present been absolutely refractory.

Conclusions

1. The trypanosomes found in (*a*) cerebro-spinal fluid of Uganda sleeping sickness cases, (*b*) cerebro-spinal fluid of Congo Free State sleeping sickness cases, (*c*) blood of Uganda trypanosome fever cases, and (*d*) blood of Congo Free State trypanosome fever cases, are all identical in animal reactions and morphology with *Trypanosoma gambiense*. The specific name *gambiense* (Dutton) must therefore for the future include the trypanosomes from the above-mentioned sources.

2. There seems to be no acquired immunity against infection.

3. There is no transmission of immunity to offspring.

4. An animal which seems to have recovered may months later show parasites once more, apparently as the result of lowered vitality.

TWO CASES OF TRYPANOSOMIASIS IN EUROPEANS

TWO CASES OF TRYPANOSOMIASIS IN EUROPEANS

(*Third Interim Report of the Expedition of the Liverpool School of Tropical Medicine to the Congo*, 1903) *

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AND

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THE following cases seem well worthy of record since they tend to indicate with what uniformity the accepted signs of the disease may be expected to occur in Europeans infected with *Trypanosoma gambiense*.

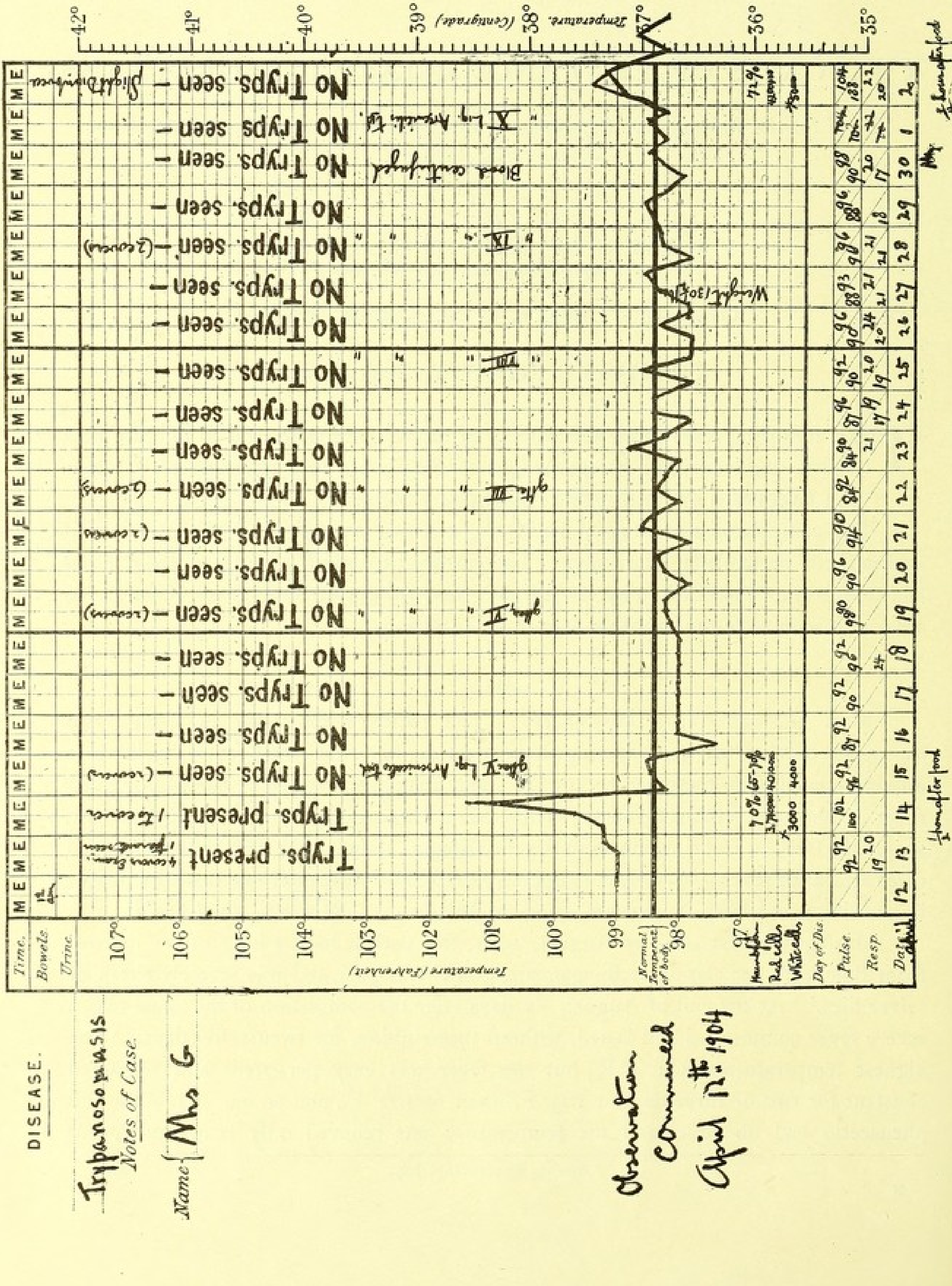
The completeness of the history of the onset of the disease in Cases I and II makes them particularly interesting. The history of Case I is compiled from notes and temperature charts taken by the patient's husband during her illness. Case II was seen very soon after the probable date of his infection.

Case I

Mrs. G., *aet.* 35, a missionary. The patient's first stay in Congo was during the years 1895-99. During this period she had four small fevers, yielding to quinine—maximum temperature 103° F.; and a supposed attack of haemoglobinuric fever. One year without fever was then spent in England, and in June, 1900, patient, weighing then 147 lbs., again went to the Congo. Soon after her return she had three attacks of fever—maximum temperature, 104° F.—which were successfully treated by quinine; and from November, 1900, to July, 1901, she was in good health.

During the first days of August, 1901, the patient took a long canoe journey from Bolobo to her station at Bongandanga on the Lopori, and was severely bitten by 'river flies.' At the end of August, six days after the completion of the canoe trip, a severe fever commenced and lasted, without interruption, for twenty-five days. 'The highest temperature was 104° F., but the fever was very persistent and remained constant for two or three days at 103° F., then at 102° F., and so on. Quinine and phenacetin had no effect and the temperature was relieved only temporarily, but

* Received for publication July.



DISEASE.
Trypanosomiasis
Notes of Case
Name Mrs G
Observation Commenced April 12th 1904
Temperature (Fahrenheit)
Temperature. (Centigrade)
Normal Temperat. of body
Time.
Bowels
Urine
Day of Dis.
Pulse
Resp.
Date
Tryps. present
No Tryps. seen
Blood centrifuged
Weight (30 lb)

unfailingly, by baths. For the next three months, weekly fever. First day, temperature about normal; second day, slight fever; third day, marked temperature; fourth day, 'always just one degree higher than third day'—highest temperature recorded, 104·6° F.—fifth and sixth days, temperature much lower; seventh day, 'about normal.' From January to April, 1902, the temperature ranged between 99° and 100° F., and was never normal.

In January, and again in February her eyes, particularly the left, were 'inflamed,' and five days were spent with bandaged eyes in a darkened room. At the end of February, and during March, while on her way from her station to the sea-coast, four more attacks of fever occurred—temperature rising to 102°-103° F. During the voyage to England, where she arrived at the end of April, 1902, the patient's temperature gradually fell to normal. She remained in Europe until August, 1903, and then again returned to Africa. While at home she, on two occasions, suffered from fever, rising to 103° F.; quinine efficacious. During June, 1902, and again in January, 1903, her eyes were once more affected, and oculists were consulted. At various periods during her stay in Europe 'red patches' as large as a 'half-crown piece,' lasting for three or four days, appeared on her legs; they were tender, and the surrounding skin seemed hard. At one time patient's joints seemed stiff, at another she suffered from an 'inflamed throat. Three months were spent in Switzerland, the patient gained rapidly in health, and on leaving for Congo, August, 1903, seemed well, and weighed 145 lbs. Her medical history from her last arrival at the Congo to April, 1904, when we first saw her, is as follows:—

'*October* 10, 1903. Fever on the river steamer; lasted for two days; maximum, 102° F.

'*November* 9. Still on steamer; temperature suddenly rose to 105° F., reduced by bath; throat bad next day, relieved by gargling; discharge of matter for two days. On Tuesday, November 10, Wednesday, and Thursday, slight fever. Friday, 13, 5 a.m., 105° F., bath; 10 a.m., 105° F., bath; 1 p.m., 105° F., bath; 3.30 p.m., 107° F., bath; 8 p.m., 105° F., bath; the temperature fell to about 101° F. after each bath; patient delirious.'

'*November* 14. Patient too weak to walk, was carried from the steamer; highest temperature, 102° F. At 2.30 on the morning of the 15th the temperature rose to 105° F., a bath was given, and temperature brought down. On the 16th the temperature was 100° F., and on the 18th normal. There was no more fever until March, 1904.'

For two or three weeks she was apparently quite well. About Christmas, 1903, severe headaches commenced; about the middle of January these began to be accompanied by vomiting. At first the vomiting and headache 'appeared at irregular intervals, later as follows:—' First day, comparatively well; second day, malaise with slight headache; third day, bad headache, vomiting two to six times (on one occasion eight times). There was no tenderness or pain, save headache, and no nausea or loathing of food. On the bad days an attempt at any exertion, even to read a letter, was certain to precipitate an attack of vomiting. About February 14 there was vomiting, once or twice, on alternate days. Took Liquor Arsenicalis, two to six drops three times a day.'

March 10. Stopped arsenic ; left her station for a change.

March 16. Headache and vomiting.

March 17. Severe vomiting, bile-stained vomitus.

March 18-20. Well.

March 22. Vomiting and headache, next day emesis more severe ; vomitus bile-stained.

March 24. Fairly well.

March 25. Severe headache, vomiting, fever (maximum 104·4° F.) The fever gradually lessened during the two following days, and from March 29 to April 12 patient was 'quite well.'

Quinine was given during this fever, but was, probably, never retained, since the ingestion of anything, liquid or solid, provoked emesis.

Physical examination.—April 15, 1904. General condition : Well-made woman ; height, 5 feet 6 inches ; weight, 126 lbs. ; rather anaemic appearance ; complains only of shortness of breath and of becoming easily fatigued.

Skin : No erythemata ; no distinct oedemas, although the skin of legs has a distinctly doughy feel ; on scratching skin capillaries contract.

Lymphatic glands : Slightly enlarged, palpable in axillae and neck.

Circulatory system : Slight venous pulsation in neck ; slight epigastric pulsation.

Heart : Apex beat normal in position ; cardiac dulness normal ; no thrill over heart or in neck ; sounds, a slight blowing systolic murmur limited to apex area, the aortic and pulmonary second sounds are rather loud ; no venous hum in neck.

Pulse : Frequent (96), tension medium, regular in time and force, artery normal.

Respiratory system : Nothing abnormal subjectively or objectively.

Digestive system : Appetite good ; bowels fairly regular, occasional slight constipation ; tongue clean.

Liver : Dulness normal, no tenderness on pressure.

Spleen : Not enlarged nor tender.

Nervous system : No headache or pain ; sensation to pain acute ; sensation to touch, heat, cold, and distance between pin points perfect ; there were distinct localized hyperaesthetic areas on different parts of the body, under right nipple, at apex of heart and on shins, slightest pressure causes acute pain. Superficial reflexes normal ; knee jerks just obtainable. Mental condition normal.

Eyes : Pupils react to accommodation and light ; both discs definitely congested (left more than right).

Throat : Tonsils not enlarged, no redness.

Generative system : Menstruation regular, flow normal in amount, generally slight temperature on first day.

Urine. April 29. Twenty-four hours specimen (preserved with thymol), volume 1,100 c.cm. ; acid, color normal ; cloudy precipitate, Sp. Gr. 1,020 (82° F.) ; no albumen or sugar ; urea, 1·85 grammes to 100 c.cm. urine.

April 30. Twenty-four hours specimen, volume 1,740 c.cms. ; color, normal ; acid, no albumin or blood ; urea, 1·55 grammes to 100 c.cms. urine.

Faeces. Careful examination showed no signs of intestinal parasites.

Liquor arsenicalis five drops three times a day was prescribed, and the patient was directed to increase the dose by one drop every third day. This treatment was followed until the 3rd of June (twenty drops t.i.d), when symptoms of saturation were evident, and this drug was discontinued for a time and iron and arsenic pills were substituted.

During 1895-96-97 quinine, grains V, was taken daily as a prophylactic against malaria. Its use was discontinued as it was thought to be the cause of 'neuralgia.' From January, 1903, to the present about three grains have been daily taken.

April 21. Slight epistaxis ; bleeding at the nose had occurred on three previous occasions, once in Switzerland, twice in Africa, always slight.

May 22. For past three days has had swollen wrists, first one then the other ; to-day one side of face is swollen, no redness or tenderness, or evidence of insect bite ; these swellings are fugitive, and last only for a day.

June 2. For last few days patient has complained of lack of appetite and loss of energy ; the swellings on face and hands persist ; a papular eruption has appeared on the chest.

The accompanying chart shews the type of temperature and the result of examinations for parasites during the first three weeks of our observations. On the 15th of April the parasites disappeared from the peripheral blood, and the temperature fell to normal. In spite of daily examinations of coverslips and periodic centrifugalization of blood, trypanosomes have not been again seen. The temperature (with one slight exception) has, during this period, always been normal.

Until signs of arsenical saturation commenced to show themselves the patient felt 'much better' ; she felt stronger and was less easily fatigued. There has been a slight increase in body weight, and in the value of erythrocyte and haemoglobin estimations.

	May 12	May 27
Haemoglobin,	68 per cent.	74 per cent.
Red Cells,	4,510,000	4,450,000
White Cells,	4,650	4,000

We have never seen malarial parasites in this case.

It was through the kindness of Mr. M., a missionary stationed at Leopoldville, and the husband of the case 'Mrs. M.,' described by Broden and Manson, that this case was brought to our notice. He felt convinced that he had, in October, 1903, seen an erythema on Mrs. G.'s forehead in every way similar to those which he had previously seen in each of the cases from the Congo described by Manson.

We have been unfortunate in never seeing this case when erythemata were present.

Case II

T., a steamer captain, *aet.* twenty-eight, serving his first term in Congo. Patient left Antwerp, November 26, 1903, and arrived at Leopoldville, December 30. He reached his station, a wood post for steamers, on the banks of the Congo, just below its junction with the Kasai, on December 31, and remained there until April 13, 1904, when he was invalided for 'fever' to Leopoldville.

Here he came under the care of Dr. Grenade, the State Physician, who found that quinine was without effect, and, suspecting the nature of the patient's fever, very kindly allowed us to study the case.

History.—Six years ago the patient spent eight to nine months in a cargo steamer plying between Sierra Leone and the Gold Coast; the steamer often remained in various ports for some little time. In spite of this he never had 'fever,' and in 1898 he returned to Europe. Since then, until leaving for the Congo, November, 1903, he had been employed on vessels plying between European ports. After frequent questioning, the patient admitted that during this period he had had very occasional 'fevers' preceded by a 'cold feeling,' and followed by sweating. No quinine was ever taken for these 'fevers.'

While on the East Coast of South America, during six months in 1894, he had yellow fever.

In 1901 he was in hospital for four or five weeks with rheumatism in legs and arms. With these exceptions, he has always had good health.

Complains of constipation since leaving Europe.

During his stay at the wood post he had five attacks of fever. The first commenced January 26, 1904, about four weeks after he reached the post, and lasted to February 3; during nine days he was ill, maximum temperature, 106·7° F.

The second attack occurred on February 17 and 18, two days' duration, fourteen days interval between it and first fever.

The third attack lasted two days, February 22 and 23, five days' interval between it and preceding fever.

The fourth fever also lasted two days, March 9 and 10, interval sixteen days.

During these last two fevers temperatures of 102·2° F. to 104° F. were recorded.

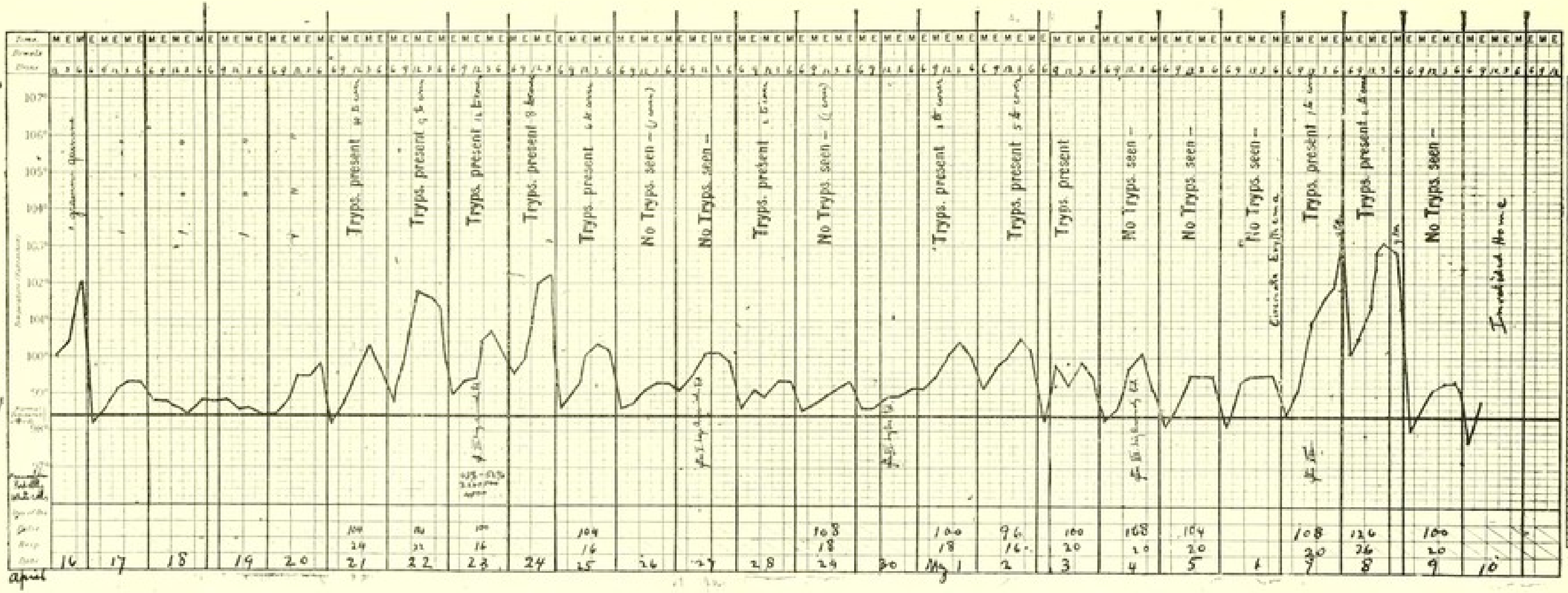
DISEASE

Trypanosomiasis

Notes of Case

Name | Capt. T.

Observation Commenced April 21st. 1904



The fifth fever commenced March 17, and lasted eleven days, ending on March 27; temperature, 104° F. to 105·8° F.

The patient stated that the second, third, and fourth 'fevers' came on suddenly and without any premonitory signs; for instance, while sitting at dinner he found himself in a high fever without any shivering fit or other prodrome. Before the first and fifth fevers, on the other hand, there was definite malaise, but no rigors.

From March 2 to April 10 he was alternately in bed and sitting in his chair; on March 31 and April 1 and 5 his temperature was raised.

During these fevers and until his arrival in Leopoldville, April 13, he took about a gramme of quinine daily.

During the last fever he was greatly troubled by daily vomiting, which did not occur, however, unless something had been ingested.

The patient's friends say that he has lost flesh.

Physical examination.—April 18, 1904. Present condition: Man of average height and build; distinctly sallow and anaemic appearance; slight blepharitis (old-standing), complains of weakness; says 'knees are weak;' loses breath quickly.

Skin: Has a doughy feel, and is distinctly oedematous, this is most marked over ankles, where there is pitting; there is no erythemata or other eruption; dermatography not marked.

Lymphatic glands: Palpable, not enlarged.

Circulatory system: Heart, action rapid; dulness, normal; difference between first and second sounds, less marked than normal; no bruits; pulse, frequent, regular in time and volume; artery, normal.

Respiratory system: Normal; no complaint.

Digestive system: Bowels constipated, goes two to three days without movement; tongue, flabby, not much furred, no tremor; throat, normal; appetite, fair.

Liver: Not enlarged (width in nipple line 6 cm.), a suspicion of tenderness.

Spleen: Just palpable; slight tenderness.

Nervous system: Sensation to pain, touch, heat, cold, and distance apart of pin points, normal; superficial reflexes, normal; knee jerk, slightly increased.

Eyes: Left eye is seen by ophthalmoscopic examination to have a markedly congested disc, there is deep cupping; choroidal vessels show very plainly.

Urine. April 29. Twenty-four hours specimen (preserved with thymol), volume, 660 c.cm., dark sherry color, acid; urea, about 3 grammes to 100 c.cm. urine; spectrum of urobilin, marked.

May 4. Twenty-four hours specimen; volume, 1,075 c.cms., dark-brown sherry color; acid, no albumen; Sp.Gr. 1,016 (temperature, 79° F.); urea, 2·6 grammes to 100 c.cm. urine.

May 10. Twenty-four hours specimen; volume, 700 c.cm.; dark color; Sp.Gr. 1,027 (temperature, 78·8° F.); acid, no deposit; no blood or albumen; urea, 2·6 grammes to 100 c.cms. urine.

April 30. Physical examination repeated, no change observed.

May 7. Patient drew attention to a redness on chest which he said was very obvious last night. On examination, red diffuse areas seen under nipple and on epigastrium, not itchy or painful; one annular area about 5 cm. in diameter on right lower costal margin, had slightly swollen periphery with injected vessels, while the centre remained uncoloured. Five diffuse injected areas, varying in diameter from 2 to 4 cm., were seen on back.

May 8. Says that temperature rose to 104° F. at about twelve last night. To-day there is marked oval ring of faint, slightly raised erythema, measuring 1 by 5 cm. just above the right eye; it is not tender or itchy, and the skin is distinctly thickened. The ring seen yesterday on right hypochondrium still persists, its capillaries are injected, and its general appearance is much the same as yesterday, its centre is yellowish; there is no extravasation of blood (glass slide test) in either of these annular areas. On left hypochondrium were more or less blotchy areas of redness, mixed with very faint greenish or yellowish discolouration.

Patient has more colour and looks better than when he was first seen, he has more appetite and says that he feels stronger and does not become so easily fatigued as when he first came to Leopoldville.

May 9. The ring of erythema over right eye has almost entirely disappeared, the blotchy areas on body are vanishing. Although patient's temperature has been about 103° F. for the past two days, he says that he has felt no inconvenience from it. His appetite has been good, and he walked about as usual.

May 10. Patient leaves Leopoldville, invalided home. The remains of ringed erythema are seen on chest. Malarial parasites were not seen in this case.

The first attack of fever occurred within six weeks of this man's arrival in Congo. He spent approximately the first week in the Free State in Boma, and then went as directly as possible to his station. In twenty-seven days after reaching the wood-post his illness commenced. It does not seem at all probable that he acquired his infection so long ago as 1898 when he was on the Gold Coast, nor do we believe that he became infected either at Boma or while travelling by train to Leopoldville. We are inclined to think that he became infected with trypanosomes after his arrival at his post. It, therefore, seems probable that the 'incubation period,' between the time of infection with *Trypanosoma gambiense* and the appearance of the symptoms associated with human trypanosomiasis, may be so short as four weeks.

It is extremely interesting to note in this connexion that *Glossinae* were extremely numerous at this post, situated on the river bank, and were a most disagreeable and constant pest.

SUPPLEMENTARY NOTES ON THE TSETSE-FLIES

SUPPLEMENTARY NOTES ON THE TSETSE-FLIES
(GENUS GLOSSINA, WIEDEMANN)

BY

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SINCE the publication of *A Monograph of the Tsetse-Flies* a little more than a year ago, our knowledge of these interesting insects, so important to the student of African trypanosomiasis, has been extended in various directions. It has, therefore, seemed advisable to embody these additions in a short paper, which it is hoped may not prove altogether unworthy of the attention of the members of this Section, and may serve to bring the author's Monograph so far as possible up to date.

In the work in question seven species of Tsetse-flies were recognized and described. But within the last few months an eighth species has been described under the name *Glossina decorsei*, by Dr. EMILE BRUMPT, from specimens recently obtained by Dr. DECORSE on the River Shari and the shores of Lake Chad.[1] An examination of some of Dr. DECORSE's specimens, however, kindly submitted by Dr. BRUMPT, shows that the supposed new species is in reality none other than *Glossina tachinoides* (WESTWOOD), which was described as long ago as the year 1850. In his Monograph, *Glossina tachinoides* was regarded by the present author as a variety of *Glossina palpalis* (ROBINEAU-DESVOIDY), the species that, since Colonel DAVID BRUCE's investigations in Uganda last year, has become widely known as the disseminator of *Trypanosoma gambiense*, now recognized as the cause of sleeping sickness. The study of further material, however, and especially of a long series of specimens obtained two months ago on the Benue River, Northern Nigeria, by Mr. W. F. GOWERS, and kindly presented by him to the British Museum, shows that *Glossina tachinoides* (WESTWOOD) is in reality a perfectly distinct species, nearly related to *Glossina pallidipes* (AUSTEN) but distinguishable at once, apart from its much smaller size, by the fact that the hind tarsi are either entirely dark, or, as in the female, are dark with the bases of the first three joints usually pale. The total number of species of Tsetse-flies now known

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therefore amounts to eight. In the paper already referred to Dr. BRUMPT considers that *Trypanosoma brucei*, the parasite of nagana or Tsetse-fly disease in domestic animals, is carried by at least five of these species,[2] and he further states that the investigations that he is making upon sleeping sleepness lead him to suppose that this malady may also be transmitted by several species of Tsetse-flies. The mere possibility that this supposition may ultimately prove to be true is perhaps sufficient warrant for thinking that no detail concerning the morphological characters, distribution, or bionomics of any of the species of *Glossina* is without importance for those interested in the sanitation of tropical Africa. In the present paper, therefore, the eight species will be considered in order, and any new facts regarded as worthy of notice recorded under each, the arrangement adopted in the Monograph being adhered to, and *Glossina tachinoides* inserted in its proper place. At the end of the paper a revised 'Synopsis of species' will be given, which it is hoped may prove useful for the determination of specimens.

Glossina palpalis (ROB.-DESV.)

The form of this species designated in the Monograph as 'Var. *tachinoides* (WESTW.)' must now be regarded as a variety which for the present may remain unnamed. It is characterized by the possession of pale femora, buff-yellow median stripe on the abdomen, and narrow pale hind margins to the abdominal segments. Specimens obtained by Drs. TODD and DUTTON on the Gambia during the Gambia expedition of the Liverpool School of Tropical Medicine belong to this form, which may eventually have to be raised to specific rank. A second variety also has the femora paler than usual; the palpi, except the tips, pale; and the abdomen somewhat reddish-brown, with the pale area on the second segment oblong instead of triangular. Owing to the colour of the abdomen this form presents a certain resemblance to *Glossina pallicera* (BIGOT). A specimen of variety No. 2 was obtained at Old Calabar on May 14, 1900, by Dr. ANNETT, of the Liverpool School of Tropical Medicine.

As many of the members of this Section are doubtless aware, our knowledge of the life-history of Tsetse-flies was originally due to Colonel BRUCE, who, during his investigations upon Tsetse-fly disease, or nagana, among domestic animals in Zululand in 1895, discovered that the species studied by him—either *Glossina morsitans* (WESTW.) or *Glossina pallidipes* (AUSTEN)—'does not lay eggs as do the majority of Diptera, but extrudes a yellow-coloured larva nearly as large as the abdomen of the mother.'[3] Specimens of the pupa of this species, kindly supplied by Colonel BRUCE, were described and figured on pp. 26-28 of the author's Monograph. Owing to the kindness of Colonel BRUCE, Captain E. D. W. GREIG, I.M.S., and Dr. NABARRO, all of the Sleeping Sickness Commission, who forwarded specimens from Entebbe, Uganda, it is now possible to describe the larva and pupa of *Glossina palpalis*.

Larva of Glossina palpalis

I have been enabled to examine a series of sixty-two larvae of this species, ranging in length from 2 mm. to 7 mm., but only one of these (the largest) can be regarded as adult. The colour of these specimens, which have been preserved in 5 per cent. formalin, varies from cream to buff yellow. In all the larvae the tumid lips on the last segment, as seen in the pupa, are plainly visible, and in a larva of $2\frac{1}{2}$ mm., which may perhaps be considered to be in the first stage (*i.e.*, before the first moult), the size of the lips is relatively, if not even actually, considerably greater than in a larva measuring $3\frac{1}{3}$ mm., which is perhaps in the second stage (*i.e.*, between the first and second moults). In the former stage, too, the lips are much wider apart than in the second, and the very young larva viewed from above may be said to be conical in shape, with a protuberance on each side of the truncate posterior extremity. In the second stage (larvae from 3 mm. to $3\frac{1}{3}$ mm. in length) the lips are nearer together, and separated by a much narrower interval than in larvae in the third stage (about $3\frac{1}{3}$ mm. in length and upwards), in which they have their final position, as seen in the pupa. In the first stage the lips, or anal protuberances, appear slightly brownish all over; in the second stage they are blackish at their extremity and at the margin of the intervening notch; in the third stage they are uniformly deep black, and the granules with which they are covered can now be easily discerned under an ordinary platyscopic lens. In the second and third stages the body of the larvae in front of the bifid anal extremity (twelfth segment) is seen to be composed of eleven clearly marked segments. In the larger larvae the tips of the mouth hooks can be seen slightly protruding from the cephalic end. The larva already referred to as being the only one that can be regarded as adult, measures 7 mm. in length, by 3 mm. in greatest width, and was obtained by Captain Greig, at Entebbe, Uganda, in April of the present year. In this larva, in the median ventral line, each of the segments from the fourth to the tenth shows on its anterior margin a narrow ridge, measuring about $\frac{2}{3}$ mm. in transverse width. The object of these ridges may be to assist the adult larva on extrusion to crawl away to some hiding place in which the pupal stage may be assumed.

All of the larvae here referred to were deposited by the parent flies in boxes, and, since all, with a single exception, are immature, it follows either that *Glossina palpalis* differs from the species described by Colonel Bruce, in that the larva feeds and grows outside the body of the mother after extrusion, or else that the parents of these larvae, probably owing to their being in captivity, gave birth to their offspring prematurely. The latter supposition would appear to be the more reasonable.

Pupa of Glossina palpalis

The pupae examined were all obtained at Entebbe, Uganda—those forwarded by Dr. Nabarro in September, 1903, while others were collected in April, 1904, by Captain Greig. Additional specimens were sent home last year by Colonel Bruce.

The pupa varies in length from $5\frac{1}{4}$ mm. to $6\frac{1}{2}$ mm., and in the greatest width from 3 mm. to $3\frac{1}{3}$ mm. In general appearance it is precisely similar to that of the Zululand species, figured on page 27 of the author's Monograph. The tumid lips on the last segment, however, are much closer together, the space between them being reduced by quite one-half, while the lips themselves are somewhat larger, and covered with sparser and therefore more conspicuous granules. The notch between the lips is somewhat deeper, and consequently approaches slightly closer to the preceding segment than in the species figured in the Monograph. Other points of difference are that the edge of each lip bears only two grooves or furrows instead of four, while the ridges connecting the lips at the base on the dorsal and ventral side, besides being lower owing to the greater depth of the notch, have a broad, shining black margin, instead of being almost dull.

Whatever be the case with regard to the larvae, it would seem probable that, did we but know them, all the species of Tsetse-flies might be distinguished in the pupal stage by the characters afforded by the last segment. At any rate, in a pupa forwarded from Entebbe by Captain Greig with those already referred to, the lips are extremely low, much wider apart than in either of the forms previously mentioned, and separated by a wide and shallow notch instead of a deep and narrow one. The longitudinal grooves with which the connecting ridges are deeply scored at the base are very conspicuous, and the connecting ridges themselves are without a broad and shining black margin. This pupa, of which the dimensions are :—length, $7\frac{1}{3}$ mm., greatest width, 4 mm., should perhaps be assigned to *Glossina pallidipes* (Austen), in which case the specimen figured in the Monograph would belong to *Glossina morsitans* (Westw.).

Distribution of Glossina palpalis

Since the publication of the author's Monograph, our knowledge of the distribution of this species has been considerably extended. As regards Uganda, Bruce, Nabarro, and Greig have published[4] a map showing the localities in which the species was obtained in the Uganda Province and Usoga. Here the fly is found on the forest-lined shore of Lake Victoria and the adjacent islands, passing down the Nile until Lake Albert is reached, all round which the species was met with last year by Mr. W. Y. Wyndham. In a letter to Dr. Nabarro, dated 'Wadelai, November 2, 1903,' Mr. Wyndham states that he has found the fly on all the shores of the Albert Nyanza, and also on the Congo side of the Nile, about eight miles to the south of Wadelai. He adds that from the results of his investigations 'there is little doubt that the fly is prevalent in this part of Africa, wherever the local conditions are favourable.' North of Lake Albert *Glossina palpalis* was encountered at Nimule, in the Nile Province of Uganda, by Dr. Brumpt, who also found it to the west of the Nile in the Belgian enclave of Lado, and all down the Congo system, from the source of the Welle to the mouth of the Congo. Eastwards Dr. Brumpt had previously met with the species on the river Omo, which falls into the north of Lake Rudolf. In West Africa (Sierra Leone) Major FRED SMITH, D.S.O., R.A.M.C., writing to the author from Freetown on May 16 last, stated that in April of the present year he had found *Glossina palpalis* all the way from Freetown to Kakena in the north of the Sierra Leone Protectorate. It was the only species met with, though Major SMITH'S native boys talked of a larger one (probably *Glossina fusca*), which, however, he did not encounter. In Northern Nigeria *Glossina palpalis* was found in March of the present year in the Kadima River Valley, thirteen miles south of Wushishi, by Dr. S. H. JONES, who kindly presented the three specimens collected by him to the British Museum. The National Collection has also received four specimens from Mr. W. F. GOWERS, collected by himself on the Forcados River, Southern Nigeria, on June 18, 1904. Lastly, it may be noted that a large series of specimens of this species were obtained by Drs. DUTTON, TODD, and CHRISTY near Leopoldville, on the islands in Stanley Pool, and at other localities on the Lower Congo from November, 1903, to May, 1904, during the expedition for the study of trypanosomiasis, recently dispatched to the Congo by the Liverpool School of Tropical Medicine.

Habits of Glossina palpalis.

Contrary to what has been found to be the case with regard to *Glossina morsitans* in South Africa, *Glossina palpalis* does not appear to be dependent for its existence upon big game, and in Uganda, at any rate, the members of the Sleeping Sickness Commission seem to have come to the conclusion that this species of Tsetse-fly subsists largely upon human blood. This is supported by the experience of Mr. W. Y. WYNDHAM on the Albert Nyanza. Writing to Dr. NABARRO from Wadelai on November 2, 1903, Mr. WYNDHAM says :—

'The fly cannot depend for its existence upon game, as in most of the places in which I found it there was none or next to none.'

On the subject of habits, Mr. WYNDHAM writes :—

'The fly seems a rapid feeder, to judge from some caught on the men. They do not appear early in the morning, but continue until evening has well set in, and I caught one which was decidedly lively after dark by candle-light.'

The following field notes concerning *Glossina palpalis* on the Congo have been kindly furnished by Dr. CUTHBERT CHRISTY :—

'We found *Glossina palpalis* to be extremely common on the banks of the Congo and its tributaries, even on the smallest streams, as far up as the mouth of the Kassi River. As to its presence beyond that I cannot as yet give you any information. We frequently observed that it was commoner and more bloodthirsty at bridges and fords, or in places where ferry canoes were kept, or where the women go down to draw water or wash, than on either side further up or down the stream. On the approach of either animal or man at a river crossing or in the densest forest, the victim is soon scented out by the Tsetse-fly if there be one in the vicinity, and then either silently or with a peevish buzz the fly makes straight for the most accessible spot, by preference the leg or foot in man, or in the ear in the pig, to which animal it seems especially partial.

'At Leopoldville we employed a brigade of boys, to whom we supplied nets and bottles. On wet or dull days their total catch was often not more than a dozen or so between them ; but on other days from December to May they brought in regularly twenty or thirty each, the boys being paid according to the number each caught. The low-lying forest and scrub by the banks of the river was the best hunting ground. During the last week in January, by the kindness of the State authorities, who placed a steamer at our disposal, Dr. Dutton and myself were enabled to make an exploratory tour of the islands in Stanley Pool. On the large forest-covered island of Bamou, where I spent two consecutive days hunting, *Glossina palpalis* were literally in myriads, and for the whole two days my hands, face, and neck were bitten unmercifully, seldom less than ten or a dozen flies attacking at the same time whenever I remained within one hundred yards of the abrupt edge of the forest. Surrounding this forest are areas of marsh many miles in extent, where patches of solid ground are few, and where not a Tsetse is to be found. In the dark, cool interior of the forest the Tsetse, although not nearly so numerous or so bloodthirsty as at the margin, were still a pest. On one occasion I counted thirty-eight probing the body of a large monitor (*Varanus niloticus*) that I had shot only a few minutes before. In the blood of this animal were numbers of *Drepanidia sp.* (*? nov.*), but no trypanosomes.

'On this island the question again rose :—" Has the buffalo any connexion with the Tsetse " ? There were many small herds which passed backwards and forwards between the forest and the marsh, spending, however, most of their time in the marsh. One occurrence, namely, the fact that I came upon a herd of buffalo resting during the hottest part of the day, actually at the extreme edge of the forest, where, as I have said, the flies were, and always are in my experience, the most numerous and tormenting, tends to show that the skin of the buffalo, which is enormously thick, is too much for the Tsetse.

'Speaking from personal experience alone, the initial stab of *Glossina palpalis* is very painful, but no subsequent irritation follows. At the seat of the bite there soon appears a hard nodule, which may remain for many days, but is unaccompanied by any marked swelling or discoloration.

'I may add that at the end of April, I again visited Bamou Island, and was surprised on that occasion to find that *Glossina palpalis* was conspicuous by its almost total absence, hardly a fly being encountered, while the few that were seen appeared to have little inclination to bite. I have long suspected that this fly only sucks blood during certain months in the year.'

Glossina pallicera (Bigot).

There is nothing to add to the account of this species given in the Monograph, and no further specimens have been received. The typical specimen, and a second one referred to on page 80 of the Monograph, have been kindly presented to the British Museum by Mr. G. H. Verrall.

Glossina morsitans (Westw.)

From a gravid female of this species taken near Yola, Northern Nigera, on October 10, 1903, by Mr. W. F. Gowers, I have extracted an immature larva measuring 4 mm. in length by $2\frac{2}{3}$ mm. in greatest width. It is of the normal type, and the tumid lips on the last segment, which in this specimen are only slightly brownish in colour, are separated by a narrow notch but almost meet together at their margins, which appear to be marked by only two grooves.

Specimens of *Glossina morsitans* from one or two new localities have been received at the British Museum since the publication of the author's Monograph. These include seven males and five females from the Mwangazi River, on the borders of North-Eastern Rhodesia and Portuguese East Africa (latitude 14° 10′ S., longitude 32° 30′ E.); presented by Mr. Robert Codrington, Adminstrator of North-Eastern Rhodesia. Besides these, Mr. W. F. Gowers has forwarded a series of individuals of both sexes, taken by himself near Yola, Northern Nigeria, on October 10, 1903, and March 12, 1904. In a letter to Professor Ray Lankester dated 'Yola, October 21, 1903,' Mr. Gowers writes as follows:—

'These specimens were caught about twenty-five miles north of Yola (the exact locality being 9° 36′ 40″ N. latitude, and 12° 41′ 20″ E. longitude), on the bank of the River Loko, a small tributary of the Benue, at the place where it is crossed by a well-used native path. There is here a belt of large trees with thick undergrowth, and, so far as the road is concerned, the fly appears to be confined to this belt, which is not more than one hundred yards across. I cannot yet say how far it extends into the bush to the east and west (the road runs nearly north and south). To the north, east, and south of this spot are many farms and villages. There are cornfields within two or three hundred yards, and a village not more than half a mile away. To the west is a stretch of uninhabited bush where game, including buffalo, is said to be plentiful, but there is no indication of game in the immediate vicinity, and it is not likely that it exists, at any rate in any quantity, in the neighbourhood of the road and cultivated land.

'The fly is found here in considerable numbers; altogether about one hundred were secured in two hours by tying up a horse there as "bait."[5] . . . I have no absolute proof at present that the bite is fatal, but the local natives all agree that cattle, horses, and donkeys are killed by it, while it is harmless to sheep and dogs[6]; the reason, however, given for the immunity of the sheep is that it is protected by its wool. I am going to test its effect on the latter two animals. Within a radius of three or four miles from the spot where the flies were caught no cattle are kept, the alleged reason being that the fly prevents it. Natives travelling with horses or cattle avoid this part of the road by making a detour to the east. Death is said to ensue from the bite in from one to three months, and from descriptions I gather that the symptoms are very much the same as in the case of fly-disease in South Africa. I fancy that Tsetse-fly will be found to be pretty well distributed throughout the southern portion of Northern Nigeria.'

In addition to the foregoing, a single female, presented by Colonel Griffiths, Chief Veterinary Officer, Egyptian army, has been received from the Pongo River, between Wau and Dem Zibehr, in the Bahr-el-Gazal Province, Egyptian Soudan, where it was taken in 1903. Since this is another new locality for the species, it may be worth while to add that the place of origin is in Goro, west of the Rol country, near the intersection of the twenty-seventh parallel E. long. and eighth parallel N. lat., and that the fly is said to be very abundant there. Other specimens of *Glossina moristans*, collected by the donor in North-Western Rhodesia in 1899 and 1902, have been presented by Mr. Val Gielgud.

As regards the connexion between Tsetse-flies and big game in South Africa, it may be noted that Mr. Robert Codrington, Administrator of North-Eastern Rhodesia in his Report on the Administration of North-Eastern Rhodesia for the year ending March 31, 1903 (Fort Jameson: Printed at the 'Administration Press,' North-Eastern Rhodesia), pp. 15-16, writes as follows:—

'The general increase of game of late years has been remarkable . . . The Tsetse-fly is now, for presumably the same reason, found in districts where it was before unknown.'

Similarly, on p. 23 of the same pamphlet, in a Report by the Civil Commissioner (Charles McKinnon, Esq.) for the year ending March 31, 1903, on North Luangwa and Awemba districts, it is stated that:—

The Tsetse-fly is increasing to an alarming extent to the south of Mirongo, which I take to be due to the increase of game.

These observations support the statements on this subject in the writer's Monograph, pp. 14-15.

Glossina tachinoides (Westw.)

As has already been stated, this species is nearly related to *Glossina pallidipes* (Austen), which, except in size, it closely resembles, but is readily distinguishable by the colour of the hind tarsi. These are either entirely dark, as in the male, or have the first three joints somewhat lighter at the base. The front and middle tarsi are pale, with the exception of the last two joints, the tips of which are usually faintly brownish. The abdomen is marked with deep interrupted bands of dark brown, leaving the hind margins of the segments only narrowly pale. In the present paper there is no necessity to enter into a detailed description of this species, more especially since its diagnostic characters will be found in the appended 'Synopsis.' It may, however, be stated that it is the smallest of all the Tsetse-flies, the males not exceeding 6 to 6½ mm. in length, while the females measure 7½ to 8 mm., exclusive of the proboscis in each case.

In addition to the extensive series of specimens of this species, taken, as already stated, on the Benue River, Northern Nigeria, in the latter half of May and beginning of June of the present year by Mr. W. F. Gowers, the British Museum has received, through the kindness of Professor Mensil, of the Institut Pasteur, and Dr. Brumpt, of the Laboratoire de Parasitologie, Paris, seven other individuals from the series collected on the river Shari, French Soudan, by Dr. Decorse. Lastly, a single female obtained by himself thirteen miles south of Wushishi, in the Kadima River Valley, Northern Nigeria, at the beginning of last March (with three specimens of *Glossina palpalis*), has been presented by Dr. S. H. Jones.

As regards the occurrence of *Glossina tachinoides* on the Benue River, Mr. Gowers has kindly contributed the following note:—

'This species of Tsetse-fly is found along the Benue River between Lau and Lokoja. With the exception of one or two small spots, no horses or cattle can be kept in this area. Above Lau, however, the river banks are swarming with cattle, and there are large encampments of herdsmen in the dry season. After the rains have commenced the fly is present on the river in sufficient numbers to be an annoyance to travellers, and continually bites the canoe-men. In the dry season, however, which lasts from October to April, it is much less numerous.

'On the banks of the Benue River within the area in question almost the only species of game to be found is *Kobus kob*, which is very numerous indeed. West African buffalo, waterbuck, and reedbuck are met with in the swamps near the river; but in the Benue Valley there are, in the immediate vicinity of the river, more kob than specimens of all the other species of game put together.'

According to Dr. BRUMPT,[7] on the Shari River and on the shores of Lake Chad *Glossina decorsei* (that is, *Glossina tachinoides*) seems to be exclusively confined to the water's edge. The author in question further writes as follows :—

'The stab of *Glossina decorsei* is disagreeable, as is that of all the species of *Glossina*, but not very painful; it causes some time after the bite a rather acute itching. Both sexes feed on blood . . . The natives of the Shari dread the effects of the bite of the *Glossina* on their herds; like the inhabitants of many other countries, they have recognized the existence of a close connexion between the presence of nagana and the bite of this fly. Nagana is very widely spread on the Shari, where it was stated to occur by MOREL, and met with again by the Chevalier Expedition.'

Glossina pallidipes (AUSTEN) *and Glossina longipalpis* (WIED.)

There is nothing to add to the account of these species given in the Monograph. Additional specimens of the former, however, have been received from Colonel BRUCE, including six individuals collected by Dr. MOFFAT at Simba, East Africa Protectorate, in a carriage on the Uganda railway, and six examples from Busoga, Uganda. The latter is a new locality for *Glossina pallidipes*. In addition to the foregoing, a long series of *Glossina pallidipes* from Kibwezi, East Africa Protectorate, has been presented by Dr. Nabarro.

Glossina fusca (WALK.)

Since the publication of the Monograph the specimens of this species in the National Collection have been augmented by a large number of examples from Kibwezi, East Africa Protectorate, received from Dr. NABARRO. Besides these, five specimens, also from Kibwezi, collected in a railway carriage by Dr. MOFFAT, have been presented by Colonel BRUCE; while three specimens, obtained on the Congo by the Trypanosomiasis Expedition of the Liverpool School of Tropical Medicine, have been received from Dr. CHRISTY. Of the specimens last mentioned, which are all females, two were captured near Leopoldville, on December 26, 1903, and February 6, 1904, respectively, while the third was taken at Leisha on April 14 last. With reference to these flies Dr. CHRISTY has been good enough to furnish me with the following notes :—

'During our stay at Leopoldville three specimens of *Glossina fusca* were collected. One was brought in by a native alive, folded up in a leaf; another was captured among *Glossina palpalis* by our juvenile fly brigade, and the third was caught under the following circumstances :—On April 14, while sitting after dinner with two State officials, as late in the evening as 10 p.m., under the verandah of the Chef de Poste of Leisha, a wood post some four days' steaming above Stanley Pool, I noticed one of the men, who as usual in addition to shoes and socks wore nothing on his legs more protective than a thin pair of trousers, holding between his finger and thumb a fly which I recognized as a Tsetse and immediately secured. It had been biting the man's ankle, and its abdomen was half full of blood. The man assured me that there was very little pain or irritation, but within ten minutes a large swelling arose obliterating the malleolus. In the morning this had somewhat subsided, but in its centre was a very distinct purple mark, as of a bruise, surrounded by a greenish-yellow area. During the next five day two more specimens of *Glossina fusca* were caught, I believe, by the same individual, at the same place and under precisely similar circumstances, but these I am sorry to say never reached me. Leisha wood post is on the bank of the river, surrounded by forest, and when I camped there for two days in April in the rainy season, *Glossina palpalis* and a large *Simulium* bit unmercifully from morning till night. At this post there were two advanced cases of sleeping sickness.

'A few days before the above occurrence, on my way up river on one of the small stern-wheelers, we found ourselves one afternoon tied up to the bank, while all the available hands on board were set to work to cut wood for our next day's steaming. At dinner that evening I wore, as a protection against mosquitoes, a pair of thin putties beneath my flannel trousers, and afterwards sat talking in the dark on deck. Towards 11 p.m. I felt a severe bite through the puttee, and, putting my hand to the spot, caught a Tsetse full of blood. By the light of the lamp in the saloon I recognized the fly as *Glossina fusca*, but unfortunately allowed the insect to escape while trying to put it into a tube. A quarter of an hour afterwards the swelling from this bite had extended nearly round my ankle. I experienced scarcely any pain or irritation, and in the morning the swelling had almost subsided, though the purple and yellow stain described above remained for days.

'On my return to Leopoldville Dr. Dutton, before I had said anything about *Glossina fusca*, told me that while I had been away a certain official from higher up the Congo, who had taken some interest in biting flies, had, while visiting the laboratory, volunteered the information that the larger of the two species of 'mvakwa'—the native name for the Tsetse—bit at night, an assertion of the greatest interest in the light of my experiences up-river.'

It may, perhaps, be remembered that specimens of *Glossina fusca* found by Captain Crawshay sitting on a path at Kaporo, at the north end of the Lake Nyasa, at sunset in February, 1895, did not bite (Monograph, p. 289). In view of Dr. Christy's observations, their failure to do so cannot have been due to the fact that they were not met with in the heat of the day, as previously suggested by the writer (Monograph, p. 99).

Glossina longipennis (Corti).

Of this species the only specimens received since the publication of the Monograph are a male and female collected in the East Africa Protectorate on the Uganda Railway in 1903, by Captain E. D. W. Greig, I.M.S., and presented by Colonel Bruce; of these the male was obtained at Kibwezi station in thorny bush.

It was pointed out in the Monograph (p. 103) that *Glossina longipennis* 'is the Tsetse-fly of Somaliland and the adjacent regions, but that its range overlaps that of *Glossina fusca* (Walk.), somewhere in the vicinity of the Sabaki River.' Dr. Brumpt states[8] that *Glossina longipennis* was the only species of Tsetse met with by him in Somaliland between July and October, 1901. According to the same author[9] this species is responsible for the dissemination of a form of trypanosomiasis among camels and mules, which is probably identical with nagana, and, like the fly itself, is known to the Ogaden Somalis by the name 'aïno.'

The other species of *Glossina* considered by BRUMPT to be carriers of *Trypanosoma brucei* in the case of domestic animals were referred to at the commencement of this paper, and it may be pointed out in conclusion that this author believes[10] that, in addition to trypanosomiasis in its various forms, Tsetse-flies must play an important part in the dissemination of other diseases due to haematozoa. BRUMPT states that in certain districts on the Upper Congo a filariasis due to *Filaria volvulus* is very widely spread; the disease occurs only among the canoe paddlers—that is, among those who are most exposed to the bites of Tsetse-flies. 'The only cases hitherto known,' writes BRUMPT, 'have been observed in the regions (such as Nigeria and Dahomey) in which Tsetse-flies abound. The lymphatic tumours caused by *Filaria volvulus* are met with, especially in the places towards which the lymphatics of the exposed regions converge.'

REVISED SYNOPSIS OF THE SPECIES OF GLOSSINA

1. Hind tarsi entirely dark, or at least all the joints more or less dark (in the ♀ of *Glossina tachinoides* the basal half of the first joint and the extreme bases of the following joints are usually pale) 2
   Hind tarsi not entirely dark; last two joints alone dark, remainder pale 4
2. Ground colour of abdomen ochraceous-buff, with interrupted dark-brown deep transverse bands, and sharply-defined pale hind borders to the segments; a very conspicuous square or oblong pale area in the centre of the second segment; small species, not exceeding 8 mm. in length (exclusive of proboscis), the males considerably smaller ... *tachinoides*, WESTW.
   Abdomen not so marked, very dark or for the most part uniformly brown, hind borders of segments if lighter extremely narrow and cinereous; pale area in centre of second segment usually triangular, with the apex directed backwards and continued into a cinereous median stripe; larger species 3
3. Third joint of antennae dusky brown to cinereous black ... ... *palpalis*, ROB.-DESV.
   Third joint of antennae pale (orange-buff) ... ... *pallicera*, BIGOT.
4. Large species: length at least 11 mm. (5¼ lin.), wing expanse (measured from tip to tip, when wings are set at right angles to body) at least 25 mm. (11¾ lin.) 7
   Smaller species: Length rarely reaching 11 mm. (5¼ lin.), often considerably less; wing expanse not exceeding 25 mm (11¾ lin.). 5
5. Last two joints of front and middle tarsi with sharply defined dark-brown or black tips ... 6
   Last two joints of front and middle tarsi without sharply defined dark-brown or black tips—front and middle tarsi entirely yellow, or last two joints of former faintly tipped with pale brown ... ... *pallidipes*, AUSTEN.
6. Generally distinctly larger; head wider; front darker and narrower in both sexes, sides parallel in ♂; abdominal bands deeper, leaving hind margins of segments only narrowly pale; hypopygium in ♂ smaller, darker, and more hairy; tip of ♂ abdomen more thickly clothed laterally with short black hair, bristles on sixth segment finer and less prominent ... ... *longipalpis*, WIED.

Usually smaller ; head narrower ; front paler and wider ; eyes in ♂ as well as in ♀ distinctly converging towards vertex ; abdominal bands less deep, pale hind margins of segments therefore deeper ; hypopygium in ♂ larger, paler, somewhat more oval in outline, and clothed with fewer fine hairs ; tip of ♂ abdomen less hairy laterally ; bristles on sixth segment in ♂ stouter and more conspicuous... ... ... *morsitans*, Westw.

7. Dorsum of thorax with four sharply defined small dark-brown oval spots, arranged in a parallelogram, two in front of and two behind transverse suture ; bulb at base of proboscis brown at the tip ... ... *longipennis*, Corti.

Dorsum of thorax without such spots, though with more or less distinct longitudinal stripes ; bulb at base of proboscis not brown at the tip* ... ... *fusca*, Walk.

Notes and References

1. Sur une Nouvelle Espèce de Mouche Tsétsé, la *Glossina decorsei*, n. sp., provenant de l'Afrique Centrale. Par M. E. Brumpt (*Comptes Rendus des Séances de la Société de Biologie*, Séance du 16 Avril, 1904), T. lvi, p. 628-630.

2. *Glossina Longipennis* in Somaliland ; *Glossina morsitans* and *Glossina pallidipes* in Zululand and elsewhere ; *Glossina palpalis* in the basin of the Congo ; and *Glossina tachinoides*, Westw. (*Glossina decorsei*, Brumpt) on Lake Chad and the Shari. Mr. Gowers also found that the latter species carries the disease on the Benue River.

3. *Preliminary Report on the Tsetse-fly Disease or Nagana in Zululand.* By Surgeon-Major David Bruce, A.M.S. Ubombo, Zululand, December, 1895 (Bennett and Davis, Printers, Field Street, Durban), p. 2.

4. *Reports of the Sleeping Sickness Commission*, No. iv, November, 1903.

5. Mr. Gowers has recently informed me that this horse died in three weeks, undoubtedly from Tsetse-fly disease. —E. E. A.

6. In South Africa dogs, at any rate, succumb to Tsetse-fly disease.—E. E. A.

7. *Loc. cit.*, p. 629.

8. *Comptes Rendus des Séances de la Société de Biologie* (Séance du 23 Avril, 1904) T. lvi, p. 673.

9. *Ibid* ; see also *op. cit.*, T. lv, p. 1497.

10. *Op. cit.*, T. lv, p. 1497.

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* N.B.—The ordinary dark-brown patch on each side of the bulb on its upper margin, which is often especially well marked in West African specimens, must not be mistaken for a brown tip.

REPORT ON THE SANITATION AND ANTI-MALARIAL MEASURES IN PRACTICE IN BATHURST, CONAKRY AND FREETOWN

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XIV

REPORT

ON THE

SANITATION AND ANTI-MALARIAL MEASURES IN PRACTICE IN BATHURST CONAKRY AND FREETOWN

BY

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ALFRED L. JONES

Chairman

CONTENTS

INTRODUCTION AND SUMMARY

TO those who watch the progress of the study and prevention of disease in Tropical Countries not only has the foresight and wisdom of the Colonial Minister and the Merchant who first set the example of founding Schools of Research in Tropical Diseases been abundantly proved, but the expenditure of time and money which their creation involved has been very amply justified. In six years the schools, not only of this country but also of France and Germany, have sent forth many hundreds of medical men far better equipped than formerly to grapple with the diseases peculiar to the Tropics. Nor have they remained content with organizing education in this country, they have also given a great impetus to the encouragement of the study of Tropical Diseases in those countries themselves where the diseases are prevalent. The majority of the expeditions which have left Liverpool have made West Africa their centre, and since the first Expedition in 1899 to Freetown, under Major Ross, there has been, with very short intervals, a continuous succession of investigators in West Africa, embracing the Gambia, Senegambia, Sierra Leone, Gold Coast, Nigeria, and the Congo. Freetown has been the seat of numerous investigations, commencing with Ross, Annett, and Fielding-Ould in 1889 ; Christophers and Stephens, 1899-1900 (Royal Society and Colonial Office Expedition) ; Logan Taylor, Ross, and Daniels, 1901-2 ; and again Logan Taylor, 1903. Bathurst and the Gambia were investigated by Dr. Dutton in 1902. At the present time Drs. Dutton and Todd are in the interior of the Congo Free State, and Colonel Giles and Dr. McConnell are visiting the Gold Coast and Nigeria.

As only a very limited time was at our disposal this winter, we rigorously confined ourselves to a comparative study of the sanitation and anti-malarial measures in actual practice in Bathurst, Conakry, and Freetown, and to the investigation of how far the teaching of Ross was accepted and acted upon, and if it could be said that, as the result of anti-mosquito measures and sanitation during the last four years, there had been a noticeable improvement in health.

In our Report we have made short analyses of the chief sanitary features of each town, we have described the anti-malaria measures and the results which may be attributed to them, and we have also ventured to make some suggestions.

In the following paragraphs we summarize the results of our observations and restate our suggestions:—

1. The essential part which the mosquito plays in the transference of malaria is becoming generally understood both by officials and merchants, and greater precautions are taken against them. Great misconceptions, however, still exist, and malaria is by some attributed to smells and the turning over of new ground. Old Coasters are often sceptical, and their indifference is copied by the fresh merchants' assistants and others who proceed to the Coast.

2. Greater care should be taken to instruct merchants' assistants proceeding to the Coast, how malaria is conveyed by certain mosquitoes (*Anopheles*), and by them only.

3. Great care should be exercised by the seniors of the factories to ensure that mosquito nets are rigorously used by their staff and that there are sufficient nets. The comparatively small annual outlay which this will entail will be repaid by the better health of the assistants.

4. A mosquito net is absolutely essential. If used intelligently and in a proper way mosquitoes are never found inside. On no account should the slightest hole be left unmended. They should always be tucked in under the mattress of the bed.

5. The Europeans should make certain that mosquitoes are not bred in their own houses or in their yards. Personal supervision is essential.

6. Until malaria in the native population is substantially reduced from its present exceedingly high percentage, it is essential for the European community to live away from the native quarters at night. There is no half-way measure as long as *Anopheles* are present in the town.*

7. As water, in the form of streams, wells, rain-water pools, marshes, and artificial collections, is necessary to the life of the mosquito, it follows that water should be the first care in tropical malarial towns, and that—

(*a*) Drinking water should be under public control, and that private wells should be rigorously abolished.

(*b*) That streams and springs in a town should be regarded from quite a different standpoint to the European one. They should be constantly inspected for the presence of larvae, and should be overhauled and rechannelled, where necessary, in order to prevent *Anopheles* breeding.

(*c*) Drainage should be carried out in a comprehensive manner by an engineer who is thoroughly conversant with the life history of the *Anopheles*. Want of the latter knowledge may render any scheme of drainage useless, as the great object in view is the prevention of mosquitoes breeding.

(*d*) In order to ensure the prevention of the breeding of mosquitoes in yards, odd receptacles, barrels, and cisterns, there should be an ample and competent sanitary staff.

(*e*) Where possible every attempt should be made to fill up marshes or to so treat their margins as to diminish the facilities for mosquito breeding. Rubbish should not be shot into them.

* This measure was first strenuously advocated by Stephens and Christophers in a Report to the Royal Society, Oct., 1900, and subsequently and independently by Annett, Dutton, and Elliott in Memoir III of the Tropical School Reports.

8. Open storm-water and slop-water drains are safer than closed drains. They should be more carefully constructed and more rigorously supervised.

9. Cess-pits should not be allowed—the dry earth and pail systems are the best.

10. The grant for sanitary administration should be increased.

11. In view of the importance of scientific investigation in connexion with both the preservation of the health of man and animals and the industrial progress of the colonies we consider that it would be of great economic value to devote a small sum to the establishment in each of the principal coast towns of a pathological laboratory and to obtain the services of a pathologist.

12. Greater attention should be devoted to the study and prevention of diseases in domestic and transport animals. The appointment of skilled veterinary officers for this purpose, as well as for conducting experiments upon the acclimatization and propagation of animals of economic value would be a very great gain.

13. Greater attention should be given to the cultivation of vegetables. Conakry shows a good example in this respect.

14. It is essential in order to measure the results of sanitation and anti-mosquito measures that the health statistics of the European population should be made complete. That all classes of Europeans should be included, and that in the case of malarial fever an effort should be made to trace, if possible, the place where the patient contracted the infection.

15. Considering the very great interest which is taken in the health problems of our Colonies we think that fuller information might, with advantage, be furnished in the annual colonial reports.

16. The anti-mosquito measures have made for cleanliness and order, and they have made people think and become more careful, and we are of opinion that both as the result of the knowledge of the means whereby malaria is spread and can be prevented, as well as by the more careful selection of those who proceed to the Tropics, the health of the Europeans is improving.

REPORT ON THE SANITATION AND ANTI-MALARIAL MEASURES IN PRACTICE IN BATHURST CONAKRY AND FREETOWN

THE GAMBIA

Bathurst

MEMOIR X, published by the School in 1903, consists of a report of the Expedition of 1902 to the Gambia, in which Dr. Dutton describes in detail the topography, climate, and health problems of Bathurst, thus rendering it unnecessary for us to go over the ground so carefully covered by him. We will confine ourselves to those features of interest, from a sanitary point of view, which appeared to us worthy of note and useful in comparing the means adopted for the preservation of health in the three coast towns which we visited, namely, Bathurst, Conakry, and Freetown.

Bathurst is well laid out, there is an extensive sea front, and the streets are for the most part broad, except in the back of the town in the native quarter where many of the streets are narrow. The population consists of about eight thousand natives and one hundred and five Europeans.

The soil is porous and sandy and, therefore, water does not tend to remain upon the surface, and drying after rain is in consequence rapid. But at the same time, as so often happens, the sub-soil water comes to within some eight feet of the surface ; a well is most easily scooped out in the ground, and in certain places the town is below sea-level—this of course together with the uniform flatness of Bathurst complicates drainage.

There is not much vegetation in the town of Bathurst, and the native compounds are for the most part free from bush or grass. Grass and weeds, it is true, are present in most of the streets, but there they bind the loose soil and help to maintain the sloping banks of the central street drain ; they become a great disadvantage, however, when they grow long and impede the water in the drains or make pools where mosquito larvae breed.

European Quarters.—The houses of the Europeans and the public buildings are close to the sea front, and there is no undue overcrowding amongst them. The older houses are built of stone and the rooms in them are large, airy, and cool ; the new houses are built on the bungalow plan and are excellent. There is no definite separation of the European houses from those of the natives, the latter often come close up to the former, only the European houses have the advantage of an open sea front.

Recreations.—Bathurst possesses in McCarthy Square a magnificent open space in the middle of the town, and shows a good example to other West African towns in respect to the encouragement which is given to out-door sport ; the Square affords an excellent centre for it. The Europeans go in for tennis, polo, cricket, and bicycling. When we visited Bathurst the town sports were being held ; they were witnessed by many thousands of spectators, and the competitions amongst the native inhabitants were excellent.

In spite of the presence of the tsetse fly in the neighbourhood horses are procurable.

Climate.—Arriving late in December we were not long in becoming aware of one of the reasons why Bathurst presents a favourable contrast to other coast towns. Almost surrounded by the sea and with the harmattan blowing from the end of October to the beginning of May, the climate is by no means disagreeable to the European ; and the great diurnal variations of temperature which occur at this period, whilst they are not so much felt by the European, are very trying to the native population. The wet season, on the other hand, from June to September, accompanied as it is by a most equable temperature and with no breeze, is the season most felt by the European.

The following is the meteorological return for the year 1903 made by Dr. Forde :—

Month	Temperature °F.					Rainfall	
	Solar Maximum	Shade Maximum	Shade Minimum	Range	Mean	Amount in inches	
January ...	160	93	56	37	71·9	—	
February ...	160	100	60	40	75·3	—	
March ...	164	100	61	39	76·5	—	
April ...	160	93	64	29	75·2	—	
May	165	88	67	21	75·4	—	
June	160	89	69	20	79·2	5·91	Total rainfall 57·13 in.
July	165	89	68	21	79·0	7·13	
August ...	159	89	70	19	79·3	35·87	
September ...	160	89	67	22	79·4	4·15	
October ...	162	91	67	24	79·7	4·07	
November ...	165	92	63	29	79·0	—	
December ...	157	89	57	32	73·1	—	

Night-Soil and Refuse Disposal.—The town of Bathurst, except near the swamps, is remarkably free from offensive smells—a fact which is entirely due to the simple system of sewage disposal largely employed. The Europeans invariably use earth closets, which are emptied daily into the sea ; and a considerable proportion of the native population also make use of receptacles, which are cleansed once a day, morning or night, in the river. Were cess-pits the rule, as in Freetown, the subsoil water would become in a short time dilute sewage. Unfortunately, however, modified cess-pits are also in use, a tub placed in the ground is used as a privy. 'Only occasionally earth or lime is mixed with the excretal matter. When full, which takes from one to two years, the tub is discarded, and another inserted in a fresh place in the compound. Both tubs and privies were found to be infested with multitudes of fly maggots' (DUTTON).

These pits are undoubtedly a source of great danger to Bathurst ; from them percolation takes place freely into the well-water, and must lead to its extensive pollution, besides acting as a fertile source for breeding flies, which, in their turn, may act as the carriers of disease. Cess-pits and wells are incompatibilities, and as long as the condition obtains, especially in Bathurst, where underground mixing must take place owing to the nature of the soil and abundant ground water, dysentery and intestinal affections must be common and be the cause of a great proportion of the mortality found in the native population, and constitute a most serious menace in the case of the introduction of typhoid and cholera.

Sir GEORGE DENTON and the Chief Medical Officer, Dr. FORDE, have both given their most careful attention to the subject, and there is little doubt that a great improvement will be made. Judging from what we saw in those compounds in Bathurst, where pans are so successfully used, and also from Conakry, where no cess-pits are allowed, we are strongly of opinion that the simple dry pail or pan method should be universally adopted, and that no form of buried receptacle should be allowed, cemented or otherwise. In a soil like that of Bathurst it would be costly to construct water-tight middens ; water carriage is out of the question, and incineration would be most costly. Taking into consideration the short distance of any part of this town from tidal water, we think that the plan which has yielded such admirable results in Conakry would also prove a success in Bathurst, and it is not too much to expect of the native when the advantages are put to him, that he should co-operate with the Sanitary Authority and empty his own pail into the sea, either at night or in the early morning (compare Conakry), and so save expenditure upon additional labour. In addition, increased public latrine accommodation could be provided for at suitable places, both in the town and on the shore. The method has the advantage of absolute simplicity and freedom from nuisance, and can be carried out at small cost. Incineration or complex methods of any kind are liable even in Europe to frequent failure, and the risks are much greater in tropical countries.

Slop-Waste.—In the native compounds the small amount of slop-waste and the urine, is thrown on to and is readily absorbed by the porous soil. There are, however, in some instances deep-cemented underground tanks for the reception of waste water.

Public urinals of a very simple and efficacious kind, and containing special receptacles which are removed daily, have been placed at suitable spots in the town, and there are also public latrines projecting out from the shore.

Refuse.—Owing to the absence of abundant vegetation in the town, there is a comparatively small amount of leaf refuse, and the success which has attended the efforts of the Medical Officer and his staff to prevent the accumulation of bottles, tins, and other receptacles for water, has resulted in the compounds of both European and natives presenting a very clean appearance. The scavenging is done by a gang of twenty labourers and two horses and carts, under the supervision of an Inspector and an Assistant Inspector of Nuisances. All rubbish, consisting of house refuse and leaves raked up in the streets, is carted to the back of the town where it is burnt and utilized for the filling in of the swamp and levelling up depressions in the open areas (Dr. FORDE). The more determined the effort to burn the decomposable rubbish the better ; it is a bad material for filling up, more especially where there is water, for then decomposition must set in ; its presence on the borders of Box Bar swamp constituted in our minds the only source of disagreeableness in an otherwise most clean town.

Water Supply.—The ease with which water can be found accounts for the very numerous shallow wells seen almost everywhere in the native quarters, and for the deeper wells for public purposes and for those in the compounds of the merchants. As mentioned above, they can never be free from suspicion, and there can be little doubt that many are badly contaminated, and that they constitute a fertile source for the distribution of intestinal diseases amongst the native population. A great improvement has been brought about by the encouragement of the use, for drinking purposes amongst the natives, of the supply at the public wells. These are placed at advantageous spots in the town as far from contamination as possible. They are covered, and satisfactory pumps have been and are in process of being fitted to them. But it is the history of all places where there is more than one form of water supply that the supply nearest to hand is the one which runs the greater chance of being used. Bathurst is probably no exception, and until the private wells are got rid of altogether they will undoubtedly be frequently used. In the meantime, the deep public wells with their pumps, which are well looked after, are attracting more people, and so mitigating the risk of infection. Whilst the native population make use of the wells, the Europeans and some of the native traders wisely use for drinking purposes the rain water collected from the roofs into large galvanized iron tanks or into large cemented cisterns constructed in the ground. As will be seen later, the wells and imperfectly closed cisterns of Bathurst supply a very large number of the mosquitoes of the town. Failing the bringing of a water supply to the town from a distance, as at Conakry, good water-tight cisterns for the rain water offer a good substitute ; and in the second line come deep public wells carefully cemented for a considerable depth, so as to avoid surface contamination, covered in and fitted with a good pump, and so placed as to be as far from pollution as possible. With the abolition of cess-pits, the possible risk of contamination from the wells will be greatly reduced.

Drainage.—The street drains of Bathurst are a very striking feature in the town, they are conspicuous by their great size, and run in the centre of the roadway, they are for the most part square, cemented, stone or brick ; in the upper portions of the town they tail off into shallow grass drains. No doubt they would be better if they were all U-shaped in section and if they were not so broad. But they have the merit that you can see what is in them—in this respect being superior to the far more costly underground street drains at Conakry—and they are certainly superior to the street drains in Freetown. They suffer from the disadvantage of a proper fall. Dr. DUTTON has pointed out that the shallow grass trenches are responsible for the majority of the mosquitoes in Bathurst during the months of September, October, and November. There is no doubt that perseverance and much supervision and the increase of the sanitary staff under the medical officer can do much to lessen the stagnation of water and therefore the mosquito breeding-places in the drainage system of the town during the wet season. But no doubt also the time has come for the making of a general survey of the town, the levelling up of the depressed compounds and streets, the completion of the filling in of Half Die Swamp, and the modification and completion of the present scheme of drainage. Bathurst requires to be treated as a whole, and proper falls made. We trust that the open system of drainage will always prevail.

The filling up of Half Die Swamp was discontinued in 1903 in consequence of the difficulty in obtaining proper labour. A large proportion, however, of that portion which had already been levelled up has now been built upon and streets laid out on it. We agree heartily with the Official Report for the Gambia, 1903, that the filling up of this swamp and the scheme for drainage of the town are intimately connected and demand comprehensive treatment, and we hope that a move will be made.

Public Works.—A noticeable feature of the administration of Bathurst is the excellent public works which have been organized at a moderate outlay by the Government of the Colony. We visited the hospital, market and slaughter-house, prison, and the barracks.

The Hospital.—The hospital is an old stone building, which, however, has been admirably rearranged and adapted to modern requirements at a comparatively small cost. The wards are well lighted and airy. The European ward is protected by wire gauze, and a similar precaution is being adopted for the other wards. Scrupulous cleanliness is everywhere observed. There is a total absence of smells, and the dry-earth closet system is most successful, and there is no danger of a contaminated water supply.

The hospital administration is excellent, and the best practical proof of this is the increasing popularity of the institution. Thus, the number of out-patients treated during the year 1903 was 8,477, an increase of 4,652 over the previous year. There was also a substantial increase in the number of in-patients, and more major operations were performed. The work of the medical staff has been greatly aided by the fitting-up of a new operating-room, excellent dispensary, and a small well-equipped laboratory for microscopic analyses.

A very striking feature in the hospital is the excellent nursing system, due to the introduction of nursing sisters. These ladies reside in a bungalow specially erected for them immediately adjoining the hospital, and, to quote from the official report of the Gambia for 1903, 'it is a pleasant duty to be able to record that to these ladies, who have not spared themselves any trouble, is due much of the improvement noticeable in the internal arrangements of the hospital, where their presence has given the greatest satisfaction to all classes of the community, especially to the lower class, who are much more ready to become in-patients than formerly, as they feel that they will now be cared for.' The natives have commenced to thoroughly appreciate the benefits to be derived from organized medical skill. This is well shown by the increasing severity of the operations which have been successfully undertaken by the medical officers, as well as by the large increase of out and in-patients. The hospital cannot fail to play a most important part in the educational welfare of the community by the excellent example which it sets in the power of medical skill and nursing, in cleanliness, and in organization. It has fully justified the modest expenditure which has been incurred, and to our minds no charity in the colony will yield a richer return for the money invested in it. The success of the hospital is a proof of what can be accomplished by constant personal supervision.

Opportunities for Investigation.—The small, but well-equipped, laboratory in the hospital affords ample accommodation for scientific work both in connexion with the cases treated in the hospital as well as those occurring in the district. It could serve as the central laboratory in the capital of the colony. Investigations could at any time be undertaken in it in connexion with the distribution of disease in man and animals throughout the Gambia. The time of the medical officers is now fully occupied in clinical work and sanitary administration, and the full advantages of the laboratory for the prosperity of the colony would probably be rendered practicable only by the appointment of a scientific assistant under the chief medical officer for the sole purpose of conducting microscopic, bacterial, and chemical analyses, and the collection and investigation of vegetable and animal parasites injurious to man, animals, and to the economic plants of the colony.

The Food Market and Slaughter-House.—The construction and arrangement of the market are good. No animal or vegetable offal is allowed to collect, and there is an absence of offensive smells. One of the most noticeable of the sanitary features is the very large wire gauze safe in which the fresh meat is hung and effectively protected from flies. The stalls for the animals brought to market are outside the market enclosure. The slaughter-house on the shore at a convenient distance from the market is new and advantageously built upon a pier projecting into the sea, with the result that all offal and blood is carried away by the tide ; it may, however, be necessary to carry it still further out. It would be very difficult to devise a simpler and more sanitary method of slaughter. The excellence of the market most materially conduces to the health of the community, as it provides an abundance of fresh, wholesome food. It is most satisfactory to note that again strict personal supervision and the rigid enforcement of cleanliness rather than capital expenditure upon elaborate market arrangements has been found to meet all requirements.

The Prison.—The building is of stone, the majority of the cells are large and well-lighted, and the sanitary arrangements thoroughly good, the simple pans, which are cleansed daily, being in use. The water supply is good, and there is no danger from sewage contamination. A few cases of beri-beri have occurred in the prison, and there were three deaths recorded in 1903 ; all three cases, however, came from the same village, in which it was afterwards discovered that the disease existed. It is very difficult to understand how this disease could originate in the prison, where there are few prisoners, no overcrowding, plenty of air, and a very liberal diet. The greatest care is taken with the rice to ensure a uniformly good quality, free from damage of any kind. In the absence of definite knowledge with regard to the causation and propagation of this disease, reliance has to be placed on the enforcement of sound hygiene.

The Barracks are old stone buildings surrounding a square and excellently placed. Alterations, consisting of the substitution of iron for much of the old wood rafters and supports, have been carried out, and further changes are contemplated.

There is ample accommodation for officers and men, and plenty of air and light, mosquito netting, scrupulous cleanliness, and the simple pail system for the removal of excreta.

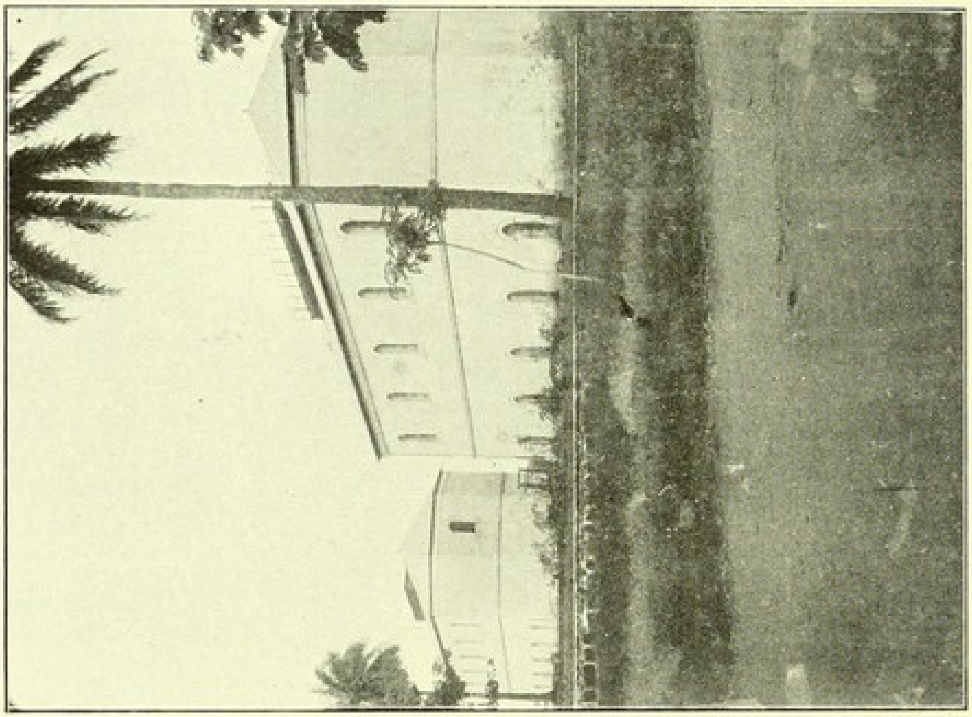
Health of Bathurst.—The health of the European has remained remarkably good. Quoting from the official report for 1903, there were forty-eight cases on the sick list out of a European population of one hundred and five. The majority of cases were of a trivial character. Two deaths occurred from malaria, one being of the blackwater type. Both had recently arrived from Senegal, where they had been resident fifteen to twenty years. There was a considerable number of cases of dysentery amongst the natives.

Table of Cases of each kind of Disease Treated in the Hospital in the Year 1903, with the Number of Deaths from each such Disease (*Medical Officer's Report*) :—

General Diseases			Local Diseases		
Diseases treated	Number of cases	Number of deaths	Diseases treated	Number of cases	Number of deaths
Malarial Fevers ...	106	3	Diseases of the Eye ...	26	...
Blackwater Fever ...	1	1	" " Ear ...	2	...
Typhoid Fever	1	1	Nervous System ...	14	4
Beri-Beri	10	3	Circulatory System ...	4	...
Dysentery	11	3	Digestive " ...	49	2
Debility	8	...	Generative " ...	7	...
Febricula	5	...	Genito-Urinary " ...	30	3
Gonorrhoea	7	...	Lymphatic " ...	12	...
Hemiplegia	1	1	Respiratory " ...	42	8
Pyaemia	1	1	Connective Tissues ...	2	...
Syphilis	7	...	Organs of Locomotion ...	28	...
Sleeping Sickness ...	11	4	Skin	108	...
Tumour	2	...	Injuries	56	1
Tetanus	1	1	Parasites	4	...
Tuberculosis	1	1	Surgical Operations ...	4	...
Rheumatism	20	..	Total ...	581	37

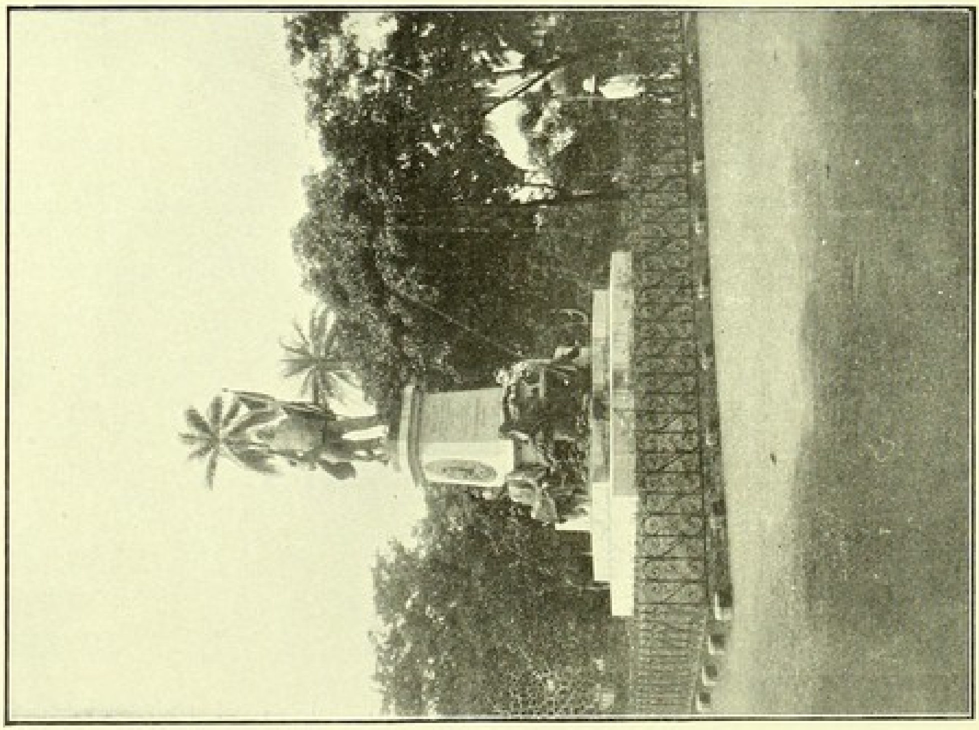
Anti-Mosquito Measures.—Bathurst is a good natural breeding-ground for mosquitoes. Half Die and Box Bar swamps and all the low-lying parts in the wet season give rise to large numbers. Owing to the want of suitable fall, and in certain places due to the fact that parts of the town are below sea level, uniform drainage of the streets is difficult, and mosquitoes breed in the pools which form in many of the streets in the rainy season. The numerous wells are a fertile source of supply to a less extent, wash tubs, garden tubs, and rain barrels. When Dr. Dutton investigated the mosquito distribution in Bathurst, in 1902, he found that the compounds of the native inhabitants and of the Europeans were extensive breeding-grounds, and that the number of breeding-places in a compound often increased with the social position of the occupier. At that time also the boats along the foreshore, and innumerable cans and bottles and other waste receptacles in the compounds, furnished a very large number of mosquitoes. Very extensive anti-mosquito measures, instituted by His Excellency Sir GEORGE DENTON, have resulted in diminishing the number of breeding-places in compounds. In 1902, one hundred and thirty-one cart loads of old tins, pots, and other rubbish were removed. In 1903, the anti-mosquito work was kept up steadily. Ten labourers were employed in collecting and removing old tins and broken bottles which were buried or used for filling up depressions. Before the rainy season set in, ten additional labourers were employed in levelling and clearing the grass drains in the streets. The Inspector of Nuisances, with his regular staff of twenty labourers, one assistant inspector, and two carts carried out the general scavenging work. The Inspector visited gardens, yards, and compounds, and reported daily to the Chief Medical Officer. Wells and other receptacles were examined for mosquito larvae, and an attempt was made to keep these covered. At the present time these same measures are in active operation. Dr. FORDE has recently reported (1904) that insufficiently covered wells form the breeding-grounds of a very large number of mosquitoes in the dry season, and steps will be taken to render the public wells, at any rate, free from this complaint. With regard to the shallow private wells, it is obviously very difficult to get the native to realize the necessity of covering them, and we think that the only remedy here is abolition. Private tanks, owing to badly-fitting covers, also are a source of mosquitoes in houses, but this is a matter which increased attention will remove. The Medical Officer has also reported favourably upon the manner in which his instructions with regard to the prevention of mosquito-breeding have been carried out, and the intelligent endeavour which has been made, both by the Europeans and natives, to assist in the anti-mosquito sanitation of the Board of Health.

General Result of Anti-Mosquito Measures in Bathurst.—The anti-mosquito measures in Bathurst, as elsewhere, have made for cleanliness and order; they have made people think and become more careful. The mosquito-net has been more regularly used, and the European population has undoubtedly remained very free from malaria. It cannot be said, however, that the numbers of *Culex* mosquitoes have diminished in the wet season. The compounds of natives and Europeans alike are much cleaner. The European trader recognizes more fully the advantage to be gained by the systematic use of the net and the good which he can do and the assistance which he can render the sanitary authority by most carefully looking after his own compound and preventing breeding-places. We feel sure that when it is realized by the native inhabitants that the mosquito is responsible for a very large proportion of the infantile mortality and sickness rate, owing to the predominant share it takes in transmitting and propagating malaria ; when it is understood by them that the *Filariasis* and *Elephantiasis* present in Bathurst is also due to the mosquito, and that Yellow Fever could at any time appear amongst them because of the presence in their midst of the Yellow Fever carrying mosquito, we venture to think that they will do all they can to strengthen the hands of the local authority by co-operating in what is after all only a movement in favour of cleanliness and general sanitation.



WATER TOWERS, CONAKRY

Photo.—Dr. Clarke



STATUE TO GOVERNOR BALLAY, CONAKRY

Photo.—Dr. Clarke

to face p. 11

FRENCH GUINEA

Conakry

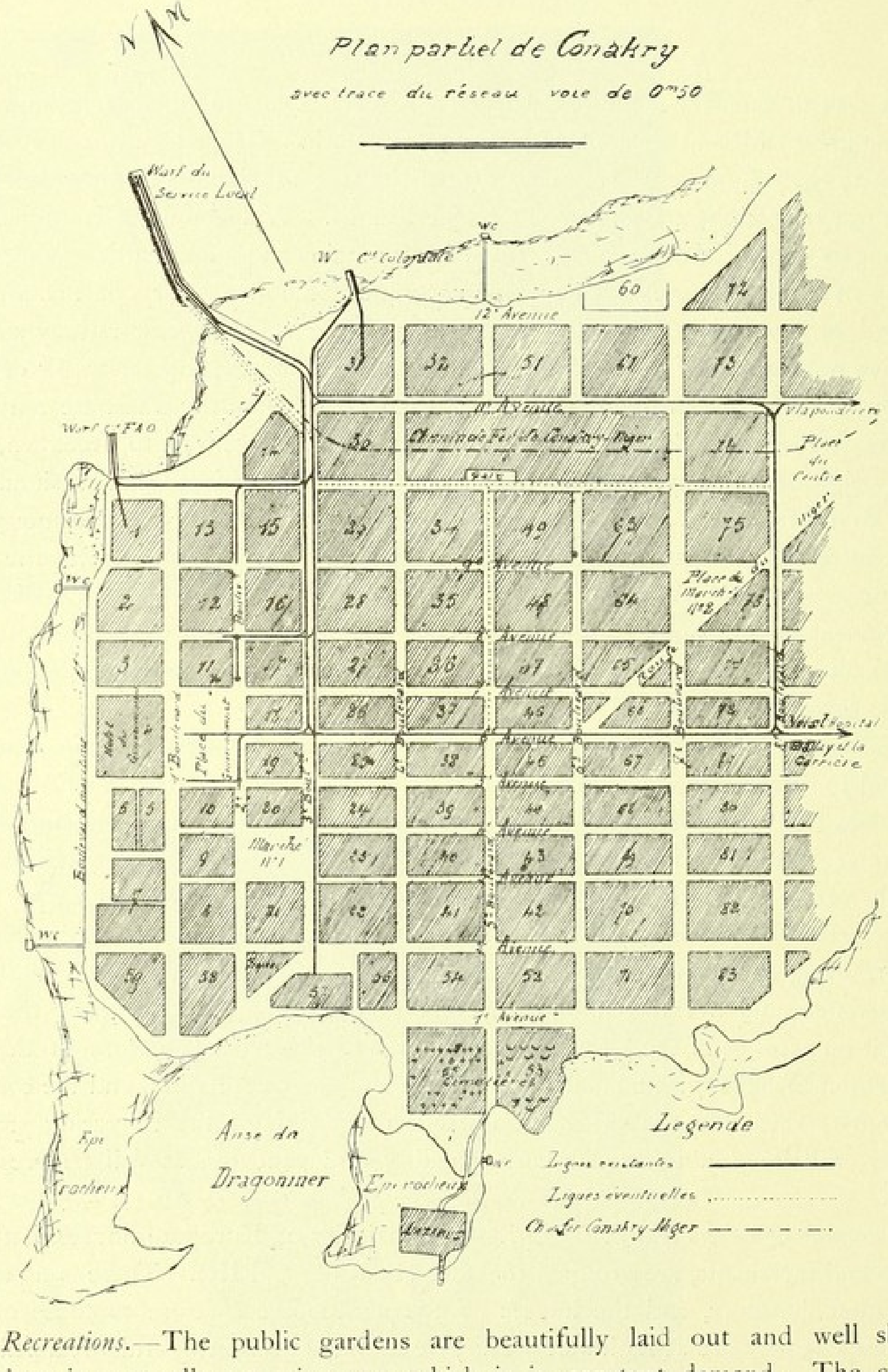
A visit to Conakry is a most instructive lesson. One cannot fail to be impressed with the great skill and energy which in a few years has planned and constructed a modern town. Commerce was its *raison d'être*, nevertheless everything has been carried out true to the classic instincts of the French. Wide boulevards intersect at right angles equally wide avenues; there are fountains and public gardens, and, most striking of all in a West African town, a very fine statue in memory of the services rendered by Governor Ballay (Plate I). A landing stage, a vast railway station, extensive waterworks of the most modern type, a new hospital, and a network of light rails, by means of which the goods landed from the ships on the wharf are conveyed expeditiously and directly into the various factories. The contrast to Freetown, only seventy-eight miles away, is striking, and the French determined that it should be so, for to use the words of the former Colonial Secretary:—'Pour lutter avantageusement contre la colonie anglaise de Sierra Leone, le seul moyen est de créer une ville rivale de Freetown.' And they have done so, and now 'L'example de Conakry est un argument sans replique contre les pretentions de nos concurrents anglo-saxons, dont les journaux repetent qu'il est inutile de nous laisser créer des colonies puisque nous ne savons rien en faire.' (Famechon).[1]

In many respects the town reminds one of Ismailia. Conakry contains some ten thousand to fifteen thousand inhabitants, of which about four hundred are Europeans. It occupies the Island of Tumbo, and is connected to the adjoining mainland by an iron bridge. It is not raised much above sea-level, but a gradual slope takes place from the centre to the beach all round, rendering drainage comparatively easy. It is not intersected by streams, and even after the severest rains in September, pools are not left, owing to the very spongy nature of the laterite. There is an abundant ground-water, and every compound has its well; they are deeper than those at Bathurst on account of the lower level of the water. The fertile nature of the soil and the non-brackish ground-water produce an abundant vegetation, and the contrast to Bathurst, where the ground water is brackish, is striking; the increasing growth, however, will no doubt have its corresponding disadvantages, as will be presently shown.

European Quarters and Social Life.—The majority of European houses, both for officials and merchants, are grouped together (Plates II and III). There is no actual segregation, however, and the houses of the natives are as close to those of the Europeans as they are at Bathurst. This, we think, is now being fully realized and its significance appreciated. The European factories are well constructed, and the

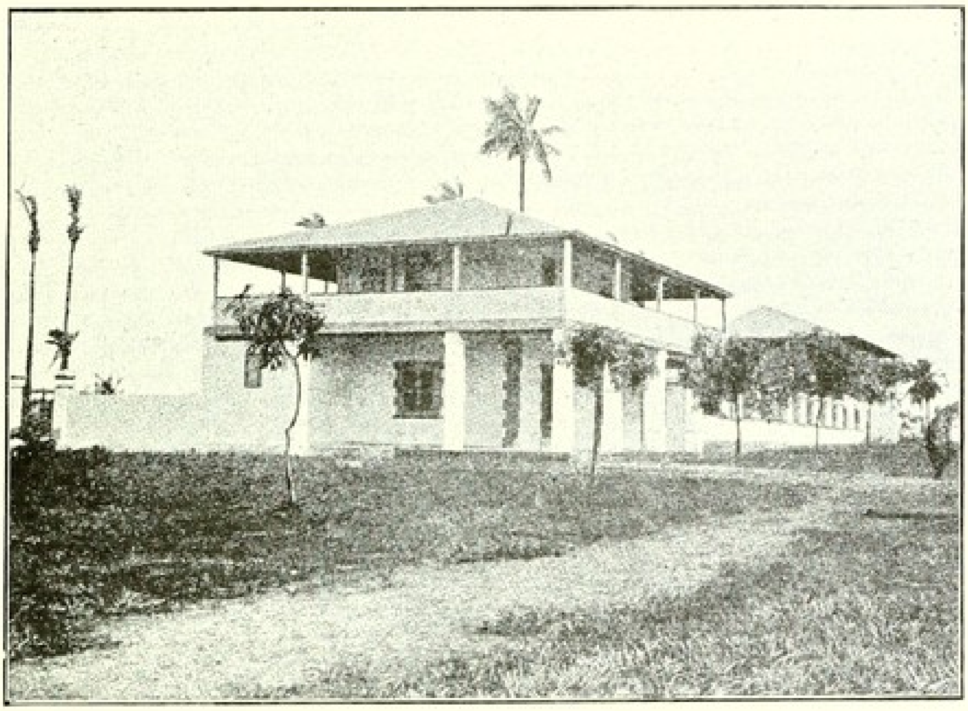
1. Preface to the Handbook of French Guinea at the International Exhibition, Paris, 1900.

merchant's life appeared to us to be passed in a far more comfortable manner than in many instances in Freetown. The town is kept scrupulously clean—roadways, factories, and compounds alike.

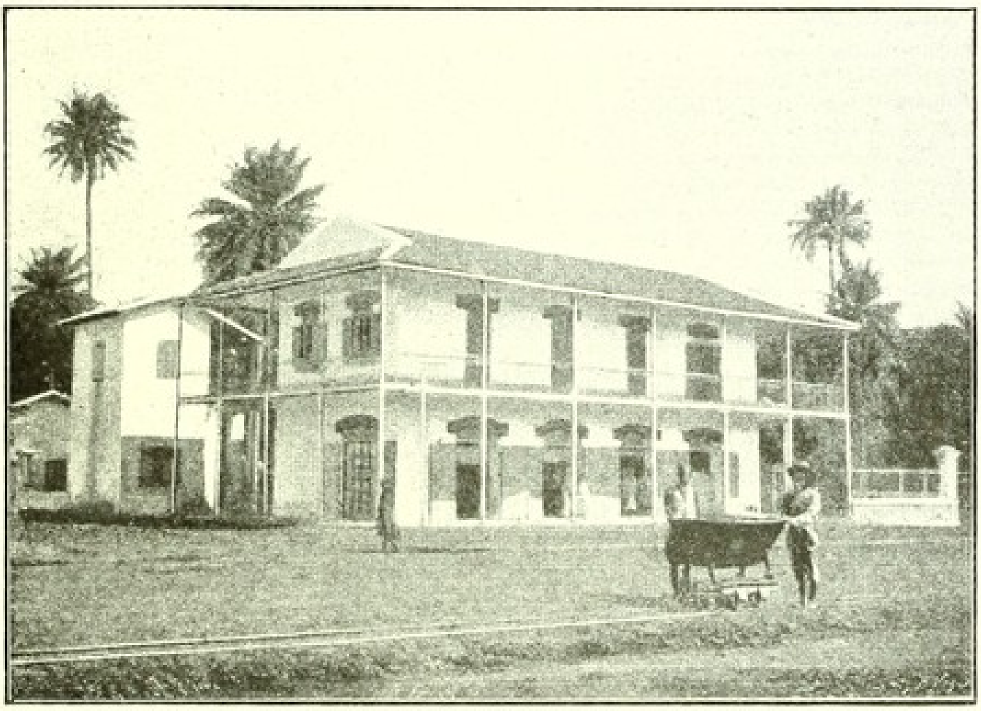


Recreations.—The public gardens are beautifully laid out and well shaded, and there is an excellent tennis court, which is in constant demand. The circular road makes an excellent promenade by the sea. There are very few horses however.

Climate.—The climate is described as good. In the month of January it appeared to us to be quite as hot as Freetown. There are no great variations of



TYPE OF FACTORY. CONAKRY (*From Government Report*)



TYPE OF FACTORY, SHOWING DECAUVILLE RAILWAY. CONAKRY
(*From Government Report*)

temperature. The harmattan in January and February lasts about thirty days. The wet season extends from the end of March well into November, and the total rainfall is approximately four metres. During the wet season the atmosphere is very oppressive and the heat is more severely felt. During the five dry months the early morning dew is very heavy and does much good to vegetation.

TABLE SHOWING TEMPERATURE, MOISTURE, AND RAINFALL FOR EACH MONTH DURING THE YEAR 1902

		Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Aout	Septembre	Octobre	Novembre	Décembre	Année, 1902
Températures extrêmes	Maxima	28·8	21·	31·2	35·	33·2	33·5	28·4	28·4	27·8	29·	29·	29·	33·5
	Minima	23·8	23·2	21·	23·	22·4	22·8	24·	22·9	22·	23·8	24·	23·4	22·4
Moyenne des températures	Maxima de chaque jour ...	27·7	27·8	30·	30·5	31·3	27·1	27·4	26·4	26·7	27·5	28·	28·5	28·1
	Minima de chaque jour ...	24·8	25·1	25·2	25·4	25·6	25·5	25·2	24·9	24·1	25·1	26·	25·3	25·2
	Du mois	26·2	26·5	27·6	27·9	28·4	26·3	26·3	25·5	25·1	26·3	27·	26·7	26·6
Pressions barométriques extrêmes	Maxima	765	767	765	767	768	767	769	768	768	768	766	767	769
	Minima	763	763	762	762	763	764	764	764	763	764	763	764	762
Moyenne des pressions barométriques ...		763·9	764·5	763·3	764	764·8	765·2	766	765·3	765·4	765·8	764·2	764·8	764·7
Etats hygrométriques extrêmes	Maxima	94	94	94	100	100	100	90	92	89	87	88	80	100
	Minima	60	51	17	30	36	71	72	70	72	68	49	32	17
Moyenne des états hygrométriques... ...		84	77	72·5	81·3	80	80	82·5	82·6	80	77	71·7	69	78·9
Nombre de jours de pluie		0	0	4	8	13	25	29	29	27	21	6	1	163
Quantité de pluie tombée		0	0	8 mm.3	47 mm. 9	170 mm. 3	560 mm.	1·218 mm. 6	1·001 mm. 2	947 mm. 7	583 mm. 1	43 mm. 1	0	1m.580 mm. 2
Etat du ciel compté de 0 á 10 (moyenne) ...		1·7	2·26	1·7	2·8	4	5·5	6	6	7·2	6	4·1	3·6	4·3
Nombre de Tornades		0	0	0	5	11	10	2	2	4	10	3	1	48
Nombre de jours de tonnerre		0	0	0	11	12	22	15	11	8	15	11	1	106

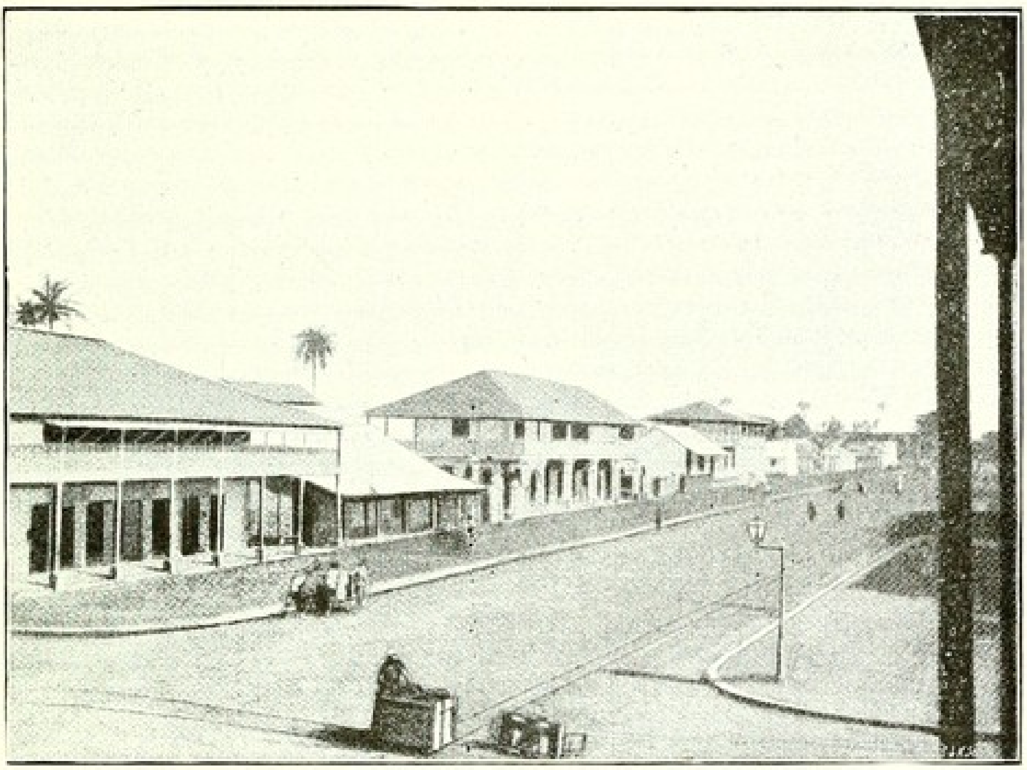
Removal of Night-Soil and Refuse.—Conakry possesses an immense advantage in that there are no cess-pits of any kind. The bucket and pan system is in use by Europeans and natives alike, and the receptacles are emptied once a day—at night or in the early morning. There are also five public latrines distributed around the island, which project from the shore (See Plan and Plate III); but in some cases they do not extend far enough out to sea. They are made much use of. There is remarkable freedom everywhere from faecal or putrid smells, and there is no doubt that this is due to the exceedingly strict police supervision. The native is compelled to assist in maintaining a state of sanitary efficiency with regard to the disposal of excreta, which is in striking contrast to the noxious cess-pit system existing in Freetown.

Refuse.—The abundant vegetation leads to a proportionate production of litter, but nevertheless compounds and streets are kept remarkably clean, and there are exceedingly few bottles or other receptacles to be found which might harbour mosquitoes. We did not, however, like to observe that the neighbourhood of the shore had been made a dumping-ground in certain places for rubbish. There are also many waste, unbuilt-upon spaces in the town which favour the production of bush.

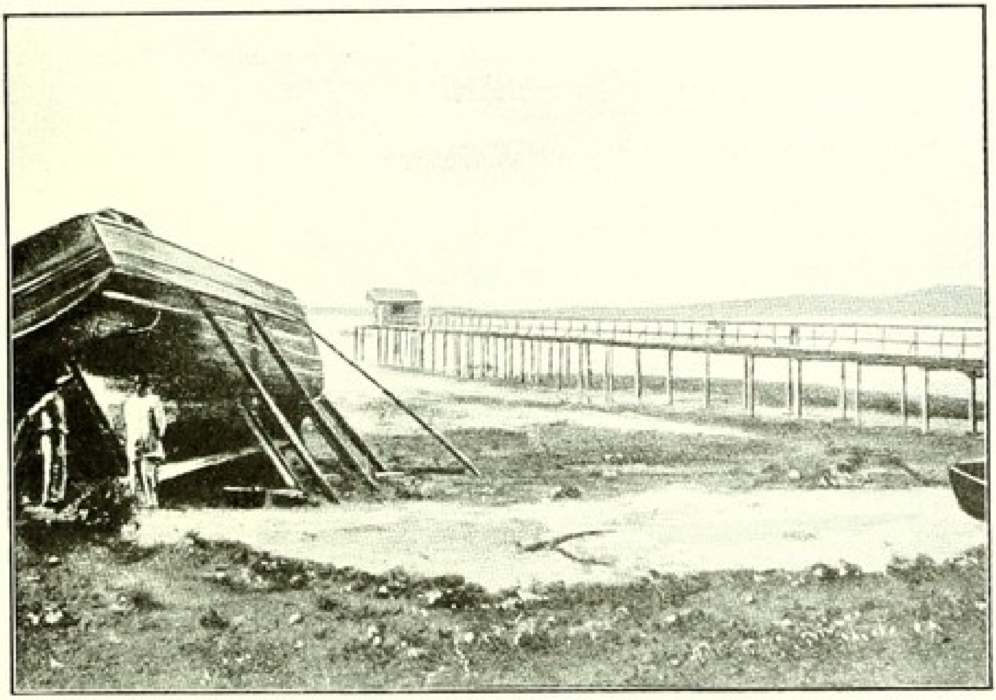
Water Supply.—The water was formerly entirely derived from deep wells excavated in the laterite. The authorities early recognized the dangers of such a source of supply; chemical analysis showed a considerable proportion of organic matter, and, furthermore, at the end of the dry season the level of the ground-water was much lowered, and the supply in consequence curtailed.

Governor Ballay initiated the undertaking, since completed, of bringing a pipe line from water courses forty-one kilometres distant. The conduit, which is capable of delivering two thousand two hundred and eighty cubic metres of water per twenty-four hours, terminates in solid, handsome, water towers containing the large iron reservoirs, and situated in the highest part of the town (Plate I). The reservoirs are protected in the tower from dust and heat. From this source the water is carried down the various boulevards and distributed to public works, factories, fountains, the public washhouse, and some forty stand-pipes situated at convenient places in the boulevards. The water supply, as shown both by chemical and bacteriological analyses, is of great purity.

The Disused Wells.—With the introduction of this pure source of supply the wells have fallen into disuse; they are very numerous, one or more being present in all the compounds; a considerable growth of shrub may now be seen emerging from them, as no attempt at filling in or covering them has, as far as we could observe, been made. Malaria is not on the decrease in Conakry, and the wells must prove an abundant and practically the sole source of *Anopheles* supply. The benefits which are to be expected from this effective and modern water supply cannot be realized as long as the obsolete wells are kept to breed innumerable mosquitoes.



PRINCIPAL BOULEVARD IN CONAKRY, SHOWING FACTORIES AND DECAUVILLE RAILS. THE MAIN DRAIN IS UNDER THE FOOTPATH ON THE LEFT (*From Government Report*)



A LATRINE ON THE SHORE AT CONAKRY (*From Government Report*)

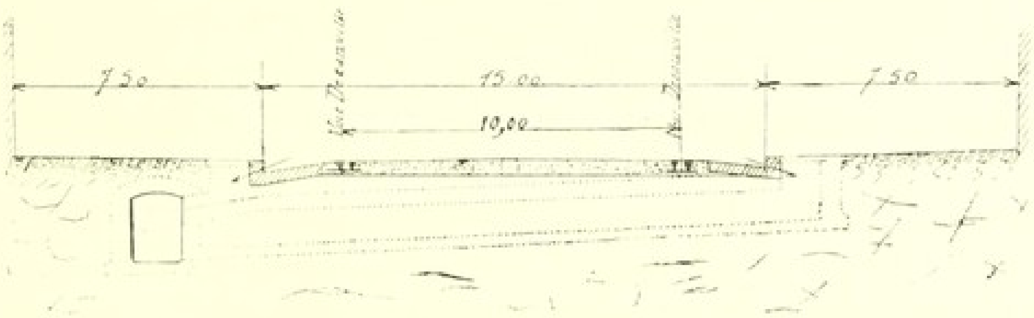
to face p. 14

The abundant new water supply is not altogether free from blame in favouring the development of mosquitoes, for usually around each standard there is a collection of water, due to the faulty taps from which the water slowly trickles away.

Drainage.—Conakry possesses superior natural advantages to both Bathurst and Freetown in respect to drainage. The soil, as in Bathurst, is porous, but the superior elevation and the deeper level of the ground-water and the freer underground drainage prevent flooding. In the severe rains the roads are not liable to be cut up as in Freetown, where the falls are very steep, and the rush of water in consequence very great.

Only the third or principal boulevard has been completed, and, including drainage, it has cost sixty-five francs per metre run to construct ; it will serve as the model for the other boulevards, if it is deemed advisable to complete them. In the construction of the drains the engineer had to calculate upon being able to cope with the maximum storm water in addition to waste water from the factories ; the largest amount of rainfall observed in Conakry, viz., 0m. 08, in three hours being made the basis.

In the words of the Report for 1903 the relatively flat form of the Island of Tumbo, upon which the town is mapped out by straight boulevards running north and south and equally straight avenues at right angles to them east and west, caused the authorities to abandon the use of wide section drains which might act as collectors, and to recommend the construction of one drain in each boulevard of sufficient section to deal with nine hundred to one thousand litres of water a second and opening at each end of the boulevard on to the beach. It was planned that the water from the avenues should be led to the boulevard drain by pottery or other form of drain.



Section of Roadway

Slop Waste.—The question of the provision for the domestic drainage was left to the future, and it was thought that special sanitary drains might eventually be constructed against the wall of the storm-water drains in order to avoid the decomposition in the main drains, which would be sure to take place, more especially in a tropical town, if slop-water were allowed access to them. It was intended also to carry the sanitary drains well out to sea. It was also thought that a special system of sea-water flushing might in the future be arranged for. The main drain in the Third Boulevard is built in concrete, and runs beneath the footwalk on one side and receives the drainage of both sides of the road as shown in the above plan. We have very carefully considered the advantages which such a scheme of drainage might possess in a tropical town over the more frequently met with open drain. There is little question that the Third Boulevard in Conakry has the appearance of a modern and well-made street in a European town. But conditions are so totally different in Europe and the tropics. In the first place, the authorities have rightly recognized that it would be fatal to connect any offensive domestic waste water with the main drains, for did decomposition occur in these large covered-in drains with their comparatively little fall, the consequences would be very bad. Covered-in drains in a tropical town would greatly facilitate decomposition, and the offensive gases would necessarily find their way through the untrapped openings by the side of the road and a very serious and dangerous nuisance would be the result. The question of drainage is difficult and costly enough in the civilized world and is far from being settled ; it seems a pity, therefore, to introduce into a West African town a system which depends upon a civilized population, constant supervision, and an abundant water supply, and, moreover, the West African town has to face immense sudden rainfalls, and the drains have to be constructed for the maximum storm water flow, and in consequence in the dry season they are far too large for domestic drainage.

The authorities of Conakry have, however, reserved their drain chiefly for rain-water in the wet season. With regard to the question of the advantage of the covered over the open drain, it appears to us that since the mosquito has now come to be recognized as the sole channel of infection in certain diseases, that the covered-in drain, unless very great care is taken, may even prove a worse breeding-ground than the open drain where, at any rate, the mischief can be seen and readily got at. The covered-in drain has also other serious disadvantages, amongst the worst of which in a tropical country is the rat. The drain suits this rapacious rodent admirably, and it is not necessary for us to dilate on the damage which these pests might do the goods in the various factories or to the health of the community by the introduction of plague. As if to accentuate the unforeseen dangers of the covered-in drain in a tropical town, it so happened that in our short stay at Conakry a young leopard escaped from the gardens and found refuge in the main drain, where it was ultimately caught. We freely admit that the open street drains, as seen in Freetown, are not calculated to impress one at first sight with their advantages over the covered, but we think that the advantage would be on their side if they were of uniform construction in stone or cement, and were rigorously kept free from rubbish. Some of the outlying streets in Conakry have shallow grass drains, concrete gutters are also found ; the majority of streets are, however, undrained.

Some Public Works.—The *Markets* are very good, simply constructed of iron, and with concrete floors. They are kept clean. The meat market presents no special feature, as at Bathurst. The *Slaughter-house* at the end of the First Avenue is built on the beach.

The *Public Wash-houses* are a great advance. That in First Avenue is an iron-roofed structure with concrete floors and concrete tanks, through which a stream of water continually flows. There is accommodation for about twenty people at one time.

The *Hospital Ballay* is a very fine modern structure, carefully planned, and when complete will consist of four pavilions, each containing twenty-eight to thirty beds, in addition to the blocks set apart for the staff, management, and nurses. The pavilions are connected together by raised covered galleries. The situation has been well chosen in the most airy part of Conakry, and at some distance from the town. The hospital also comprises a large pharmacy, a small microscope and post-mortem room, and a disinfecting chamber. Separated from the European hospital there is a block devoted to the treatment of the natives; it contains accommodation for about thirty in-patients. The native ward did not appear to us to be as well-equipped nor as comfortable as those at Bathurst and Freetown.

At the present time the question of nurses is a difficulty, as the Sisters of St. Joseph no longer officiate.

The Health of Conakry.—Table I shows the number and variety of diseases which were treated in the hospital in 1902. Table II indicates the death-rate amongst Europeans for the years 1900, 1901, 1902.

Table I

Genre due Maladie		Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Aout	Septembre	Octobre	Novembre	Décembre	Totaux
Fièvre paludéenne ...	Européens	1	2	6	1	2	3	2	13	16	14	9	6	75
Anémie palustre ...	Européens	...	1	2	3	3	2	1	1	1	1	4	...	19
Accès pernicieux ...	Européens	1	...	...	...	...	...	...	...	2	...	...	...	3
Fièvre bilieuse hémoglobinurique ...	Européens	...	...	...	...	1	1	2	2	...	3	1	...	10
Congestion du foie et hépatite	Européens	1	2	1	...	1	1	2	2	6	1	2	2	21
Dysenterie	Européens	...	...	1	1	...	...	1	...	...	...	1	...	4
	Indigènes	...	...	...	...	...	...	...	...	...	...	...	2	2
Diarrhée endémique	Européens	...	...	...	...	...	...	1	1	...	...	...	...	2
	Indigènes	...	...	...	...	...	...	...	...	...	...	1	...	1
Insolation	Européens	1	...	2	...	...	...	1	...	...	...	...	...	4
Ténia	Européens	...	...	2	...	...	...	...	...	...	1	...	1	4
	Indigènes	...	...	...	...	...	...	...	...	1	1	...	...	2
Maladies sporadiques	Européens	...	1	...	1	...	1	...	1	...	1	3	5	13
	Indigènes	...	...	2	1	...	1	...	...	1	2	...	1	8
Maladies chirurgicales	Européens	1	...	1	1	2	2	...	1	1	1	1	4	15
	Indigènes	1	...	1	...	1	1	...	1	1	1	4	2	13
Maladies vénériennes	Européens	1	...	1	1	2	...	2	...	...	3	...	1	11
	Indigènes	...	...	1	...	...	...	...	...	...	...	...	...	1
Totaux		7	6	20	9	12	12	12	22	29	29	26	24	208

Table II

Genre de Maladie	1900		1901		1902	
	Entrées	Décès	Entrées	Décès	Entrées	Décès
Fièvre bilieuse hémoglobinurique ...	15	4	8	3	10	...
Accès pernicieux	4	4	2	2	3	3
Anèmie palustre	8	...	10	1	19	...
Fièvre typho-malarienne	2	1	...	...	...	...
Dysenterie	5	1	...	...	4	...
Maladies sporadiques	15	5	9	2	13	1
Maladies épidémiques	...	...	1	1	...	...
Autres maladies	104	...	93	...	128	...
Totaux	153	15	123	9	177	4

From these tables it will be seen that there is a very considerable number of malaria cases, especially at the end of the rainy season—probably as many as one hundred and twenty amongst the Europeans. It is the most formidable disease amongst them ; dysentery and diarrhoea are rare, no doubt, owing to the excellent water supply. 'Of the one hundred and seventy-seven entries of Europeans, one hundred and seven, or two-thirds, were due to malarial infections : these were not all primary cases, as very many preferred the advantage of the new hospital rather than be nursed at home.' Very many of the cases also came from the interior.

Blackwater fever is comparatively common ; there were ten cases in 1902, but none terminated fatally. The statistics for 1903 are not yet available, but from the information which we obtained neither the simple cases of malaria nor the blackwater cases show signs of decrease ; the tendency is the other way. When we visited the hospital there were two cases of blackwater fever in the wards, and one death occurred in a Syrian. The treatment of blackwater in the hospital consists in raising the blood-pressure by normal saline intravenous injections, and the administration of quinine.

A case of *Yellow Fever* occurred in 1901, but rigorous isolation directed towards the prevention of mosquitoes having access to the case, no doubt, prevented spreading. Yellow fever is always a disease to be feared along the coast, for *Stegomyia* is very generally found.

In 1902, cases of leprosy and elephantiasis were noted amongst the natives, as also one case of Madura foot. Conakry is, especially, to be congratulated upon the comparative rarity of dysentery.

Diseases in Animals.—There are very few horses, as the *Trypanosome* is said to kill them.

Opportunities for Investigation.—Conakry affords the student a very large field for investigation, especially in the various forms of malaria, such as blackwater. In the large hospital every convenience could be obtained, and it is to be hoped that the French authorities may decide to establish there a research laboratory for the investigation and prevention of malaria and other tropical infective diseases in Guinea.

Anti-Mosquito Measures.—It is impossible to ascertain from the various health returns published by the Sanitary Department what are the total number of cases each year of primary malarial infection in Conakry itself. A large number of those who enter the hospital have contracted their malaria elsewhere. It is a very great disadvantage that this analysis is not made, for until it is done it is difficult to say definitely whether malaria is increasing in the town of Conakry or not. We were led to infer that it was on the increase. During our visit in January the disease had appeared amongst the Douaniers, and in one man especially, who had not left Conakry. We made enquiries and found that the customs men did not make use of mosquito nets, and that there were the usual uncovered wells in the yard. Mosquitoes made their appearance at night, but the men did not notice their bites.

It is of interest to note, as indicating the attitude of the authorities to malaria in Conakry, that it is stated in the 1901 Report on the French Guinea (dated June, 1902), that Conakry, like other West African towns, affords all the conditions favourable to malaria—such as nature of soil, growth of vegetation, heat, and moisture. On the contrary, we are of opinion that there ought to be little excuse for malaria. In the 1902 Report, Dr. Tautain, Colonial Secretary, refutes the soil theory of malaria, and states that the malaria cases in 1902 were on the whole less serious than in previous years, in spite of the fact that owing to laying the water-mains 'never was so much fresh earth disturbed along the Boulevards in Conakry, and that, too, in the rainy season.' Dr. Tautain now regards the mosquito as the transmitting agent, and he is directing attention to them.

With model water supply under the control of the authorities, no streams, a good porous soil, and perfect sanitation, mosquitoes should be got under control, and the freedom of the Europeans and of the natives from malaria guaranteed. Mosquitoes are present in Conakry, and both *Anopheles* and *Stegomyia* have been found, and no doubt the disused wells and the overflow from the stand-pipes are the chief sources of supply—the increased vegetation is also a matter of concern. In our opinion the wells should be closed and vegetation kept well under control, and the use of the net might also be much more rigorously enforced.

The merchants and their assistants enjoy very good health, and from personal knowledge we know that the net is largely used amongst them.

Although we were unable to obtain definite figures of the proportion of malaria in the young native population, cases do occur, and observations similar to those conducted at Bathurst, Freetown, and other West African towns would no doubt reveal its presence in the proportion of 80 per cent. It is, however, a matter of great importance to have this point settled.

Risks in Connexion with Public Gardens

The Experimental Garden at Camayen.—For this very extensive garden irrigation is essential, and there are several wells from which water is pumped. There is a pavilion for the director and his assistants, and there is a well close at hand. We found *Culex* larvae, and no doubt with more extensive searching we would have found *Anopheles* larvae also. The European employees suffer from malaria. It appears to us that the wells and the system of irrigation employed in gardens around public buildings and hospitals, in botanical and experimental gardens in tropical countries, should be more closely watched in order to prevent mosquito-breeding.

SIERRA LEONE

Freetown

Freetown may be seen from two aspects. Looked at from the steamer in the harbour it gives the impression of some small English seaside town, well situated with its cathedral and churches, warehouses, and private residences. Upon the numerous wooded hills, which form a magnificent background to it, are advantageously placed the barracks, officers' quarters, and military hospitals; in the distance high up on the right is the recently established European cantonment, and dotted about are numerous private villas. Everything looks green and homely without any overcrowding (Plate IV).

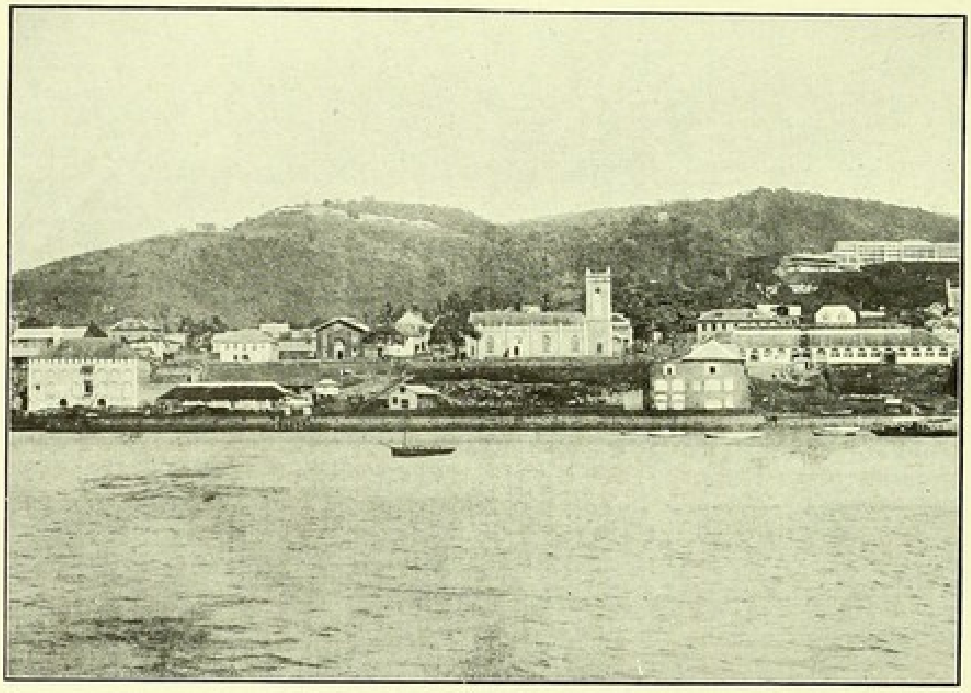
Viewed, however, from the hills above and behind the town, a totally different impression is produced. It appears as an extensive and irregular town, crowded with houses and buried in a luxuriant tropical vegetation (Plate V).

Freetown is a city with a municipal council, a mayor, and a population of more than thirty-four thousand beings. Native life is everywhere prominent as well in the various professions as in trade. It possesses a Protestant cathedral, numerous churches of various denominations, and Church of England and Nonconformist colleges and schools. The work of the city council is like, in many respects, that of an English town council. Much has been accomplished by it in the past, but it is also aware that a great deal remains to be done.

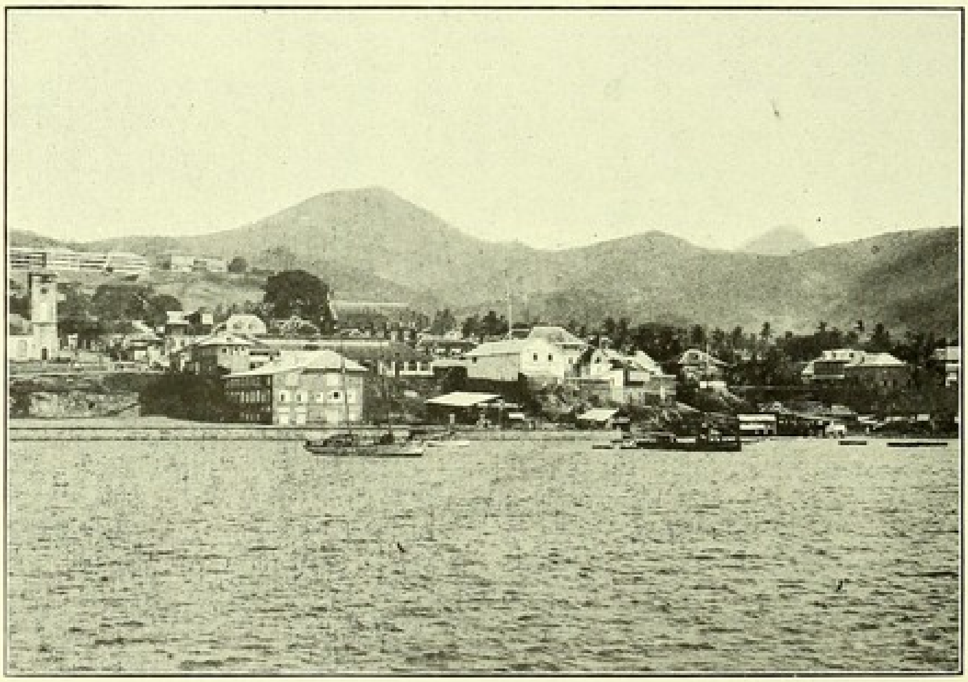
However closely the life of the city of Freetown may be modelled upon that of an English town, great differences must continue to exist. Whilst the native in the interior of the Protectorate naturally follows out the simple laws and customs which have been handed down to him by his ancestors, the Sierra Leonian has adopted, with very little training, complex western methods which bring with them corresponding responsibilities. He cannot, unaided, at once reap the benefits which he expected from them, nor will he at once realize his responsibilities; only under the patient direction of the white man will this be made possible.

Considerations like these are to be borne in mind in any analysis of the sanitary progress of Freetown. Those who are familar with the difficulties of health administration in European towns must be prepared to be confronted with still greater ones in a community which has only comparatively recently adopted Western methods. Let every credit be given to the city of Freetown for what it has already accomplished and let it be encouraged to further work.

Freetown is not regularly laid out as in the case of Conakry or Bathurst. The houses are mostly constructed of wood; many appear well built, but there is a very

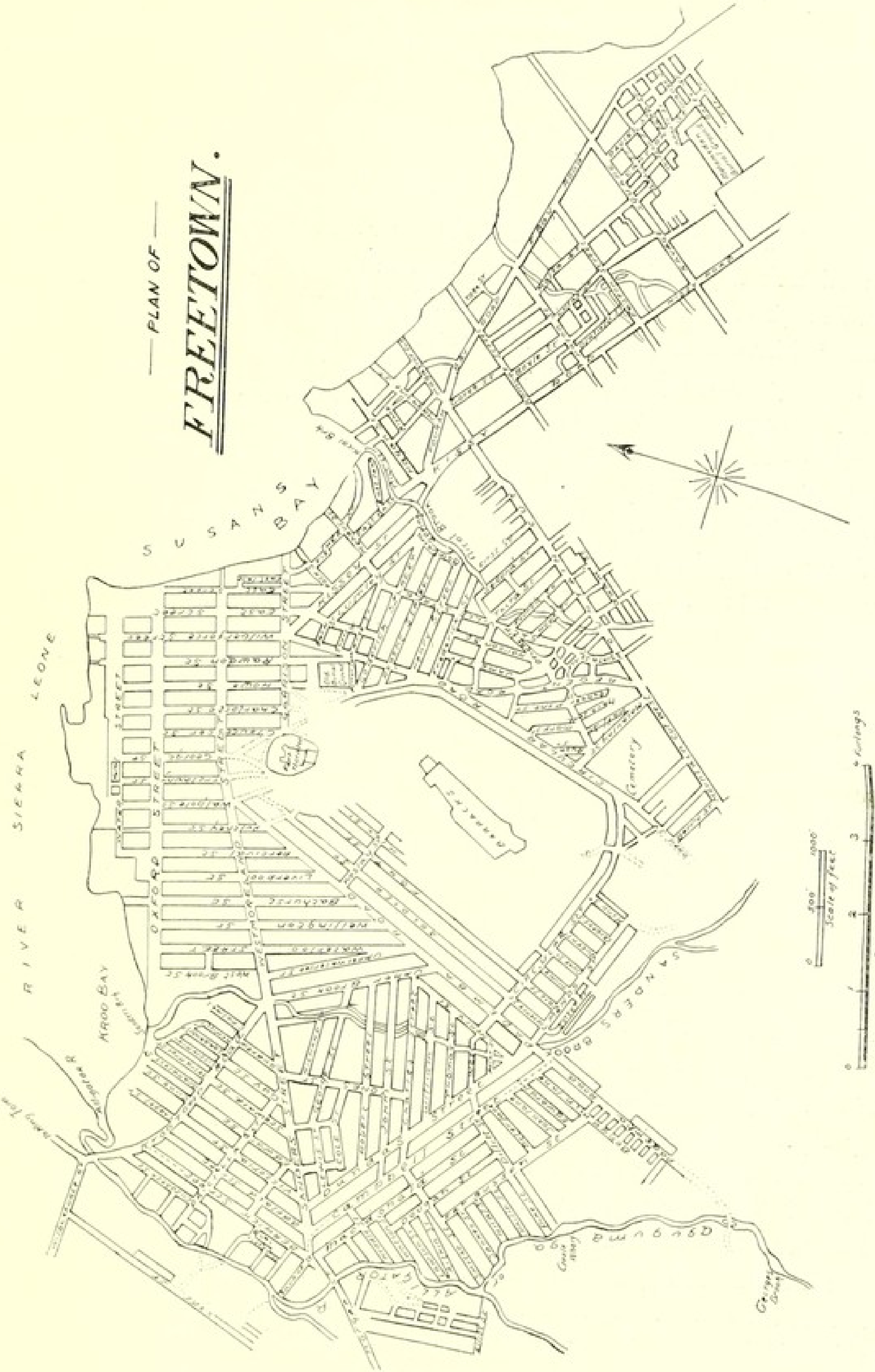


FREETOWN, FROM THE BAY. TOWER HILL BARRACKS ON THE RIGHT ABOVE; MOUNT AUREOLE AND KORTRIGHT HIGH UP ON LEFT



ANOTHER VIEW MORE TO THE WEST; HIGH UP ON THE RIGHT IS PLACED THE NEW EUROPEAN SETTLEMENT

to face p. 23


PLAN OF
FREETOWN.
SUSANS BAY
RIVER SIERRA LEONE
KROO BAY
OXFORD STREET
Cemetery
Scale of feet
Scale of ½ Mile

distinct English influence in the construction of the better ones which is not at all suitable to the tropics. There is no uniformity in size or style, and houses that are well kept may be found side by side with others running to decay; indeed the impression produced by dilapidated property is not good (Plate VI).

The surface of Freetown is very uneven; one part of the town is built upon a steep slope extending from the hills to the sea, and many streets are in consequence steep; on the other hand, those which cross them may have very little fall. The houses upon one side of a roadway may be considerably lower than those upon the opposite side, and the road itself may be higher on one side than on the other (Plate VI). Parts of the town are flat. The result of this irregular configuration is that in the wet season the storm-water either rushes down the steeper streets and overflows the drains and cuts up the roadway, or many of the side streets and the houses on the lower levels, as well as the lower portions of the town, become flooded and sodden.

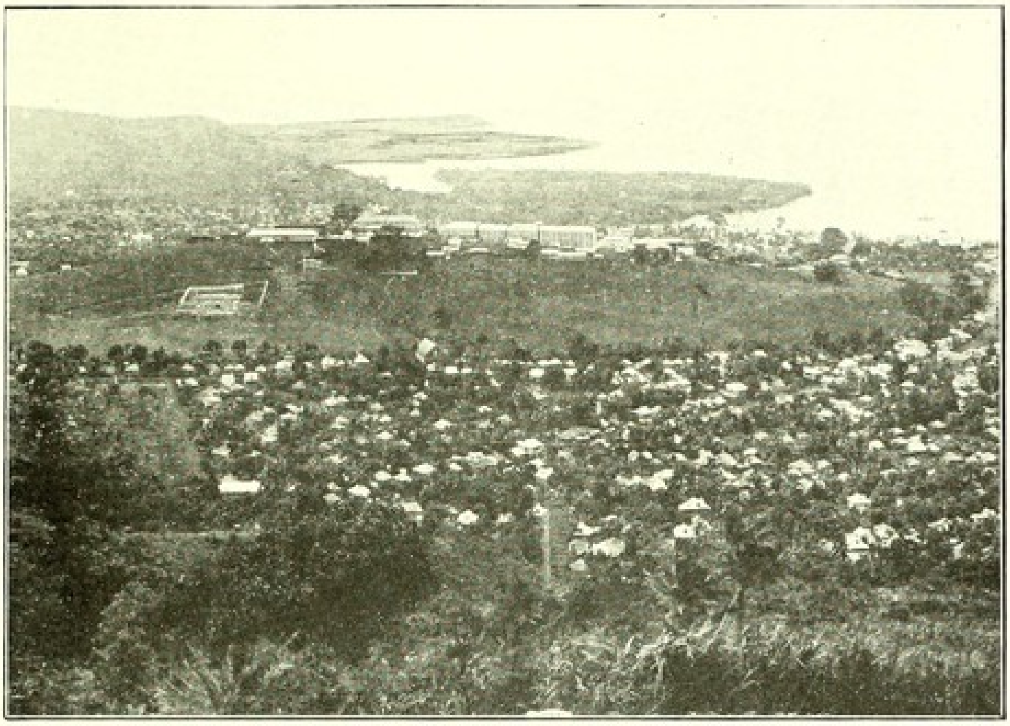
Streams.—There are three which serve as the natural water courses from the hills to the sea; during the heavy rains they are converted into torrents. There are also numerous small streams and springs. The three large streams pass through the city, and in doing so they become sewage contaminated. We found the sewage fungus (Sphaerotilus) present in many places, nevertheless the streams are in constant use for washing purposes.

The Soil.—The soil is, in some districts, porous and sandy, but more often hard laterite is found. Many of the roadways consist of this hard material and their surface is in consequence irregular, and contains very numerous pockets in which water remains after the rains.

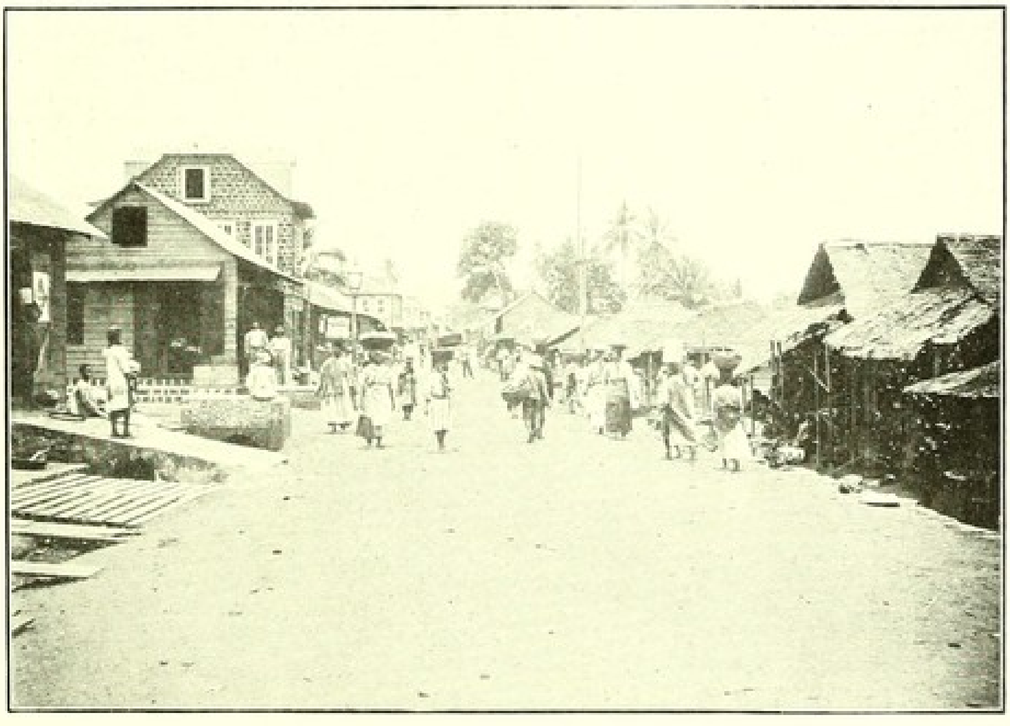
The Sub-Soil Water.—The height of the sub-soil water must vary considerably in Freetown owing to the configuration of the land and the nature of the soil, and during the wet season there is a very considerable rise; in some places the water will drain away easily, in other places it will pocket. Wells abound, they are usually deep and the water in them varies according to the height of the sub-soil water.

The Vegetation.—The soil and moisture favours an abundant vegetation. The hills are covered with dense bush which penetrates into the town. Vegetation is everywhere overgrown and requires to be checked.

European Quarters and Social Life.—The sites which have been chosen for the military appear to us to be excellent, for they are all high above the town. The buildings on Mounts Aureole and Kartright are some eight hundred to one thousand one hundred feet above sea level; the barracks at Wilberforce are six hundred feet and those nearer to the town, on Tower Hill, some four hundred feet high. Around Tower Hill the bush has been cleared for a considerable distance, and efficient drainage carried out. These sites are all cool and airy, and the native houses are at a considerable distance. The military hospital on Mount Aureole appeared to us, both on account of its situation and sanitation, to be a model of its kind.



VIEW OF FREETOWN, FROM THE HILLS AT THE BACK ; SHOWS THE CROWDED NATIVE TOWN AND DENSE VEGETATION



A STREET IN FREETOWN, SHOWING DRAIN AT SIDE AND NUMEROUS GANGWAYS OVER IT. HOUSES ON RIGHT SIDE ARE LOWER THAN STREET LEVEL

A great improvement has also been effected in the life of the European population. A site for a cantonment was selected on a high ridge, nine hundred feet above sea level, far from native houses, and in 1904 some twenty-two model bungalows were finished. These have been occupied by the Government officials, and an adjacent area has been reserved for the erection of merchants' houses. A pure water supply is laid on to each house, and a most convenient highland railway, five and three-quarters miles long, carries the residents to and from Freetown to Hill Station. The bungalows are raised up and supported upon iron pillars upon concrete beds, and a concrete platform has been constructed beneath each bungalow. With stringent and careful sanitary regulations this colony should prove a very great success, and no effort should be spared to make it successful. The European merchants have not as yet taken advantage of this site. It is, no doubt, difficult for them to leave their warehouses at night-time, but we feel sure that the advantages which would be gained by the change of fresh air in the evening and during the night, or the rest at the week end, would outweigh any inconveniences, which, moreover, we venture to think are not insuperable. Furthermore, we feel convinced that social life would be promoted between the various elements of the white population, and this is a matter which is rightly considered of great moment where there are only some two hundred and seventy Europeans in a vast population of thirty-four thousand. The government has made a great experiment, which in the light of all modern knowledge and of the local conditions existing in Freetown, is a wise one, and one which it behoves, therefore, all those who are interested in the promotion of the health of the colony to help. If it is permissible for us, as the result of our short visit, to make comparisons, we think that both in Bathurst and Conakry the merchant draws a more strongly marked line between his business and his social life than is the case in Freetown, and we can well imagine, with no loss of profit to business and certainly with greater benefit to health and well-being, conditions which, in the long run, are best for business. When comparison is made of the density of population, of the sanitary conditions, and of the accommodation for the merchants in the three towns, it is clear that Bathurst and Conakry lead, and that until Freetown itself is rendered more sanitary it is wisdom for the merchant to avail himself, in the meantime, of every help that is offered. The European is slowly appreciating the fact that endemic malaria exists to the extent of at least eighty per cent. in the young native population of the West Coast, and that it must take a considerable time and most vigorous anti-mosquito measures before this figure is measurably reduced. The European cannot, therefore, make a wiser move than to follow the first steps which would be taken in every civilized country to avoid an infectious disease ; these precautions, moreover, do not interfere with full intercourse and the conduct of business with the natives during the day, and, therefore, with the primary object of the merchant. The government has also set another example and taken a wise step in erecting mosquito-proof houses for the railway officials at Cline

Town. It was necessary for these officials to be close to their work, special houses were, therefore, constructed in an area at some distance from the native quarters ; the ground has been cleared all round and recreation arranged for. Although the site is low the soil is sandy and water does not remain.

Recreations.—For its size, in comparison with Bathurst or the French town of Conakry, Freetown seems not to have paid much attention to outdoor games. But this will no doubt be soon remedied, as a golf course has already been laid out ; but a lung in the town such as McCarthy Square, in Bathurst, would serve a most useful purpose. There is a public garden, but it is not so large as that at Conakry. It is a matter of great regret that there are no horses. It is said that they would die from Trypanosomiasis ; but we think that an experiment might with advantage be made of introducing horses free from blood parasites and determining definitely how long they do survive. The experiment could be tried at one or other of the military stations.

Climate.—In the dry season the air on the hills is very fresh and cool ; in the wet season some of the hills are said to be damp owing to the condensation of the moisture in the air due to the fall in temperature at night of some 6° to 7°. Owing to its being shut in by the hills, the air in Freetown itself is close, except at points along the bay. The average shade temperature is 80° F., and there is little diurnal variation. The rainfall is exceedingly high ; it varies from one hundred and twenty to two hundred inches per annum and from five to ten inches in one night. The rainy season lasts from May to October.

Disposal of Excreta and Refuse

Excreta.—**The great abomination of Freetown is its foul system of cess-pits.** In 1897 Dr. Prout made a most careful survey and found that there were some two thousand six hundred and fifty cess-pits and two hundred and eighty-six open pits in the various yards. As many as one thousand two hundred persons had no accommodation of any kind, and the occupiers would have been obliged to seek the shore or waste places. Since that date the number of cess-pits has increased.

In addition, pits when they become full may be covered over and new ones made. They vary in depth ; some are twelve feet deep. Dr. Prout estimated that seven hundred and fifty tons of faecal matter and over two million gallons of urine were deposited in these cess-pits during the year. A more objectionable method of the treatment of excreta could not be found, and to it must be attributed a very large proportion of the diseases prevalent amongst the native population.

In company with Serjeant Walker, the chief sanitary inspector, we had many opportunities of examining the cess-pits. They all presented the same bad features :

they were close to the house and usually within a few feet of the well, they swarmed with maggots, and they had a most objectionable smell.

The dangers of the cess-pits may be classified as follows :—

1. Pollution of the atmosphere.
2. Pollution of the ground-water and wells ; leading to
   Intestinal diseases, such as dysentery and diarrhoea, typhoid, cholera.
3. Breeding of mosquitoes.
4. Breeding of flies.

1. *Pollution of the Atmosphere.*—In a tropical town seven hundred and fifty tons of dejecta in the year left to decompose slowly in half-closed cess-pits must poison the air. It has been shown that sewage gas is harmful, and there can be little doubt that the health of Freetown must suffer in consequence.

2. *Pollution of the Ground-Water.*—Seven hundred and fifty tons of excreta and two million gallons of urine slowly soaking into the earth and mixing with the ground-water must infect the water. The cess-pits are not so deep (ten to twelve feet) as the wells (twenty to thirty feet), and often in the sloping portion of the town they are placed above the wells, so that in the rainy season when the cess-pits become flooded, the diluted contents of the latter may be washed into the former. Analysis has shown that the water is not good, and it never can be free from danger. To this fouled water must be attributed the numerous cases of diarrhoea and dysentery, and probably a large proportion of the infantile mortality. If cholera was introduced the consequences would be disastrous. By means of the new pipe line the dangers from drinking water have been mitigated, but until cess-pits and wells are abolished a vast amount of preventable disease must occur.

Breeding Mosquitoes.—Both in the wet and dry season *Culex* mosquitoes have been found in abundance in the cess-pits, urinals, and privies. Dr. LOGAN TAYLOR reported 'that in the privies erected over the cess-pits large numbers could always be found, and on kicking the wood-work they would fly up in large numbers.' The cess-pits and sewage water are therefore responsible for breeding a very large number of the *Culex* of Freetown. The *Culex* is not a harmless mosquito ; it has been shown to transmit *Filariasis*, and it is possible that other diseases may be associated with this blood-sucking insect.

Breeding Flies.—Enormous numbers of flies breed in the cess-pits, and as they are close to the houses there is every opportunity for direct contamination of the food.

As far back as 1897, the principal medical officer—Dr. PROUT—in a report to the Municipal Council upon the sanitary condition of Freetown, said, in dealing with the cess-pit system, that the only course was the *closure of all cess-pits*, and that it be made a punishable offence to make new ones. He then analysed in detail under the wet system and the dry system the best substitute for cess-pits, and concluded that a dry method, such as the pail system, was the best. To-day, Dr. Prout is of the same opinion, and in his official report to the Government for 1902, states as follows :—

The Pail System

'Some modification of the dry system appears to be the most suitable ; and the one which I have recommended, after careful consideration of all the facts, is the pail system. The initial outlay in comparison with the water system is comparatively small, consisting of pails, sanitary carts, mules or oxen, etc., and the annual upkeep would not be extravagant. I need not go into details here, but a regular system of house-to-house visitation would have to be organized, and the question of the disposal of the night-soil thus collected by hoppers or by depositing it in the soil would have to be carefully considered. A series of experiments which I made at the lunatic asylum showed me that by emptying excreta in very shallow trenches three or four inches, mixing and covering with soil, the whole disappeared in the course of a few days and created no nuisance. With the assistance of the railway the transport should not be a matter of difficulty, and this method of disposal is worthy of consideration. I may quote in conclusion the report already referred to :— "An examination of Ismailia certainly predisposes one in favour of a dry system of sewage for the tropics, especially if sand is available. The wet underground tank system in the European houses has shown me the dangers of this plan in a clearer light than I ever saw it before ; this, and the state of the Arab quarter, has enhanced in my mind the suitability of the dry system for small tropical towns where, for any reason, a perfect water-borne system may be unobtainable." 'I am convinced that if some such system were adopted here it would do much to improve the health and diminish the discomforts of Freetown. I venture to express the hope that now the water supply is in course of completion, it will be found possible to provide funds to take the matter in hand at an early date.'

We thoroughly agree with Dr. Prout that for a tropical town the dry method is the best. It works well where it has been tried ; Conakry, as we have shown, is a model, whilst one of us can endorse what Sir William MacGregor has said concerning the mosquito breeding capacity of the water-closets and *puits perdus* at Ismailia. Unsatisfactory, for other reasons, is a water system of sewage disposal, *tout a l'égout* will not work in a tropical town. The cost would be prohibitive, the water supply would have to be increased on a vast scale, and the difficulties to its efficient working in the hands of a native population of thirty-four thousand would be immense.

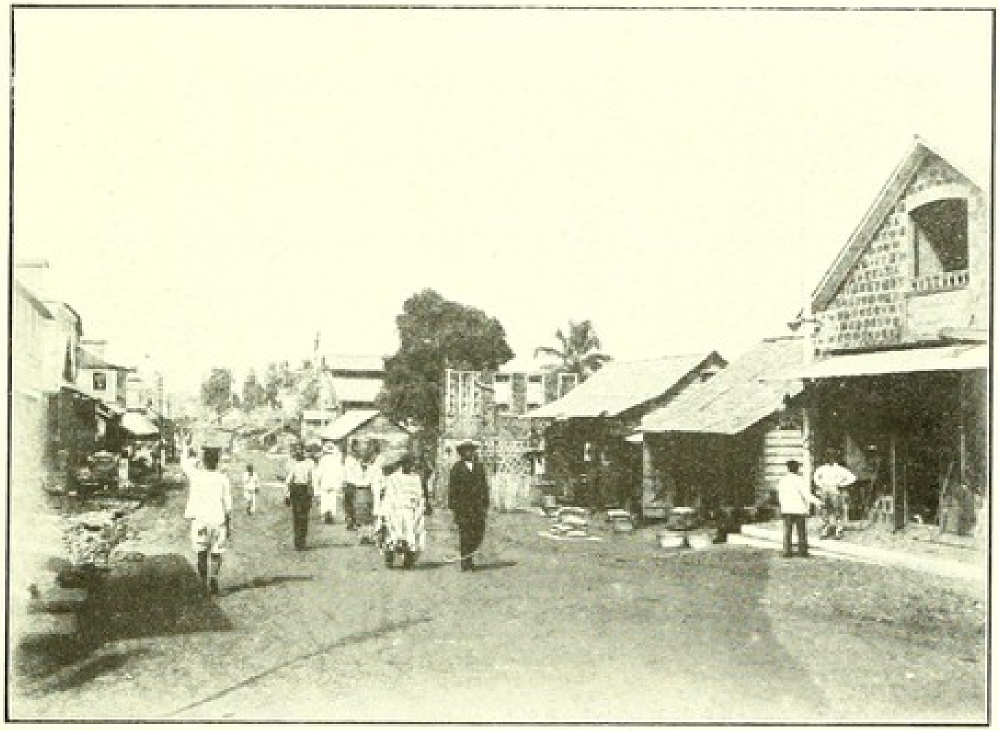
We would suggest the increase of latrine accommodation ; there are already six, which is an insufficient number, and the setting apart at selected places in the town of night-soil areas, consisting of at least three feet of good porous and sandy soil, thoroughly and freely underdrained. These areas to be used for burying the night-soil in shallow trenches, the pails being brought in the early morning or night-time by the natives themselves, just as at Bathurst and Conakry they are carried to the sea and emptied. It would materially lessen the burden of the municipality if the native population were obliged to assist, as in other towns, in the disposal of the night-soil. If this is impossible, a special staff would have to be employed for collecting the pails. The extent of ground necessary at each selected place would have to be calculated on the number of persons using it and upon the rate of disintegration of the faecal matter, which should be determined by laying out an experimental plot and watching it for a year. On account of the very great rainfall in the wet season, great care would have to be taken to ensure efficient drainage so that the soil would dry quickly, as a sodden, saturated soil would be worthless and retard disintegration. It would be necessary to keep the plots under constant supervision and railed in, and a water supply should be laid on for the necessary cleansing of vessels. Both at Bathurst and Conakry the night-soil problem is a simple one, on account of the proximity of the shore and its comparative ease of acccess. In Freetown the shore is more difficult to reach, and disintegrating plots are necessary.

From direct experimental observation we know that the method of mixing organic matter with loose dry soil is one of the most rapid biological methods of sewage disposal, where faecal matter and urine are concerned.

Slop-Waste.—For the most part this is kept out of the cess-pits ; it is also thrown upon the ground to soak in as best it can, and it then tends to become a nuisance. Very often a stone-faced or cement gutter carries the waste from the yard to the drain in the street. Owing to their irregularity and bad fall they very frequently contain foul water and offend both the sense of sight and smell, they also act as breeding-grounds for *Culex*. The disposal of slop-waste is a serious difficulty ; in Bathurst and Conakry it can readily soak into the porous soil, but a definite means of disposal has to be found in Freetown. Under Conakry we mentioned that the French authorities had discussed the advisability of establishing a separate conduit system for the slop-waste to run side by side with the storm-water drains. This plan, however, had not been carried into effect, and we are under the impression that to get over the difficulty the waste from the factories has, in certain instances, been conducted in cement channels to the storm-water drain. But it is very objectionable and altogether unsuitable, if it can be avoided, to use the storm-water drains for the slop-waste in countries subject to immense rainfalls. In the dry season the drains are very large empty channels, and the slop-waste from the houses let into them simply produces a trickle or a sewage puddle. Either a small open cement drain should be constructed along the roads of sufficient size to take the slop drainage and to allow of flushing, or else the main storm-water drains must be reconstructed, rendered water-tight, given proper falls and a proper shape in section, and be kept flushed ; the latter consideration, however, raises the question of drainage of Freetown, a subject which will be dealt with further on.

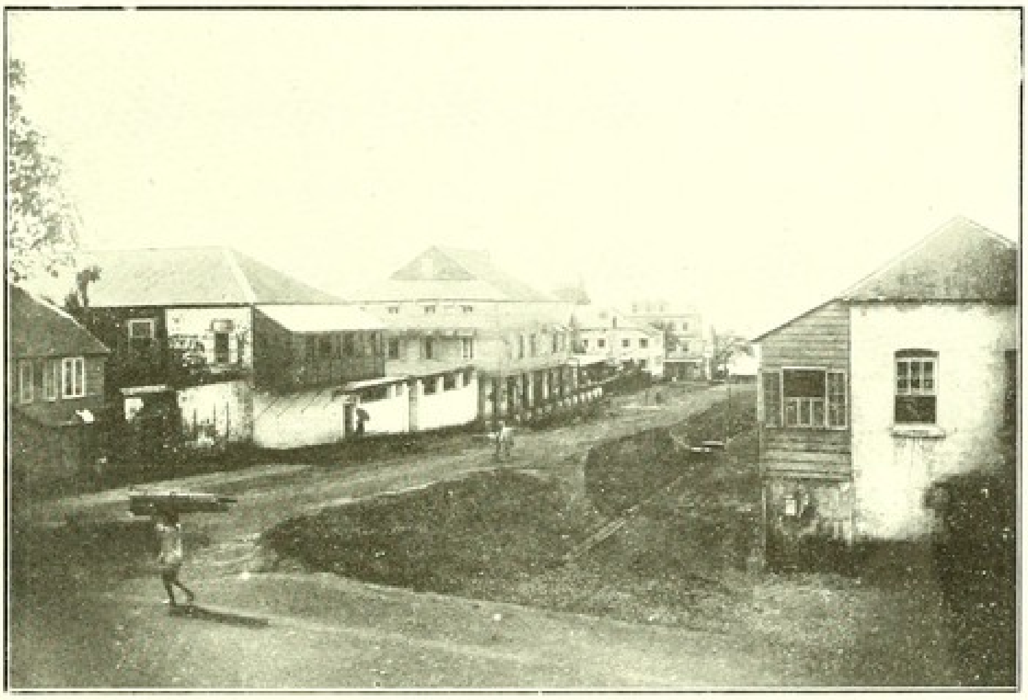
Dry Refuse.—There is too much refuse in Freetown, the overgrown bush furnishing a very large proportion. Special shoots and dust-bins have been set apart, but it is very evident that no place is sacred in Freetown as the youngsters pitch refuse away at the most convenient places. To our mind simple incineration should be more frequently made use of, but we cannot do better than quote the report of the Chief Medical Officer upon the *Removal of Refuse from Houses and Yards.* 'The duty of removing refuse and keeping yards clean devolves by the local laws upon the occupiers, and to facilitate this being properly done dust-bins are placed in various parts of the town, and shoots have been constructed in one or two places on the shore. When yards are found to be in an insanitary condition, notices are served on the occupiers. In this way three thousand eight hundred and thirty-six notices were served in 1902, the majority of which were complied with. Seventy-eight summonses were taken out for non-compliance and for offences against the sanitary laws. Special attention is given to the removal of old tin pans, etc., which are capable of retaining water and harbouring larvae, and people have been warned against keeping collections of water in their yards sufficiently long to breed mosquitoes. It is absolutely imperative, however, that it should be made a punishable offence to have receptacles containing larvae in any yard, and the provision of proper covers for all vessels intended to store water should be made compulsory. This is provided for in a consolidated Sanitary Ordinance, which is now in the hands of the printer.

The refuse from the yards is emptied by the occupiers into the dust-bins referred to, which in their turn are emptied by the carts as frequently as the limited number will allow. Over 3,000 loads were removed during the year. I cannot regard the present arrangements as altogether satisfactory ; it requires a very persistent system of inspection, which is expensive and should be unnecessary, and the formation of collections of rubbish at the dust-bins in various parts of the town is not only unsightly but at times insanitary (Plate VIII). In my opinion the time has now come for the municipality to consider the advisability of establishing a regular sanitary service for the removal of household refuse. A sufficient number of carts should be provided to allow of every street in the town being visited daily, or tri-weekly, at stated hours. Householders should be compelled to provide themselves with proper receptacles for household rubbish, which would be emptied by the sanitary carts, and the rubbish deposited in the various shoots or in selected places outside the town. It would be still more satisfactory if a destructor could be erected to deal with the enormous mass of vegetable and other refuse which accumulates so rapidly in a tropical town.' We agree with Dr. PROUT, and are of opinion that it would be impossible to keep the yards, roads, and waste places of Freetown free from accumulations with a staff



A STREET IN FREETOWN, SHOWING A DRAIN ON THE LEFT. NOTE IRREGULAR SHOPS

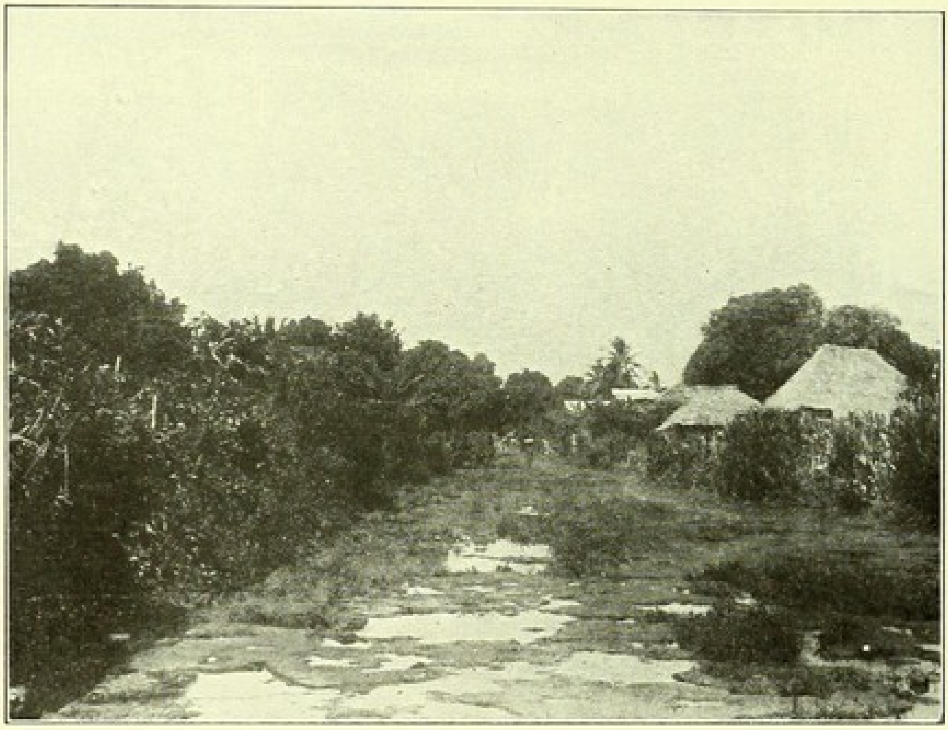
Photo.—Dr. Logan Taylor



A STREET IN FREETOWN. HOUSES ON RIGHT SIDE IN BIG DEPRESSION AND LIABLE TO BE FLOODED

Photo.—Dr. Logan Taylor

PLATE VII



A STREET IN FREETOWN CONSISTING OF ROCK SURFACE, IN WHICH THERE ARE INNUMERABLE POOLS BREEDING ANOPHELES (RAINY SEASON)

Photo.—Dr. Logan Taylor

ANOTHER ROCK-POOL STREET SHOWING GROWTH OF WEEDS AND IRREGULAR HOUSES

Photo.—Dr. Logan Taylor

to face p. 31

of sixty men and three carts. Bathurst, with a population of 8,000, has forty men. The remedy is to largely increase the staff and equipment and change the methods, as pointed out by Dr. Prout, and if possible to obtain the services of additional trained sanitary inspectors. In English towns a great improvement has taken place since inspectors have been properly taught.

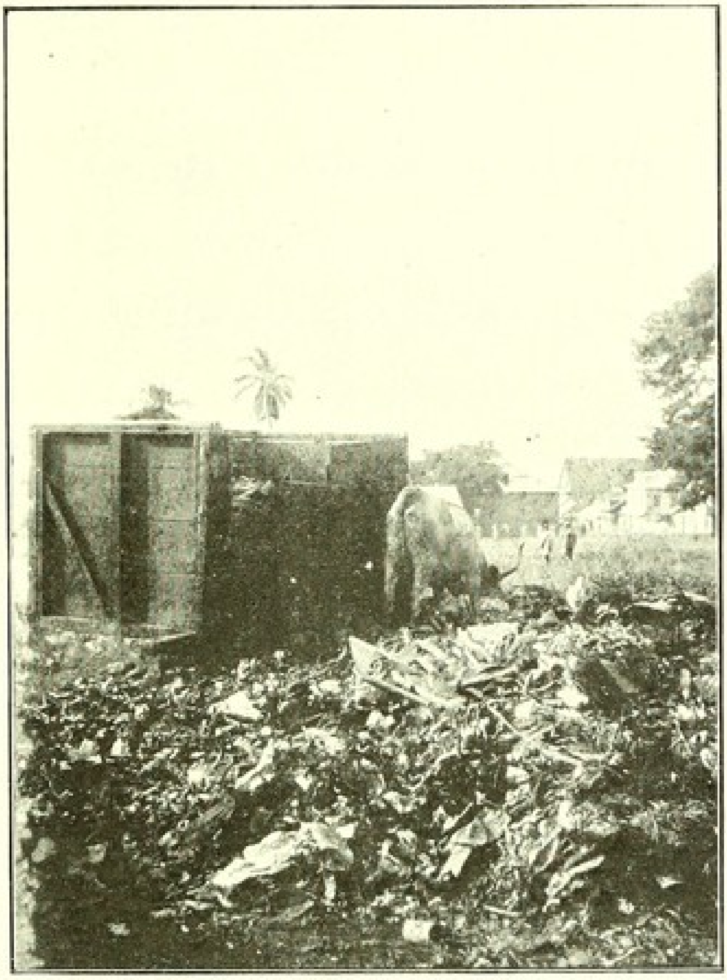
Water Supply.—A great improvement has taken place in the water supply. Pure water has been brought from a protected source in the hills to a covered reservoir on Tower Hill, from whence it is distributed to various parts of the town, stand-pipes being fixed at convenient places. The leakage which we described as taking place from the stand-pipes at Conakry also occurs in great abundance in Freetown, and leads to the formation of pools. Unfortunately, the whole of the city is not yet supplied from the new source, and therefore well-water is also used. Before any scheme of efficient drainage can be carried out, the town must be in possession of its new water supply, for one of the first essentials is to fill in all wells. We have before alluded to the fact that if there are two sources of water supply, observation shows that the one which is nearest runs the chance of being most frequently used in spite of the impurity, and the experience of Conakry demonstrates that the advantage of a pure supply are counterbalanced if the disused wells are left unfilled to act as mosquito breeding-grounds. Therefore the completion of the pure water supply of Freetown can be bracketed with the abolition of the cess-pit from the point of view of immediate urgency.

Wash-houses.—At present the streams are extensively used for washing. They are polluted, and we have noted the presence of the sewage fungus in one which was being used. The evil results of washing clothes in sewage polluted water are no doubt mitigated by the sterilizing action of the sun, but nevertheless, from the point of view of cleanliness and order, it would be better to abolish this system and introduce the model washing places as in Conakry.

Drainage.—In considering this question it is of interest to quote the following paragraph from the 1902 Report of the Principal Medical Officer upon the subject of drainage:—'This is a matter which I have advocated for many years as one intimately connected with the public health, and in my Report for 1898 I pointed out "the necessity for a thorough survey of the town, with the view of putting the surface drains in proper repair, and I would again recommend the advisability of taking this in hand as funds permit. Should the theory that malarial attacks depend upon infection by the mosquito be generally accepted—and proofs are already not wanting that this, at least, is one of the methods by which malaria is contracted—the importance of at once removing all surface water and thus depriving mosquitoes of their breeding-places is evident." Since the above was written, the causation of malaria has been so definitely proved to be dependent on the presence of a particular variety of mosquito, that the surface drainage of a malarious locality has become one of the prime factors in all schemes of tropical sanitation.'

Since 1902 many new drains have been constructed, and these have led to an appreciable diminution in the number of *Anopheles*. But now, as in 1898, a thorough survey of the town is even still necessary with the view of dealing with the drainage in a comprehensive manner. Very little need be said by us upon the present drains in Freetown, as they have been described more than once in the reports of previous expeditions which have visited Freetown. They are open drains ; they run on both sides of the street ; in section they are either saucer, U, square, or V-shaped ; they may be faced with stone, made of cement, or cut out of the soft or hard laterite. They require constant supervision ; they become frequently chocked, especially where they dive under the roadway. Their falls are very various and, in some places, it would be very difficult to discover any fall ; pools therefore readily tend to form in many of them, and in these *Anopheles* have been shown to breed in abundance.

What is the remedy ? No doubt a vast improvement could be made as suggested by Dr. Prout, in pushing on with new drains, and we would further suggest with what appears to us to be equally essential, namely, the employment of a larger staff of labourers under very strict European supervision to see that the drains are respected by the inhabitants, and not made convenient receptacles for rubbish, and that they are kept in thorough repair. But unfortunately this will not bring about efficient drainage in all cases. Many of the roads as we have pointed out have a hard rock surface (Plate VII) in which there are numerous rock pools, the steeper roads are often channelled in the centre by the great rains and secondary drains are formed, some roads are higher than the houses along the side (Plate VI), and the latter receive the overflow. There is no question of gentle turtle-back slopes as in Conakry, the gradients vary very greatly, some streets are very steep, whilst other portions of the town are flat. The rainfall is excessive, and in the steeper streets the loose soil is readily washed out and the surface of the roadway soon becomes grooved and irregular. The problem therefore is a most difficult one, and must necessarily involve considerable expenditure. The road making and drain making are part of the same problem ; at Conakry we have shown this has been the case, and in Freetown both require to be dealt with in a comprehensive manner by a skilled engineer. It appears to us very essential that particular attention should be given to the form of drain, and that one form should be adopted throughout. The drains in the wet season have to be prepared to carry away the maximum storm-water flow, whilst in the dry season they will only receive the comparatively small trickle of slop-water from the yards ; these two extremes have to be met. If in the dry season it could be arranged to divert the water from the streams and to make it circulate through the properly constructed drains, with absolute certainty of not increasing the breeding of *Anopheles* thereby, a constant cleansing of the latter would result at that portion of the year when it was most desirable ; and, at the same time, the great disadvantage which attaches to the streams in the dry season, viz., that they constitute in Freetown, at that period,



A DUST-BIN AT FREETOWN

Photo.—Dr. Clarke

A STREET IN GRASSFIELDS, FREETOWN, SHOWING DRAIN CUT OUT OF THE ROCK AND ROAD MADE UP, SO ABOLISHING STREET POOLS

Photo.—Dr. Logan Taylor

the chief sources of *Anopheles* supply, might very materially if not entirely be removed, because we are of opinion that, under the new circumstances, it would not be difficult to deal with the small pools remaining in the bed of the streams either by clearing the bed or by the use of paraffin. In the wet season the streams would follow their natural course ; at this season it has been shown that the rapid current prevents *Anopheles* breeding, and that in consequence they are harmless.

The Streams.—We have pointed in the preceding paragraph—with a reservation—to a possible method of utilizing the water of streams in the dry weather. In October, 1901, Dr. DANIELS, in a letter from Freetown to Professor ROSS, suggested either the formation of a central channel in the bed of the streams, with larger collections of water in sufficient number of places for drinking purposes, and lower down the stream other places for washing, or to dam up the streams so as to obtain a sufficient head of water to flush out the whole of the channels at intervals. He was further of opinion that the number of streams could be reduced, and some of the smaller diverted into the larger channels, and the number of breeding-grounds thus diminished. Since Dr. DANIELS wrote the drinking-water question has been practically solved, and it now only remains to deal with the public washing which goes on in the streams. We have pointed out that what Conakry has done in this respect can be repeated at Freetown with, we believe, comparatively small outlay. Admitting then that the streams are no longer used for drinking purposes, and are not necessary for washing purposes, then, as we have pointed out, the water might in the dry season be diverted into the street drains for cleaning purposes. If this is impossible, owing to the difficulty of obtaining suitable falls and to the liability to the formation of sluggish corners where *Anopheles* could breed, then **the bed itself of the stream has to be remade and converted into a well-made drain, in which it will be impossible for collections of water to form in dry weather**.

Summed up, the alternative schemes appear to be as follows .—

1. Reconstruction of the bed of streams.
2. Diversion of water for flushing of town drains in dry weather.
3. Construction of dams in streams and flushing of beds at intervals.

Some Public Works.—As in the case of the other two towns, we visited the principal public works, such as the hospital, barracks, prison, markets, and slaughter-houses.

The Barracks.—We have already commented upon the excellent quarters provided for the military. If there is anything which we would venture to urge in connexion with them it would be a more stringent use of the mosquito net. The military hospitals, containing, as they invariably do, cases of malaria, should be rigorously isolated by the net. The streams in the neighbourhood should also be most carefully watched, and the breeding of *Anopheles* prevented.

The Colonial Hospital.—An immense amount of good work is done in the overcrowded building which serves as the hospital. As at Bathurst, it has been found that the 'advantages of a trained European nurse are incalculable.' The number of in-patients in 1903 was one thousand four hundred and ninety-three, and out-patients six thousand five hundred and ninety-three. Forty-three major and three hundred and nineteen minor operations were performed in 1903. It was extremely gratifying to find the medical officers and the nurses devoting so much of their life and energy to this large hospital. On the other hand, we did not hear that the natives themselves, for whose benefit these sacrifices are being made, did much to help to maintain the institution. In addition to the hospital there is a nursing home, under the charge of European nurses, where Europeans are attended ; this has been a success.

Princess Christian Hospital.—This hospital is under the patronage of Her Royal Highness the PRINCESS CHRISTIAN, and was opened in 1892. The number of out-patients in 1902 was 7,046. In addition to treating the sick poor, both in its in and out-patient departments, the hospital accomplishes excellent work in training nurses.

Opportunities for Investigation.—The laboratory accommodation in connexion with the hospital is quite inadequate to the requirements of Sierra Leone. The large clinic affords abundant opportunity to the student of medicine for the investigation of tropical diseases. A small, suitably equipped laboratory would be a great acquisition, especially if it were put in charge of a Pathologist, acting under the Principal Medical Officer. The scientific investigation of the diseases of man and animals in the colony and protectorate would repay the comparatively small outlay. In countries where disease in man plays such an important share in limiting the extension of commerce, we venture to think that there can be little difference of opinion upon the practical good which would result from the establishment of a small scientific station.

The Markets and Slaughter-House.—For the size and trade of Freetown the market accommodation is small, and compares unfavourably with Conakry and Bathurst. More market accommodation is needed, and we would suggest, from the degree of efficiency which we observed at Conakry and Bathurst, the construction of the simplest style of building—an iron roof, open sides, and a concrete floor, with proper falls in order that it could be readily flushed. The slaughter-house is not in a good place—King Jemmy's wharf is overcrowded and very public—we saw the cattle tethered to the slaughter-house on one side, whilst on the other there is a public latrine.

Health of Freetown.—Dr. PROUT, in his 1902 Report, has carefully analysed the death-rate in the native population, and the death and sickness rates amongst the Europeans.

The following table, taken from the report, shows the death-rate from 1896 to 1902 :—

Year	Estimated population	Total Deaths	Death-Rate
1896	32,142	878	27·2
1897	32,570	871	26·7
1898	32,998	866	26·2
1899	33,427	923	27·6
1900	33,855	895	26·4
1901	34,284	959	28·9
1902	34,712	865	24·9

The average death-rate is 26·8, a figure which Dr. Prout does not regard as high for a tropical town, but he is of opinion that it can be lowered by the adoption of the sanitary improvements to which we have alluded to previously.

The largest number of deaths occur in January and June, and he points out that there are two periods of good health—one immediately preceding the rains, and the other immediately succeeding or during the period when they are very heavy. At both these periods the causes which produce malaria diminish. The dry season will cause a diminution, and in the very wet season the torrential rains will wash away the larvae. Dr. Prout is further of opinion that efforts to exterminate the mosquito should be made during the dry season and early part of the rains, at which time breeding-places are less numerous. In the early part of the year there is a rise in the mortality which may be due to changes in temperature, for the causes of death are mostly to be attributed to the respiratory system. The infant mortality is high, and Dr. Prout regards malaria as the chief cause after that attributable to labour.

The following table shows the mortality due to different diseases at all ages—(Medical Report, 1902).

TABLE V. SHOWING THE MORTALITY DUE TO DIFFERENT DISEASES AT ALL AGES

Diseases	January		February		March		April		May		June		July		August		September		October		November		December		TOTAL
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	
General Diseases :—																									
Fever, Intermittent ...	4	10	2	4	8	4	6	6	5	7	5	13	8	7	6	8	3	8	7	6	4	6	5	5	147
Fever	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fever, Remittent ...	...	...	...	1	1	1	...	...	...	...	2	...	...	...	...	...	1	...	...	...	...	...	...	...	6
Syphilis	...	1	1	...	...	...	...	...	1	1	1	1	...	...	...	1	...	...	...	1	...	1	...	...	9
Debility	11	5	6	5	5	9	4	8	5	3	4	8	4	7	8	5	2	3	5	4	3	5	4	12	135
Rheumatism	2	1	3	1	...	...	1	...	...	1	3	...	2	...	1	...	1	1	2	...	...	...	1	3	23
Tubercle	2	4	3	3	3	1	1	1	1	...	2	1	1	2	2	...	1	1	1	1	1	1	1	...	34
Other Diseases	2	3	7	1	8	6	2	1	3	1	3	5	3	3	1	1	3	3	6	3	2	1	...	3	71
Local :—																									
Nervous System ...	2	3	3	...	2	4	2	5	4	5	5	4	5	1	4	4	3	3	6	1	4	2	5	2	79
Circulatory ,, ...	...	...	...	1	...	...	...	1	...	1	2	1	...	...	2	...	1	4	...	2	2	...	1	2	20
Respiratory ,, ...	9	5	7	9	10	8	5	1	8	2	5	7	6	1	3	5	1	2	5	3	8	5	12	3	130
Digestive ,, ...	6	6	5	6	4	2	3	2	8	4	3	4	6	3	4	5	1	3	6	3	5	5	5	5	104
Lymphatic ,, ...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Urinary ,, ...	1	1	...	...	1	...	1	...	1	...	1	...	5	...	3	...	4	1	1	...	3	1	1	2	27
Generative, Male	...	...	...	...	...	...	...	...	3	...	1	...	...	...	...	...	...	...	...	...	...	...	..	...	4
,, Female ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Affections connected with Pregnancy ...	..	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	2
Affections connected with Parturition ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	1	3
Connective Tissue ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Skin	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Injuries	...	2	...	1	...	1	...	2	2	...	1	...	3	...	...	...	1	...	...	..	...	1	2	1	17
Unclassified	6	1	5	5	2	2	1	...	...	4	2	2	4	1	...	2	1	2	3	2	3	2	1	2	53
TOTAL	45	42	42	37	44	38	26	28	41	29	40	46	47	25	34	31	23	34	42	26	35	31	38	41	865

European Death-Rate and Sickness-Rates.—Table showing the number of deaths since 1886 amongst the residents :—

Year	Cause		Total
	Climatic	Otherwise	
1886	...	...	...
1887	...	2	2
1888	1	3	4
1899	3	6	9
1890	3	1	4
1891	3	2	5
1892	6	2	8
1893	4	4	8
1894	13	2	15
1895	4	2	6
1896	5	2	7
1897	13	...	13
1898	8	4	12
1899	3	6	9
1900	8	7	15
1901	8	2	10
1902	3	2	5

Dr. Prout calculates that, assuming the European population has remained about the same since 1899, the death-rate would be—

1891	...	...	25·6
1899	...	...	33·3
1900	...	...	55·5
1901	...	...	37
1902	...	...	18·5

He states that we are hardly justified in attributing the diminution to a permanent improvement in sanitation, allowance has to be made for individual susceptibility and new arrivals. But he adds, 'The greater knowledge of the causes which produce malaria and the precautions which are taken are undoubtedly having their effect, while there is no doubt the nursing home has had an appreciable effect in reducing the number of deaths.' In 1900, amongst Government officials it was 5·8 per cent., in 1901, 4·9, and in 1902, 4·8 per cent. It is a great pity that this return is incomplete and does not embrace all Europeans, but Dr. PROUT hopes to remedy this defect. A return is badly wanted showing the nature of the illness, and in the case of malaria whether due to infection in Freetown or elsewhere.

These figures are encouraging, and with the additional measures of safety which have been taken in 1903-4, more especially the construction of mosquito-proof houses, and the erection of the Hill Station, there is no doubt that there should be a further diminution in sickness, especially from malaria.

The Anti-Mosquito Measures.—As the result of an almost continuous series of expeditions from 1899 to 1903, one sent by the Royal Society, and the others by the Liverpool School of Tropical Medicine, the mosquito breeding-grounds of Freetown have been worked out in a most thorough and comprehensive manner. For convenience we summarize from a report by Dr. LOGAN TAYLOR the distribution of *Culex*, *Stegomyia*, and *Anopheles* throughout the year.

No.	Breeding-places	Wet Season			Dry Season		
		Culex	*Stegomyia*	*Anopheles*	*Culex*	*Stegomyia*	*Anopheles*
1	Tins, bottles, and small waste receptacles in yards and compounds	present	present	...	...	...	...
2	Gutters and flower vases ...	present	present	...	...	...	...
3	Receptacles in houses, filters, and water jugs	present	present	...	...	...	...
4	Water casks and cisterns ...	present	present	...	present	present	present
5	Wells	...	...	present	...	...	present to a limited extent
6	Water from hydrants ...	...	...	...	...	...	present
7	Cess-pits	present	less frequently	...	present	...	...
8	Sewage and slop drains ...	present	less frequently	...	...	...	...
9	Rain-water pools in street drains	present	...	present	...	...	...
10	Rain-water pools in compounds and streets	...	...	present	...	...	...
11	Water at sides of streams and springs, and rock pools ...	...	...	present	present	present	present

This table shows that in the dry season the supply of *Anopheles* is kept up by the natural streams and a few springs passing through and in the neighbourhood of Freetown, and also to a much less degree by the wells when full, and by the waste water collections from the hydrants.

That in the wet season the chief sources of *Anopheles* are the rain-water pools in the streets, both on the irregular rock surface of the roadways and in the side-drains, also the wells, and to a less extent the streams.

In the case of *Culex* and *Stegomyia* these are abundant in all collections of still or dirty water in all sorts of receptacles. In the privies throughout the year, in cisterns, casks, slop water, and the streams in the dry season. Because of the greatly diminished breeding area of the *Anopheles* in the dry season, it has been suggested to commence comprehensive anti-mosquito measures first in the dry season, by abolishing wells and preventing leakage from the hydrants, and above all by dealing with the streams which are the major source of *Anopheles* supply. We have already alluded to methods of treating the streams in order to prevent mosquito breeding. There is no question that they constitute at present a real source of danger to all those living within a considerable range of them, and the further European quarters can be removed the better ; the Hill Station possesses a great advantage in this respect.

In the wet season the breeding grounds of *Anopheles* are enormously increased owing to the totally incomplete state of the roads and drains, and the pools and wells in the compounds. The getting rid of the wells will do something, but the cure is roadmaking and drainage ; we have already alluded to both.

It is surmised that were it possible to get rid of the *Anopheles* in the dry season, that there would necessarily be an absence of them in the wet season. It is quite conceivable that there would be a marked diminution, but it would be very rash to prophesy a disappearance.

Culex and *Stegomyia* can be diminished and abolished by domestic sanitation, abolishing cess-pits and wells, and by keeping the yards and compounds perfectly clean.

The anti-mosquito measures which are at present employed consist in the gradual construction of suitable drains, a work which was commenced in 1902, and the supervision by the Municipal Sanitary Staff of the yards and compounds with the view of enforcing cleanliness.

Mosquito nets are very generally used, but whether in all cases they are properly used and looked after it is difficult to say.

We have already alluded to the mosquito-proof houses at Clinetown for the railway officials, and to the excellent hill cantonment for the Europeans. The latter constitutes the most extensive anti-mosquito measure which has been so far carried out in Freetown.

It is evident that a great deal remains to be done before there can be any appreciable diminution of malaria in the native population. To sum up, the measures required in Freetown are :—

1. The reconstruction of the bed of the streams.
2. The abolition of wells.
3. The closure of the cess-pits.
4. The reconstruction of the roads, the repairing and making of new street drains, and the draining of the compounds.

Results of the Anti-Mosquito Measures.—We think that it is beyond dispute that as at Bathurst and other places the anti-mosquito measures in Freetown have made people think and become more careful.

From personal knowledge we know that a great number of the merchants insist on the use of the mosquito net, and the establishment of a separate European colony at Hill Station is proof that the danger of living amongst a population which harbours malaria to the extent of eighty per cent., at least in the children, is fully realized. We think also that there is every justification for believing that the health of the Europeans has improved during the last few years—whether this is to be attributed solely to anti-malarial measures or to better selection of the men it is perhaps difficult to say, probably both are at work in a good circle.

We feel convinced that the money which has been spent so freely upon Freetown in organizing expeditions of investigation, and in actually conducting anti-malarial operations has been of the greatest good in demonstrating the hopefulness of success and the practical good of anti-malarial measures.

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GENERAL SANITATION AND ANTI-MALARIAL MEASURES IN SEKONDI, THE GOLDFIELDS AND KUMASSI

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XV

GENERAL SANITATION AND ANTI-MALARIAL MEASURES IN SEKONDI, THE GOLDFIELDS AND KUMASSI

AND A COMPARISON BETWEEN THE CONDITIONS OF EUROPEAN RESIDENCE IN THE GOLD COAST WITH THOSE EXISTING IN INDIA

BY

LIEUT.-COLONEL GILES

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ago it was a mere group of fishermen's huts lying beside the quaint old Dutch fort; but now it has become a considerable town, mustering perhaps 150 Europeans and over 10,000 natives. The European population fluctuates greatly, being mainly composed of Civil officials and railway staff, whose duties require them often to be absent for several days together on inspection duty; and the representatives of mercantile houses concerned in the supply of the mines, who equally have to make frequent trips to meet their customers, so that any attempt to trace infection of any kind definitely to Sekondi itself could hardly fail to be fallacious. The native population is growing so rapidly that it can only be surmised. At present the control of the town is in the hands of the Civil authorities, but it is understood that it is proposed to institute a Municipal council. Let us hope that West African experience of native control of sanitary matters may be more favourable than experience in India, where the plan of local self-government has had a long trial, the last ten or twelve years of which have been largely occupied in trying, with indifferent success, to modify the worst evils of the system.

Viewed from the sea, Sekondi and the shore we coasted for some hundreds of miles, much resemble Burmah. In both countries there are similar ranges of hills of moderate elevation, but with abrupt slope, reaching almost to the beach, and on landing one finds that these hills are in each case separated by marshy valleys. As a natural result, however, of the rather less moist climate of the Gold Coast, the West African jungle has not the same impenetrable character of that of Burmah, though the magnificent cotton trees lend it a dignity which is wanting in the uniform height of the masses of foliage of a Burmese forest.

Topography.

The old Dutch fort, which forms the nucleus of Sekondi, is perched on a small hill forming a headland, which is continued out to sea to form a reef which affords considerable shelter for the handling of lighters and boats, and so gives to Sekondi whatever claims it may have to be considered a port. To the west of the fort is a straight exposed beach, while to the eastward the shore curves and forms a broad, shallow bay, the steep hillsides coming down absolutely to the beach, so that the hills bounding it form particularly favourable building sites. The beach to the westward is bounded by lower ground, interrupted by a low hill. A few hundred yards to the westward of the fort a small stream, almost dry except during the rains, runs into the sea; but its mouth is obstructed by the piled-up beach. The bed of this stream runs directly through the most closely inhabited part of the town, forming a troublesome marsh, soft at all times of the year, and generally goes by the name of "No. 1 lagoon." Further to the west a similar stream bed forms "Lagoon No. 2," and is contiguous to a growing native portion of the place, though at present no European residences come to any extent within its influence.

Between the fort and the shore end of the reef lies a closely-packed native village, inhabited mainly by fisher-folk, and as the District Commissioner's house is placed just to the west of the fort, it almost overlooks and is in close proximity with this most undesirable neighbourhood. During our visit steps happened to be undertaken with a view to the formation of a club, and, most unwisely, as it appears from a sanitary point of view, it was proposed to adopt a site close to the fort and the District Commissioner's house. But this is close to the fishing settlement; and moreover, the fort hill is bounded on the other side by "Lagoon No. 1." . . There is probably no time of the day when people are so liable to be bitten by mosquitoes as when resting after the evening game of tennis, billiards, or cards, in the dusk, and if the intention of placing the club on this site is maintained, the result will be that the European residents will, for the most part, assemble each evening in a place where a free supply of mosquitoes is insured by the proximity of the "lagoon," and their infection rendered a very simple matter by that of the crowded native village. Undoubtedly a more salubrious site would be the hill to the eastward, on which the railway settlement is placed, and where there is still plenty of room. The objection raised is that the climb to the top of the hill would be hard on the mercantile community, who mostly live on the low ground, between the fort and railway hill. There is no doubt that the commercial and departmental offices must continue to be placed in this locality, and there is little danger in its occupation during the day; but the sooner the merchants recognise that this site, however necessary for office work, is a most dangerous one to sleep in, and remove their private residences to the high ground to the eastward, the better it will be for their health, for the business part of Sekondi is already closely packed with European and native establishments, inter-mingled in a manner which cannot now be remedied. It appears very doubtful indeed, if it be at all practicable, under the conditions of trade on the Coast, to maintain any separation between the business premises of the two races, nor is there any particular necessity for its being attempted, always provided that the office and private residence of the European merchant be kept separate.

"No. 1 Lagoon" and the low ground round it form a large space in the very midst of the inhabited area, and the line to Kumassi leaves the town, by way of the valley that feeds the swamp, the railway station being situated on its southern bank. It was, I understand, at one time proposed to fill in the swamp, and utilise it as a site for the station, and it is most unfortunate that the idea was not carried into effect, as it would have at once done away with one of the greatest sanitary defects of the site of the town. As matters stand, on the contrary, the engineering works in connection with the railway have, as is so often the case in the Tropics, greatly intensified the sanitary difficulties of the case. The embankment of the permanent way and the borrow-pits on its sides, now form permanent breeding-places for mosquitoes; whereas, but for this, after the prolonged drought that Sekondi had experienced at the time of our visit, there would have been no natural breeding places whatever on the site. Dr. Collier, the sanitary officer, told us that, during the rains the "lagoon" swarms with larvae, and that owing to its considerable extent, and the amount of vegetation, it is most difficult to deal with it by means of kerosine. This I can well understand, and it is clear that the filling in or drainage of this swamp is a *sine qua non* to the sanitary salvation of Sekondi, and the same remark applies to "Lagoon No. 2," though it is a more urgent matter to deal with "No. 1."

Apart from these marshes, the site of Sekondi presents many advantages, as the hills have a considerable slope, and they are composed of porous material throughout, consisting of a considerable thickness of gravelly soil, over-lying a pervious conglomerate rock. Most of the official residences are placed on the summits of these ridges, the hotel and railway quarters being situated on the ridge to the south of "Lagoon No. 1," while the hospital and medical quarters are on that to the north of it.

Housing.

Most of the houses are built of wood and corrugated iron, and are ill-suited for any tropical climate. Their best point is that they are for the most part well raised above the ground. In the business part of the town are some buildings of more substantial construction, but they are even worse planned, as they differ but little from the ordinary type of European dwellings. As, however, I propose to return to this point later on, it is needless to allude further to the point in this place.

"SEGREGATION."

The separation of the European residences from the native quarters of the town is far from satisfactory. As already noted, in the business portion of the place, no attempt appears to be made to secure this, and the Fort-hill is quite close to native habitations on two sides. In the Eastern portion of the town some attempt at segregation exists, in the case of the railway quarters, but even these are far too close to an extensive native quarter which is growing up between them and the railway line. Worse than this, the railway authorities themselves were building quarters for native clerks close to those of the European staff, and the fact that the former are doubtless people of education, and quite inoffensive neighbours from a social point of view, cannot alter the fact that they and their families are as dangerous, from the point of view of harbouring the malarial parasite, as their less cultivated countrymen. It is unfortunate that the attempts to utilise recent West African experience in the planning of this rapidly growing town have been so incomplete, as it is hard to remedy accomplished facts, but as the entire surroundings of Sekondi are practically unreclaimed jungle it is to be hoped that its future extension will be regulated, and some definite plan laid down whereby the institution of an European residential quarter, well separated from the houses of natives of all ranks may be secured.

CONSERVANCY.

There are no earth closets or special contrivances, the closet, in the case of European houses being usually furnished with an old paint drum, on the top of which is fitted an annular wooden seat; and a receptacle containing sand.

The native quarters are fairly well furnished with latrines, worked on much the same principle, though, of course, the receptacles are of a more special nature. The night-soil is removed daily by prison labour, as there appears to be a difficulty in obtaining free agency for this purpose, and is carried out on to some rocks in the East bay, and thrown into the sea. This plan seems to answer well for the present, but would be inadequate, should the place increase in population to any great extent ; under which circumstances, the building of a pier, furnished with an improvised tramway, would be imperative. The success of so primitive a plan, as that of the sand-box and shovel, depends entirely on the individual care of each household, but even under the best of circumstances, the retention of the soil in the privy for 24 hours is very undesirable, and in large establishments, such as the hotel, almost unworkable, as long as decent cleanliness depends on so troublesome a plan as that described. The sand, too, was often damp, and the quantity supplied inadequate, and it is obvious that the provision of proper earth closets, operable by a simple pull-up valve, is urgently required ; and should be insisted upon by municipal regulation in all houses, whether European or native, in which a private closet is allowed to exist on the premises. It must be remembered that, in a properly planned earth closet the soil receptacle can be ventilated in a way that is impossible with the rough and ready appliance in vogue at Sekondi. Another desideratum is the provision of sheds for the storage of dry earth, as it must be impossible, during the rains, to obtain anything but wet sand. Simple structures of jungle poles and thatch would be quite adequate for the purpose, so that the cost of such an improvement should be very trifling.

There are, I understand, but 17 paid scavengers, and the remarkable cleanliness of the town, with so small a staff, speaks highly for the excellence of the sanitary supervision of the place, and the natural cleanliness of the inhabitants, but it is obviously out of the question for so small a number of hands to attend to anything outside the first rudiments of sanitation, so that the clearing of jungle and superfluous vegetation during the rains cannot possibly be attended to in the way it should be.

Water Supply.

This very essential sanitary requisite is most unsatisfactory. No natural water of good quality is obtainable on the site, the very porous strata of which are so infiltrated with sea water, that all the wells that have been made are brackish to a dangerous extent, so that unless artesian borings be adopted, it is most undesirable that any further wells should be constructed. The results of artesian borings, however, are always uncertain, and the expense of making them is very heavy, and as there is said to be excellent water obtainable about six or seven miles up the line, it seems most undesirable to spend much money in attempting borings, which very possibly might only result in disappointment. At present, practically the entire supply of drinking water depends on the storage of a very limited and capricious rainfall. Observations are only available for the last two years, the average of which works out at 32 inches, that of 1904 being 26 in., and of 1903, 38 in. In each year the rainfall between October and April was inconsiderable, and it is clear that, to be on the safe side, storage should be provided for a possible drought of seven months. To provide anything like an adequate supply for so long a period, must necessarily involve an immense expenditure on tanks, and when all has been spent, such a system can never be satisfactory, as the roofs from which the water is gathered must necessarily gather also a certain amount of organic and inorganic dust, and when left stagnant and unaërated for such long periods, such water necessarily offers considerable facilities for the multiplication of pathogenic germs, and must needs become unwholesome. I am informed that each of the large cast-iron tanks recently adopted for Government quarters costs something like £200, and there can be no doubt that the sum already expended on tanks by the Government and the general public, would have gone far to meet the cost of a reliable and constant piped supply of filtered water.

At the time of our visit, the wells were yielding only a few gallons daily of brackish mud, and the tanks were reduced to their last few inches. Salt water is absolutely useless for washing clothes, and, if used for washing the person, in the case of Europeans at any rate, is almost certain to give rise to a most intractable form of tropical lichen with the usual sequelae of abrasions and boils. To be reduced to a gallon or so of fresh water *per diem* would be considered almost intolerable even in Europe, and only those who have tried it can well realise what is implied by such a state of things in a tropical climate; so that there can be no doubt that the provision of an adequate supply of pure water for Sekondi, is a matter of acute urgency. At the same time, it must be remembered that an ample water supply is by no means an unmixed blessing in tropical towns, unless proper care be taken to prevent the formation of wastage puddles. In India, for example, enormous sums have been spent in providing some of our larger towns with water systems on European lines, and the result has been that, without exception, the death-rate of these towns has increased simultaneously with the introduction of the piped water, and has failed to return to the old level. Cholera and other bowel complaints have, indeed, decreased, but the prolongation of the malarial season throughout the dry weather, through the agency of puddles around the stand posts, and other wastage accumulations, has more than neutralised the good results we hoped to reap by the provision of what is undoubtedly a first requisite of sanitation in all climates. In India, however, we labour under exceptional difficulties as to surface drainage, the average gradients in the Gangetic Plain being not much over a foot a mile, whereas in Sekondi for the most part it is difficult for puddles to collect, and, provided due care be taken that no standpost be placed in a situation where its drippings cannot drain away, no difficulties need be apprehended on this score. Where standposts must necessarily be placed where their wastage can possibly give rise to puddles, they should have constructed beneath them a blind well of fair depth, covered by a grating so arranged that the interior is quite dark, under which circumstances any drippings that may remain for any length of time unabsorbed cannot serve as breeding-places, because *Anopheles* larvae cannot live in darkness, and indeed, will rarely be found even in shady situations. On this account no danger is involved by the construction of underground drainage channels, though where they have to carry sewage water they are usually very objectionable in tropical climates, on other grounds than the formation of breeding-places for mosquitoes. It cannot, however, be too strongly emphasised that in the construction of water systems in tropical towns the most minute care should be taken to prevent the possibility of the formation of wastage puddles, as it is an unfortunate fact that this point has not hitherto received the attention that it should from engineers.

Mosquitoes and Anti-Malarial Sanitation.

It is said that mosquitoes are never very obtrusively common in Sekondi, and at the time of our visit they were extremely scarce: indeed, I have never met with any place where they were so uncommon, except at times of the year when these insects are all dormant from cold, and it is a literal fact that in most parts of the town one ran as little risk of being bitten as in a London square in summer, so that, save as a protection against malaria, no one would have found mosquito curtains necessary. In the hotel, although we were always on the look-out for specimens, we took only two or three individuals of *Stegomyia fasciata*, but this species did not appear to be breeding at the time, and probably here, as in India, only does so during the rains.

Dr. McConnell took a single *Anopheles costalis* in the hospital, but with these exceptions, we could find no mosquitoes beyond those we obtained by breeding out, though no doubt a few might have been found in the houses close to the "lagoons," but the remaining breeding-places were too limited to supply more than a limited area. In the puddles about the "lagoons" we found an amount of larvae, which, on breeding, proved to be those of *Anopheles costalis* and *Culex thalassion* (Theob.) The puddles in which these were found were very brackish, from the infiltration of sea water, one of them being undiluted (2,100 parts of chlorine in 100,000), while the other held as much as 545 parts of chlorine per 100,000.

The salter of the two puddles from which water was brought home was filthy to a degree, thick with a black deposit, and redolent with sulphuretted hydrogen. For the analysis of the specimens we are indebted to Professor Donnan, of Liverpool University, and it is obvious from his results that in these parts of the world nothing is to be hoped for from the flooding of marshes with sea water, which has been so successful in Italy, in the case of *An. maculipennis*, as it is clear that *An. costalis* can breed in undiluted sea water. Further, like *An. Rossii*, this species has no objection to filth, for one of the puddles was nothing better than salt sewage, while the other was none too clean. Under these circumstances, as might be expected, there was little or no active malaria to be met with in the town at the time. No fish were to be found in the marsh, probably because the water of the few small puddles remaining was too salt for fresh water species. It is possible, during the rains, that the water may become fresh enough to admit of their surviving, but, on the whole, unlikely, as it is well known that fish are extremely sensitive to variations in the properties of the water in which they have to live. As will be seen, these "lagoons" are in this respect a great contrast to those we met with above the level of the tide during our trip inland. The tolerance of *Anopheles costalis*, during the larval stage, to salt water, obviously offers an explanation of the great unhealthiness of African mangrove swamps, as contrasted with similar tracts in other parts of the world, which are not more unhealthy than other low-lying ground. Not only mosquitoes, but insect life generally, was remarkably scarce, house flies being so uncommon that in most parts of the town it was difficult to secure specimens. It is said that tsetse flies are to be found in the bush, at a short distance from Sekondi, and it is undoubtedly the case that horses and cattle cannot be kept there, so that this absence of house flies is probably an indirect outcome of the presence of the tsetse, on account of the absence of dung and stable litter, which are as necessary to the breeding of common flies as water is to that of mosquitoes. On this account the fly-proof *chicks* (mats formed of finely split bamboo), which are indispensable to comfortable existence in most hot countries, are quite needless here. Another point in the natural history of this region, which bears on the question of the propagation of malaria, is the singular absence of the semi-domesticated animals that insist on sharing the habitations of men, in the prolific climates of most of the hotter countries of the world. In India, last year, I was much struck, when examining a considerable number of gorged mosquitoes, to find that only a very small proportion of the insects had attacked the inmates of the bungalow, as by far the larger proportion were filled with the blood of birds, and, in some cases, of lizards. Now, on the West Coast, within the houses, there are none of the birds, lizards, squirrels, civet cats, etc., that swarm in and about human habitations in, I believe, most similar climates, and the result is that these house mosquitoes must needs attack man, or stay hungry, so that a comparatively small number of mosquitoes will perform a larger amount of duty in the transmission of malaria. On this account the real scarcity of the insects might be expected to produce a sense of false security, for the actual facts of the case are such that it is easy to understand anyone not specially trained to search for them, asserting the entire absence of mosquitoes ; and it speaks well for the sound sense of the inhabitants, that although one can sleep in perfect comfort without mosquito nets, as far as ordinary annoyance is concerned, it was found that their use, as a protection against malaria was almost universal among the European part of the population.

With the exception of the "lagoons," the only possible breeding-places are the numerous water tanks, but there is a regulation in force that all of these shall be kept carefully covered, and this is enforced with such care by systematic inspection on the part of the health officer, that even in the native part of the town all tanks are provided with a cover of some sort. No doubt, in many cases, the covers do not fit as well as they might, and we were shown by one of the medical officers instances of how small a defect will serve to allow the passage of mosquitoes, but these cases were distinctly exceptional. Some time ago I noticed in a periodical a reference, which I cannot now trace, to a simple form of cover for water butts, devised by one of the Colonial medical officers of this coast, the adoption of which might very well be insisted upon by municipal regulation. The contrivance is described as being constructed of a circular piece of canvas or sacking, spread loosely over a heavy iron ring, such as a barrel-hoop ; and, from the nature of the case, must securely close the top of the water cask over which it is placed. The objection alleged to its adoption appears to be the difficulty of contriving a simple way of locking it on to the cask ; for water is so precious a commodity at times that security against theft is essential, but it ought not to be difficult to overcome this objection. Empty tins and such-like dangerous refuse are systematically collected, and the lagoon is dealt with as far as possible by means of paraffin; but the density of the vegetation, and the considerable extent of these marshes during the rains, must make the successful application of this agent very problematical. Speaking generally, there can be no doubt that, as far as hand-to-mouth anti-malarial measures are concerned, about all that can be done is carried into effect; though it is obvious that a very much larger staff is required to bring them to their fullest efficiency. The efficiency of such measures, however, depends on the most constant vigilance, and, in view of the local conditions of Sekondi, can never amount to anything better than palliation.

The difficulties involved in the storage of water would, of course, disappear with the introduction of a regular piped-water system, and surface drainage is obviously being improved as rapidly as can be well expected; as there have already been constructed a very respectable length of masonry channels, which, it is understood, will before long form a complete system. In view of the long periods of drought, or little rain, it would be an improvement to construct these drains with a cunette running along the bottom of the channel, but this is a detail. The real problem to be faced, however, in the anti-malarial sanitation of Sekondi is that of how to deal with the "lagoons." As already pointed out, the level of these marshy tracts is below that of high water, and hence, under existing circumstances, no continuous outfall is possible.

I understand that it is proposed to run a masonry channel along the line of each lagoon, provided with sluice gates at the seaward end, but, personally, I doubt strongly if this will effect any improvement at all commensurate to the expense.

Infiltration from the sea must necessarily continue, and at the best a water-logged space will be left which, even after the most careful levelling, will be always difficult to keep clear of puddles; besides which, the outlet cannot fail to become periodically obstructed by the heaping up of the beach by wave action during spells of heavy weather. It is clear, moreover, that the site would be quite useless for building purposes. The only reliable method of dealing with the lagoons is undoubtedly to fill them in, and though the plan would certainly be costly it must not be forgotten that a large building site would be provided on the reclaimed ground, which, in view of the rising value of land, would probably go far to recoup the outlay.

Fortunately, abundance of material is available close at hand, as the marshes are bounded on each side by hills formed of easily excavated gravelly material, which, from its porous character, would form an ideal material for the purpose. A subterranean channel, would, of course, have to be left along the middle line, and it would be well also to place a system of ordinary agricultural sub-soil drainage pipes a foot or two beneath the surface, but above high water level at its lowest point. It may be objected that the outfall of the subterranean channel would be below high water, but the bulk of the flow would be over the surface, and along its surface drains, and the remainder might be trusted to flow out through the sand at low water as it does now.

Possibly, the sub-soil drainage pipes would suffice alone, but this is a matter which could best be answered by engineering experts. In dealing with very similarly placed marshes in the Roman Campagna, after Prof. Celli's plan, no subterranean channel is constructed, but the lower layer of the spoil used for filling in the depression is formed of large rubble, through the interstices of which the water flows quite freely, so that it is very curious to see a considerable stream, springing at once from what appears to be the face of a solid bank. It is doubtful, however, if any material that could take the place of the broken tufa used for this purpose can be obtained from the hills beside the Sekondi "lagoons."

General Conclusions.

Possessing, as it does, an exceptionally dry climate for a country so close to the Equator, a gravelly soil, and a site in many other ways favourable to natural drainage, with plenty of unoccupied favourable positions for the extension of a separate European quarter, there appear no good reasons why Sekondi should not be made at least as healthy as other towns similarly situated.

To gain this end, however, will involve considerable expenditure, as the two principal desiderata, viz., the provision of an ample, but well guarded water supply, and the filling in of the "lagoons" are each of them considerable undertakings. The more thorough separation of the European and native quarters also requires attention. The exact mortality of Sekondi is a matter that cannot be determined with any approach to accuracy, on account of the rapid growth of the population, and the short time for which records are available. All, however, seem agreed that the anti-malarial measures that have been adopted have resulted in a marked improvement of health; but, in spite of this, there can be no doubt that the place remains decidedly unhealthy. Moreover, from the character of the local obstacles to the successful suppression of malaria, it is to be feared that little further improvement can be hoped for by the extension of what may be called "hand-to-mouth" anti-malarial measures.

As, however, there can be little doubt as to the future importance of Sekondi, it is to be hoped that, serious as the expenditure may appear, it will not be considered too high a price to pay for the improvement of health that must necessarily result.

The Line from Sekondi to Kumassi.

Throughout the entire distance, the railway runs through what is practically unreclaimed jungle. Here and there small clearings, occupied by a few native huts, may be met with, or one may notice a path winding laboriously through the thick bush, but with these exceptions the country has been left to the forces of nature. With the exception of a few places where a low watershed or spur is crossed, the line always follows that of the valleys, and as the pace is very deliberate, the journey affords an excellent opportunity of observing the general physical characters of the country.

Throughout the entire distance the line winds among hills, usually no more than a few hundred feet high, but in a few cases reaching over a thousand feet. As a rule, the hillsides are so steep that no water could lie, even after heavy rain, and the general gradient of the valleys between them is quite sufficient to admit of free drainage, assuming the channels to be unobstructed. These valleys are very narrow in places, widening out between the constricted portions, and as the result of floods it is natural that the narrow portions should become obstructed with material denuded from the hillsides above, and with branches and other vegetable detritus.

These accumulations, matted together by the luxuriant vegetation, then necessarily form a very efficient dam, which results in the formation of marshy tracts filling the wider parts of the valleys. As compared, however, with the hilly ground, these marshes form but an insignificant portion of the surface of the country, and from watching the gradients of the line, as it winds along the valleys, often keeping for long distances at an almost uniform height above the streams, it becomes obvious that in a large proportion of cases the marshy tracts could easily be drained, at comparatively little expense, by simply cleaning out and deepening the channel where it is obstructed. These facts have an important bearing on the question of the anti-malarial sanitation of the mining camps, which are scattered along the line and its neighbourhood.

From the point of view of the first-class passenger, the rolling stock of the railway might be easily improved, as the carriages give one the impression of having been designed in England, by someone quite unfamiliar with the requirements of tropical comfort. It is quite impossible to lie down, and not very easy to sit in any particularly easy position, and the lavatory accommodation extremely defective, there being no water, nor even basin for washing. I understand that in the case of sick persons it is customary to make use of a goods truck, with a tarpaulin spread for shade, but in hot countries, even when there is no night travelling, lying down accommodation is quite essential for even healthy European passengers. During the first day we were 12, and on the second, four hours continuously in the train, and the fatigue of maintaining a constrained position for so many hours in a climate of this sort was very trying; nor is an improvised ambulance, in a goods truck exactly ideal travelling for a sick person.

The third-class carriages, on the other hand, are at least as good as those in use on our Indian railways of similar gauge, and no doubt, as the present manager of the railway is an officer of extended Indian experience, in time the present uneasy contrivances will be supplanted by the more suitable type of tropical carriage in use on Indian metre gauge lines.

Kumassi.

Kumassi much resembles a small Indian station, consisting of the headquarters of the civil administration of the district, together with that of a native regiment. It is, of course, unavoidable that the quarters of the officers should be placed near those of the men of the regiment, but there is still a considerable space between them, and the native town is also fairly distant. In this native town, however, there are already settled a considerable number of European traders, and the place is growing up so rapidly since the restoration of law and order, that the number of these is steadily increasing. This is much to be regretted, but the remedy obviously rests entirely with the mercantile community, as it is clearly impossible for the authorities to forbid their living above their shops or offices. In some cases, no doubt, the establishments are small private enterprises in which the expense of maintaining a residence separate from the place of business is prohibitory ; but the greater number are the agencies of important firms, and it would be well if the commercial leaders at home could realise how dearly the small economy is bought, at the price of the inefficiency that must necessarily result from the sickness and invaliding of their staff. The Yorubas, who form the least civilized portion of the community, are excellently placed in a separate town, on rising ground on the other side of the annular lagoon described below, and nearly a mile from the European settlement.

Site.

The hills surrounding Kumassi are lower, and the valley broader, than is met with anywhere on the line between there and the coast. The European settlement and the native town, with the exception of the Yoruba village, are placed on a slight elevation, almost completely surrounded by marshy land, and the entire area of the higher ground is too limited for any portion of it to be protected from the necessarily malarious influences of the marshes. This annular swamp drains by the valley, through which the railway reaches the town, and the station is placed on the low ground beside the marsh. Now, this valley has a considerable gradient, and, in view of this circumstance, it appears almost certain that the draining of the swamps around Kumassi should be a by no means impossible task, and until this is effected, it is perfectly certain that the place must necessarily remain unhealthy, for on account of the large area of the marshes, palliative measures such as the use of paraffin, are out of the question, and the employment of the ordinary anti-malarial measures, such as the closing of tanks, and the clearing away of empty vessels, too much of the nature of the " drop in the ocean " for them to be expected to effect any noticeable improvement. *Anopheles* and *Culex* larvae were found in considerable numbers in the pools of this marsh, especially in places where the water was foul from the proximity of native houses, the worst place being one where the natives were in the habit of washing their clothes. The *Anopheles* larvae were those of *An. costalis* (Loew), and, taken in connection with their presence in the exceptionally filthy pool at Sekondi, it appears probable that this mosquito has a predilection for dirty water as a nursery for its ova. The swamps are a mass of ferns and other dense vegetation, and even if drained their clearing and systematic cultivation would be essential to the success of any scheme of anti-malarial sanitation, and at best the large level area will be always difficult to deal with. The site is, in fact, a most unpromising one, with nothing but its historical importance to recommend it.

Housing.

Owing to the fortunate circumstance that European building materials are, on account of the cost of transport, very expensive at Kumassi, the houses are better suited to a hot country than is the case at Sekondi. Owing to this, shingles take the place of that most unsuitable of all materials, corrugated iron, and rubble masonry of wood. The very practical plan, too, has been adopted of utilising the ground floor as offices and living rooms, and placing the sleeping chambers on an upper floor; but the rooms are still too low pitched, and the verandahs too narrow to keep the sun from falling upon the walls of the building. It is well worthy of note that the "medical bungalo," which is one of the few in which this plan has not been followed, has the reputation of being the least healthy house in the station. That the accommodation for each officer is very limited is, perhaps, only to be expected in a place in so early a stage of development.

Climate.

Kumassi has a much heavier rainfall than that of Sekondi and the neighbouring coast towns, and it is much more evenly distributed, so that the place never, apparently, suffers from lack of water. On two of the mornings of our short stay the place was enveloped in a thick mist, which lasted till the sun was high above the horizon, and reminded one much of the cold season in Assam, where similar fogs often last till mid-day; but the climate does not appear to show the extreme damp of the Brahmaputra Valley, as these fogs are said to only occur occasionally, whereas in Assam they are almost the rule at this time of the year for months together. The difference is due probably to the influence of the great Brahmaputra River, as the rainfall, the configuration of the country, and the surroundings of dense jungle resemble each other closely, and both, it may be noted, are notoriously unhealthy localities.

Conservancy.

The management of latrines and the removal of night soil are conducted in much the same manner as at Sekondi, with the exception that the latter is buried instead of being thrown into the sea. The general results are excellent, as even in the Yoruba Village, who are mostly Mahomedans, and tanners by trade, and are, for West Africans, a very dirty community, there is little evidence of fouling of the surface, and one can walk anywhere without annoyance to the sense of smell.

Water Supply.

The natives obtain their water partly from wells and partly from the marsh. For Europeans is reserved a sort of spring flowing from an outcrop of rock in the marsh not far from the railway station, but well removed from habitations. This rock is of a porous nature, and in the general sense of the word, no doubt it acts as a very efficient filter. The general quality of the water appears to be good. From the surface of the rock the water flows into a trough constructed to carry it away. In all probability the water, as it issues from the surface of the stone, is good enough, but it is obvious that the methods of collection and protection leave much to be desired. Naturally, being exposed, although the flow is continuous, it is liable to the usual forms of pollution. There is, however, some difficulty in suggesting any inexpensive and self-acting plan of improvement, as the out-flow lies so low that, if stored in a covered tank, provided with taps, it would be difficult to construct any approach at a lower level which would not be flooded during rainy weather. On this account, the only plan would appear to be to cover in the source, with its troughs, and to pump up the water to a service tank by manual labour. Of course, such a plan still involves the carriage of the water in buckets and barrels, and therefore cannot afford any ideal security, but it would be a great advance on the present arrangements, and, moreover, would cost but little to carry out.

Prevalence of Mosquitoes and Other Insects.

Mosquitoes are much more in evidence at Kumassi than at Sekondi, as plenty may be met with at dusk, near the marshes, but on the higher ground, where the European settlement is placed, they are remarkably scarce, for a place so situated, and in point of fact, I was unable to discover a single *Anopheles* in or about the bungaloes, and even *Culices* were few and far between, so that, apart from the risk of malaria, no one would have felt the need of a curtain. The same was the case with other insects, house flies being very scarce. The mosquitoes taken included all species found at Sekondi. In the leather-worker's quarter, meat flies were naturally common. Tsetse flies, though often looked for by persons familiar with them, have never been taken near Kumassi, and a fly infesting the Yoruba cattle, which I thought might belong to the group, proved, when caught, to be *Hippobosca maculata* (*fide* Austen). These flies confined their attention to the cattle, while, on the other hand, the horses were pestered with clouds of *Stomoxys* belonging, Mr. Austen says, to two undescribed species brought by Vet. Captain Carr from Northern Nigeria, and believed by Carr to convey a trypanosome disease, very disastrous to horses there. Now several animals in the Kumassi "horse lines" were very ill, and Dr. Cowen, one of the local medical officers, had actually found that the blood of these ailing horses swarmed with trypanosomes. On dissecting out the intestine of a *Stomoxys* taken off a sick horse, I found its solid contents accumulated in the hind part, while a clear fluid filled the fore portion. In the former, examined fresh, no bodies clearly referable to any stage of a trypanosome were met with ; but a smear of the clear fluid, stained since returning to England, is rich in both fixed and motile forms of the asexual stage of a parasite of this class. Several series of sections have also been since prepared, and a set from a female, in the œsophagus, close to the stomach, contains a few of what are almost surely ookinets, probably female, of a trypanosome ; so that the culpability of the *Stomoxys* as the alternative host of the horse trypanosome may be taken as proven. Dr. McConnell was to have made some smears of the horse's blood for subsequent determination, but this, unfortunately, was not done ; so that the exact species of trypanosome remains uncertain.

Horses can just live in Kumassi ; that is to say, that the officers of the Gold Coast Battalion manage to keep themselves mounted, but that the horses rarely keep in condition for any length of time, and usually die in a few months.

It remains uncertain whether one or both of the species of *Stomoxys* is concerned, but they resemble each other so closely that their pathological relations are scarce likely to differ.

The *Stomoxys* seemed to attack only the horses, and were not seen on cattle, though some of the latter were grazing close to the horse lines; nor were any of these flies to be met with anywhere else than in close proximity to the horses. One of them bit me sharply on the ankle, while I was engaged in capturing a supply of specimens, but the grooms did not complain of being troubled by them, though this may only mean that they were indifferent to such attacks. Nothing seems to be known as to the life history of these flies, but it is highly probable that the larvae breed in horse dung, and the careful destruction of this by burning would be worth trying, in the hope of diminishing their numbers. They seem to bite only during the day, as a batch of specimens collected at dusk included a much larger proportion of non-biting flies than was the case in the morning. The only attempt at protecting the horses from their tormentors consisted in keeping a small smoky fire burning near their heads as they stood tethered in the open, but for all practical purposes this might as well have been left alone, as, owing to the drifting of the smoke and its small volume, it quite failed to keep the flies off, even from their heads, and the poor animals were literally covered with them. One horse, that was in worse state than the rest, was kept in the stable, but without any smoke protection, with the result that within the stable it was easy to catch a dozen or more of specimens, by a single sweep of the net. Now it is quite possible that the free use of smoke, within a confined space, such as a stable, would alone suffice to drive out the flies, but in any case there can be little doubt that by the use of smoke in a stable protected from the entry of flies as far as possible, it ought to be practicable to reduce the chances of being bitten to a minimum. That it is quite possible to protect the horses from the bites of insects by the use of smoke in their stables, even without any mechanical protection against their entry, has already been amply demonstrated by Mr. Henry Power, while working on the subject of "Horse-sickness" in Zululand, and Mr. H. W. Pitchford, the Government Bacteriologist (in Natal Government Notice No. 252, of 1903), regards this as so definitely proved, that even though he is still in some uncertainty as to the exact species of insect involved, he does not hesitate to recommend the adoption of the plan to agriculturalists and other horse owners in the colony. There is no need of going to any heavy expense in constructing an experimental stable for the purpose, as it ought to be perfectly easy to make a fairly fly-proof stable from the rough materials available on the spot. What I would suggest would be to build an ordinary round hut, such as is now in use at Kumassi, for sheltering horses; leaving the upper two feet of the wattling unplastered, for the sake of light and ventilation, and making it more secure against the entry of flies, if necessary by securing up to the thatch, pieces of split bamboo matting, such as are known as *chicks* in India, and which could easily be manufactured on the spot.

Closed by an ordinary door of rough planks, such a stable might be made practically fly proof, and with the aid of smoke protection, might be a safe refuge for the horses during the day. As far as possible the animals should be exercised after sundown, and should wear, when out, an ordinary fly net, such as is provided for every well-cared for horse in India, as a protection against ordinary flies. There is no reason why the net should not be worn while the animal is in use under the saddle, but, as a matter of fact, the flies do not appear to follow the horses from the lines, in the same way that is the case with the ordinary non-biting insects. These fly-nets are made of ordinary coarse cotton twine, and though the mesh is so large that the insects could pass through it with the greatest ease, are wonderfully effectual in keeping them off, the twitching of the threads imparted by the movements of the animal, apparently scaring the flies away. The disease does not appear to be as rapidly and surely fatal as the *Tsetse Trypanosome*, so that possibly much depends on the volume of the infection, and there is therefore the more hope that paliative measures might be fairly successful.

General Conclusions.

The site of Kumassi is so unfavourable to the success of anti-malarial operations, that undoubtedly the best solution of the difficulty, if it be in any way practicable, would be to remove the seat of the District Government to some more favourable positon ; but failing this, it is probable that a great improvement might be effected by the thorough draining of the marsh surrounding it ; and it seems probable that a good deal could be effected in this way, at no very prohibitory expense.

Remarks on the Possibilities of Anti-Malarial Sanitation in the Mining District.

During our expedition along the line of rail to Kumassi, we passed through the heart of the district in which there is already settled a considerable European population concerned in the gold mining industry, and we passed a few days at Obuassi, and also at Taquah, at which places some of the most important and completely equipped mines are situated.

The sanitary possibilities of a mining camp necessarily vary greatly with the stage of development of a mine, for it is impossible for the most experienced expert to decide on the eligibility of a site, until several months have been expended in experimental borings, and until this has been done it would be out of the question to expect anything beyond the minimum possible expenditure on the development of the sanitation of a site that, as likely as not, may have to be abandoned. As a matter of fact, three or four years of preliminary work must needs be accomplished before the value of a mining concession can be thoroughly estimated, but after this, it may be fairly assumed that the site will be occupied by a considerable population of Europeans and natives, for a period which will warrant reasonable expenditure on sanitation.

Prospecting work is undoubtedly hazardous in the extreme, a good deal more so probably, than the chances of ordinary warfare ; and the early history of any mine is usually darkened by a melancholy death roll ; but the enlightened self-interest of the management of some of the largest mines is rapidly making them by far the least unhealthy spots in this unsalubrious colony. On this account, no fair idea of the risks to life, in a fully-developed mining camp can be formed from the general average mortality of the mining population, but even when considered from that point of view the mortality but little exceeds that of officials, and is strikingly lighter than that of the trading community. In the Gold Coast colonial report for 1903, the death rates of the different European communities, per one thousand, is as follows: Officials 15.3, Mercantile community 35.8, Mining community 19.2, Missions 21.2 ; and the comparatively low rate for the miners is the more striking, when it is remembered that the rank and file of the mining community is drawn from a much lower social stratum of the home population. On the other hand, the invaliding rate is much higher than that of either of the other classes. This may be partly due to the vigilant care that is taken on most of the larger institutions, but is so much higher, that I was inclined to suspect that it may include dismissals from other causes of sickness, than those peculiar to tropical climates.

In one mining concern, of which the medical officer was good enough to furnish me with the statistics of a year, only two were invalided, in the ordinary sense of the term, one of which was for tuberculosis, while eleven were sent home on account of alcoholism. The average European strength of this group of mines was 130, and though there were no deaths, and no cases of black-water fever, the Medical Officer in question notes that those addicted to alcoholic excess were far more prone to malarial attacks than those who were temperate. It is obvious that a community including so large a percentage of intemperate persons cannot be fairly compared with a picked body of men,drawn from the most highly educated class of Britain, and the fact that the mortality of the entire mining community exceeds that of officials by so small a proportion, shows how very high a standard of sanitation has been attained on some of the longest established and best equipped mines. Whether any marked impression has been made on black-water fever it is difficult to say, as this inexplicable disease has a way of cropping up at irregular intervals, at times and places which are otherwse more healty than usual ; but at any rate Major Hickson, R.A.M.C., Retd., one of the Medical Officers of the Ashanti Gold Fields Corporation, informed me that in four tours of service, of over a year each, he had never seen a dead European.

As examples of the comparative healthiness of some of the older mines may be cited the following :—

The Obuassi Mine has an European population, served by its hospital, of about 100. The total admissions to hospital last year were 93, with one death (from black water). Of the total admissions, 55 were for malaria, and five for black water. The average stay in hospital of the malaria cases was 7.2 days, including convalescence, as in this concern, the cases are retained in hospital until returned to duty.

It is perfectly obvious that, with so short an average stay in hospital, the cases must necessarily have been, for the most part, of an extremely mild type, and, in fact, there was only one case in which the stay in hospital was so prolonged as to indicate really serious illness. Of course, here, as elsewhere, a certain number of admissions took place at all seasons of the year, though the hospital was empty at the time of my visit. This accords with experience of malaria in every part of the world, and is inevitable in a disease which is rarely cured, in the true sense of the word, but in which the seeds of the malady may lay hidden in the tissues for years, and are always liable to start into renewed activity, when their opportunity is found, in a lessened resisting power of the organism of their host, due to some other cause of depression of vitality. But here, as everywhere else, there are distinct malarial seasons, during which numbers of fresh infections, plus the usual quotum of relapses, swell the admissions to hospital in an unmistakable manner. The admissions for Black-water, on the other hand, show no relation whatever either to the seasonal prevalence of malaria or to any particular seasonal prevalence of its own. The dates of admission of the Black-water cases were as below :—

May 6th.—Relapsed, after apparent improvement, and died in 17 days.
July 23rd.—Cured in 24 days.
Oct. 7th.—Cured in 13 days.
Dec. 17th.—Cured in 15 days.
Dec. 17th.—Cured in 15 days.

Of the cases that recovered it will be seen the average stay in hospital was 16.75 days.

Dr. Hickson informs me that, during the seven years he has been connected with Obuassi there have been 5 deaths, one of which was the result of accident. The average European strength during this period may be put down at somewhere about 50, and, therefore, works out at about 16.5 per thousand, which is probably about the same as that of some parts of India.

The other case in which I have been kindly furnished with statistical information is that of the group of mines at Taquah, under the charge of Dr. F. W. Moir, which include a detailed statement of all sickness among the Europeans employed on the Abbontiakoon, Wassaw, Fanti, Effluenta, and Tamsoo Mines, and those of Bray Brothers, Diamond Borers; with an average strength of 130. The cases include also those of a few outsiders, belonging to the commercial firms at Taquah, who may muster perhaps another eight or ten persons. Unfortunately, they relate to the eight months of 1904, from May to December inclusive only, so that they cannot be made the basis of a calculation of the sickness of an entire year but for the period included they are very complete and detailed, and Dr. Moir tells me that about 50 *per cent.* of the malaria cases were verified by microscopic examination of the blood. There were no deaths, and no cases of Black-water fever, and this, I understand, may be said also of the entire year.

The following table epitomises the information included in Dr. Moir's monthly statements :—

Return of all sickness on the group of gold mines at Taquah, under the charge of Dr. F. W. Moir, for eight months of 1904, from May to December inclusive :

	Intermittent Fever		Remittent Fever		Influenza		Hepatic and Gastric Congestion		Respiratory Catarrh		Other Causes		Total Admissions	
	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital	Number of Cases	Stay in Hospital
May	7	29	4	22	...	...	1	4	1	3	1	7	14	65
June	7	42	10	69	...	...	...	...	1	2	1	12	19	127
July	12	61	11	70	1	14	2	4	1	2	...	...	27	151
August ...	2	7	3	18	...	...	1	1	...	...	1	6	7	32
September ...	...	...	1	6	...	...	3	15	1	2	3	31	8	31
October ...	3	11	2	16	...	...	2	4	...	...	1	5	8	36
November ...	6	19	...	...	...	...	1	1	...	...	1	3	8	23
December ...	8	28	2	16	1	2	1	3	1	5	3	11	16	65
Totals ...	45	197	33	217	2	16	11	32	5	14	11	65	107	544
Average stay in Hospital	4·4		6·6		8·0		3·0		2·8		5·9		5·1	

The heading, "Other causes," includes 2 cases of Anæmia ; one of Pulmonary Consumption, twice admitted, and finally invalided ; and one each of Lumbago, Nostalgia, Suicidal mania, Fracture of Tibia, Diarrhœa, Ulcer, and Abscess.

The predominating importance of malaria, as a cause of sickness in tropical countries, could not be more forcibly illustrated than by this table, as, out of a total of 107 admissions, involving the loss of 544 days' work, no less than 77 admissions and 414 days' work are referred to this cause alone ; but here, too, as at Obuassi, it is clear that the type of malaria cannot be said to be severe, as the average stay in hospital was but 5.3 days. Putting aside malaria, it is evident that the state of the general sanitation of the miners must be a very high one, the practically entire absence of bowel complaints being conclusive on this point. Possibly some of the cases of malaria, in which the blood was not examined, may have been due to influenza, which appears to have been hanging about, but, with this exception, malaria is the only member of the zymotic group of diseases which is represented.

Another point which is clearly shown, in spite of the incompleteness of the year's record, is that there are two maxima of malarial intensity during the year, the more important of which occurs in July, and the lesser in December, while the minima, as shown by records examined elsewhere, may be placed in September and February. When we had the pleasure of visiting Abbontiakon, indeed, the hospital was absolutely empty, and only 3 cases of malaria had been admitted during January. This distribution of malarial intensity, it may further be noticed, is only what might be deduced from the records of the rainfall, which, like those of all localities so near the Equator, shows two rainy seasons in each year, which here, as elsewhere, precede somewhat the dates of the malarial maxima.

The eleven cases of Gastric and Hepatic Catarrh were said to be mainly of alcoholic origin, and, excluding these and the broken leg, we are left with only 18 cases of ordinary sickness, involving an average stay in hospital of only 5.7 days each.

The only serious cases were one of Tuberculosis, contracted in England, and that of mania, which appears to have been of alcoholic origin.

It may fairly be said then that, but for malaria and the ever-present dread of the invasion of Black-water, these mines may be considered an exceptionally healthy place of residence for the tropics, and I think it may be said that the measures that have been adopted there have already greatly diminished this main cause of sickness, while those that are projected cannot fail to have an even more marked result.

General Surroundings of Mining Camps.

Although the number of mines visited was necessarily very small, the general character of the country along the railway, which passes at no great distance from by far the majority of the camps, is so uniform that there may be said to be a strong family resemblance running through all of them. The general character of the sites may, in fact, be deduced from what has been said with regard to the country, as seen from the railway line—steep, but not lofty hills, with intervening marshy tracts in the valley bottoms. Kumassi, which is placed in one of these valley bottoms, at a distance of a little over 100 miles from the coast in a direct line, has an elevation of 680 feet above the sea, and through the winding course of the valleys that drains it is doubtless a great deal longer than the direct line, it is obvious that so marked a fall is ample to secure an adequate outfall throughout their entire course. As a rule, the valley bottoms are so narrow that the areas requiring drainage are very limited, and the majority of them could undoubtedly be dried up, by simply cleaning out and grading their natural lines of drainage. Everywhere the country is a primeval jungle, unmodified by the presence of man, as the natural stage of civilisation of the native African is so low that the profound modifications of natural conditions brought about by the agency of man, over the entire surface of Asia and Europe, are absolutely wanting. A jungle remains a jungle, and a swamp a swamp, and the utmost of which the native seems capable is to slightly extend some natural clearing, where he can erect his hut and scratch the ground a little to supplement, by some rudimentary cultivation, the natural sources of supply.

On this account, when the European undertakes the task of reducing the country to habitability, he is not, as in most countries, the inheritor of a large capital of native work in clearing and improvement, but must needs start afresh, and it is this that makes his work so deadly until he has acquired absolute political control of the country, and can find the funds to effect in a few years the work that has elsewhere resulted from centuries of civilisation. Anywhere else these easily drained swamps, with their rich soil, would be the bones of eager contention, and every inch of them would be utilised in such a way that their dangers would be enormously diminished. The area of swampy ground, however, does not appear to be anywhere large, and good sites, alike for European and native locations, are everywhere available by clearing the jungle from the hills. It must be understood that a mining camp necessarily includes two distinct settlements, as the hard manual labour is everywhere performed by the native, and the European acts only as supervisor, or as a skilled mechanic. Each must necessarily be in close proximity to the mine-head, but they ought to be, and generally are, kept as far apart as possible. The mistake, however, that has very commonly been made has been to regard any site as good enough for the native location, so that very commonly it has been allowed to grow up at haphazard on the edge of marshy ground.

Now, apart from the importance of keeping the native labourer in a state of healthy efficiency, the European cannot gain the full advantages of a healthy site unless the native enjoys the same advantages, as it is from the latter that the European "catches" the tropical maladies, that cause so formidable a roll of sickness and mortality. Both at Obuassi and at Abbontiakoon the native villages were placed on low-lying ground, which no ingenuity could convert into really desirable building sites, and though, at both places, the managers had gone to great expense in laying out and almost rebuilding the villages, it was clear that the true remedy lay in the abandonment of the old and unsuitable site, and the clearance and settlement of one more suitable.

The Taquah Mining Co., on the other hand, has selected a much better site for their native labour, but can hardly reap the full benefit that might be expected from it, as the houses of the Europeans in their employ are almost as near the native quarter belonging to another mine as those of the mine itself.

There can be no doubt that the selection of suitable sites for the quarters of Europeans and natives alike is a matter of the first importance to the health of all concerned, and that the financial success of a mining company depends far more on this and similar points than is usually recognised, for at present the cost of paying and nursing sick men, and the heavy expenses involved in invaliding and replacemen constitute a heavy drag on the industry that might be undoubtedly lessened by steady attention to sanitation, to an extent which would yield handsome interest on any money so expended.

From the character of the country, excellent sites are almost everywhere available, and the obstacle to their adoption is simply the expense involved in clearing the dense junge. It appears that a useful step might be taken if the clearing and drainage of a certain area around the mine-head, within a certain number of years, were made one of the conditions in granting any new concessions. As a rule, the managers show an enlightened policy in the matter, but their efforts would undoubtedly become more continuous and systematic if their work in this direction could be triumphantly pointed out to the Board of Directors as so much accomplished towards securing their permanent tenure of the property they are engaged in developing.

Characteristics of the Industry Bearing Upon Sanitation.

The general plan and appliances of a gold mine closely resemble those of tin-mines. Unlike a coal mine, where the greater part of the spoil is at once removed, and directly saleable, the amount of mineral removed from the spot is infinitesimally small, in comparison with the bulk of ore brought to the surface and left there. Part of this is non-gold-bearing rock, which is simply sorted out, and thrown aside on the nearest convenient spot. This consists of coarse rubble, and would form ideal material for forming the lower layer of material employed in filling any marshy hollows that cannot be easly drained. The rest consists of the fine sand that comes from the stamps and cyanide vats, and from its porous character would serve well as an upper layer in such operations. This material, known as "tailings," is easily carried to some distance by a current of water, and I noticed more than one case where, either by accident or design, considerable swampy areas had been reclaimed in this way; while, in other cases, it had rendered matters worse, by interfering with drainage. Being composed of absolutely pure and insoluble mineral matter, it is almost impervious to the advances of vegetation, so that the land so covered becomes useless for cultivation, but there is little dearth of suitable garden sites, so that this is a small matter. There can be no doubt that if an eye were kept upon the filling in of dangerous hollows with these materials in the first place a good deal might be done in the way of anti-malarial sanitation, at but little cost as compared with that involved in re-excavating and handling the material anew, with this specific object. In each mine, their sanitary adviser should draw up a systematic plan for what the Italians call the "bonification" of the settlement generally, and with this before them, managers might often effect most important improvements without a penny of additional expense.

A second point in the industry that has an important bearing on sanitation is the enormous volume of water pumped up from the workings or brought in flumes from streams to feed the stamps. It is a matter of the most obvious importance that all water either brought to the surface or carried from higher levels on to the site, should be carefully and expeditiously conducted away, but this is, unfortunately, by no means the case, and at the time of our visit it was surprising to notice that it was in such collections alone that larvae were to be found, as the marshes so swarmed with fish that in several instances it was impossible to find a single larvae in marshy tracts that appeared ideal situations for their residence. Had anyone told me that these spots were barren of larvae I should certainly have regarded the assertion merely as so much evidence that the speaker did not know how to search for them. This is, however, no argument for neglecting to deal with the marshes, as whatever may be the case in the dry season, the reproductive powers of the mosquitoes during the rains must in all probability get the better of the destructive powers of the fish, and, in any case, they render the air and soil in their neighbourhood damp and unhealthy.

A third point involved in the industry is the large destruction of forest for the supply of fuel for the engines that work the various pumps, hoists, stamps, etc. To a certain extent, of course, this process is beneficial, by contributing to clear the site, but unfortunately a large proportion of the trees are of little use as fuel, and these are accordingly left untouched, while the disturbance of the surface that necessarily results from the felling operations has a tendency to produce depressions, which may result in puddles. Conducted with care, this should not be the case, and were this point attended to, the improvement of ventilation resulting from the thinning out of the forest, must needs be beneficial. It is highly desirable, however, that a considerable area around the habitations of all employed on the mine, whether white or black, should be thoroughly cleared from forest and bush, leaving only a few large trees for shade and ornament. If the superfluous trees are not good enough to be burned in the engine they should be burned on the spot.

Underground, the temperature of the air is usually somewhat higher than that at the surface, but was by no means oppressive, and the ventilation appeared excellent, large volumes of air being continuously driven through the workings. The character of these varies, being in places quite dry, and in others dripping with moisture, but as a rule the floor, though hard, was muddy, so that, given the necessary infection, it is clear that all the conditions that favour anchylosto-though no offence was noticeable, the skips are not working continuously, so that some provision of the sort is certainly desirable,as the black miners work almost in a state of nudity, and it is difficult for an European to move about the mine without the muddy water getting into the boots, so that both classes would be liable to suffer should the infection of that disease once gain an entrance. The natives seen in the mine, however, did not show any signs of Anchylostomiasis, but the danger is, nevertheless, one that should be borne in mind and guarded against.

Prevalence of Mosquitoes

As already mentioned, no larvae could be found in any of the large marshes, and but few of either these or imagines, were in evidence anywhere, a few Culices alone being met with in the house. It is difficult to account for this, as unregarded collections of water were extremely common, and the temperature of the air was in every way suitable to the breeding of these insects. A few *Anopheles* larvae were found in certain disused mining utensils containng water.

Food.

As a rule, as elsewhere on the "Coast," too great dependence is placed upon tinned provisions, and the supply of vegetables is scanty and insufficient. Some of the mines, however, have already started gardens, and others are proposing to do so, and hence an improvement may be expected in this respect. There can be no doubt that a vegetable and fruit garden should form an item of the equipment of every mining community,as it is well known that preserved food of this description is in no sense a substitute for the fresh article. The methods of the native gardeners are, however, very rude, and it is a matter of common experience that the growing of European vegetables in tropical climates is a special business, and requires experience that is entirely wanting in the freshly imported European horticulturist, so that it would be well to import gardeners, accustomed to this sort of work, from either India or China, who could teach the native gardeners the special methods essential to success. In making a choice of such men, those should be chosen who have worked in the true tropics, such as Madrassis,as a man from Northern India would find himself almost as "at sea," as an European. Some attempts at melon cultivation are a case in point :—There are plenty of absolutely ideal spots for the growth of this most wholesome and delicious fruit,but the attempts were made in the wrong way. To anyone who had ever seen how this cultivation is worked in similar climates, indeed the attempts were absolutely farcial. As far as could be gathered,no attempts had been made in inarching mangoes, with the result that most seemed agreed that the fruit was not worth eating ; while the local plantain, though possibly very rich in nutriment, is about as tempting as a dish of maize porridge.

Short as was our stay, I noticed several Europeans, with a spongy condition of the gums, which would certainly have elicited the wrath of an Inspector General of Prisons, if found in an Indian jail. In the matter of the supply of fresh meat, matters will, no doubt, soon be bettered, as more than one of the mines are putting up refrigerating plant, with the view to storing imported meat, and this, with the accompanying free supply of ice, will undoubtedly help greatly to improve the health, and therefore the efficiency, of the miners. There is one further point in this connection which I would desire to bring most strongly to the attention of the managing authorities of mines, and that is the desirability of instituting instalments for the production of aerated waters at a reasonable price. From personal experience, I know that such an instalment is very easily worked, and yields a good profit at a penny a bottle, but nothing but imported waters are to be met with on the "Coast." It requires a teetotalism of the most robust kind to imbibe the luke-warm flatness of tropical water, and with "soda" and ginger beer at 7d. and 9d. a bottle, it is much cheaper to qualify the uninviting fluid with something more than a modicum of spirit. There can be no doubt that nothing has done more for the cause of temperance, in the case of the British soldier in India, than the institution of regimental factories for aerated waters. It has been found to pay well with much smaller bodies of men than are employed on many mines, and there can be little doubt that the same step would have as beneficial effect in the case of the miner as it has with the soldier.

Housing.

This varies greatly. Some of the huts used during the early stages of mines, but now abandoned, were mere shanties, constructed out of old packing cases and odd scraps of tin, and small and ill-ventilated at that. An ordinary Indian Kabul tent would form a sanitary palace, compared with the worst of these, and it is only surprising that the results of inhabiting such structures in such a climate, were no worse than they were. In some other cases, the obvious ignorance of the designers as to the essentials of tropical domestic architecture, has resulted in the erection of an inferior type of workman's dwelling, on strictly English lines, but in the majorty of cases, the newer quarters, though sharing in the almost universal faults of European buildings, in this country, are good of their sort.

The number of mines inspected was, of course, very small, but in each case this desideratum had received due attention, and though the necessities of the case demand that the miners, whether European or native, should live close to their work, they are kept better separated than in either of the two towns we had the opportunity of visiting. All of the mines are not, however, quite on the same footing as to their power of securing efficient sanitation in this and other respects, as the conditions under which concessions are granted have, it is understood, been modified of late years. The managers of the older mines, it appears, possess certain quasi-magisterial powers, which enable them to evict natives, for example, from undesirable situations, and to enforce general sanitation in a way that is precluded under present conditions, so that the reconstruction of a native settlement cannot be enforced in the same manner as is practicable under the older tenure. This seems unfortunate, for, though the English working miner may be somewhat of a "rough diamond," the managers must necessarily be highly competent and scientific men, who have too much experience of the tact necessary to work smoothly with native labour to be likely to be led into arbitrary or tyrannous measures, to say nothing of the fact that the native has always the right of appeal to the civil executive, who are always easily accessible, and might be trusted to prevent that tactless form of sanitary regulation which secures its own defeat, without rendering helpless the invaluable knowledge of the man on the spot. In questions of ordinary discipline, or those involving payments, it is, no doubt, inadvisable to give too free a hand to European employers of native labour, and it is more than probable that the withdrawal of really salutary powers in regard to conditions bearing on health was a mere oversight that might easily be remedied. In such matters, subject to the approval of the sanitary officials of the Government, the powers of the mine manager should certainly be as nearly absolute as possible.

Conservancy and General Sanitation.

Pit latrines are sometimes employed for the natives, and, in the case of Europeans, much the same system as that already described as adopted in the towns. In other cases regular latrines are provided for the natives also. That the general results are satisfactory is shown by the remarkable absence of bowel complaints and filth diseases generally.

Medical and Sanitary Supervision and Hospitals.

The mines are remarkably well provided with medical assistance, almost every mine having its own medical officer, who, in many cases, has passed through one of our schools of tropical medicine. Many of these gentlemen are keen and able sanitarians, and it is not surprising to find that mines under the guidance of men so well equipped with the necessary knowledge are rapidly improving in health, and are far safer places of residence than any of the towns. In stating this conviction, nothing is further from my intention than to institute any comparison between public and private medical officers, as the conditions under which they work are totally different, on account of the far greater power practically possessed by the mining official, whose only difficulties lie with outside native resident on or near the site of a concession ; all others, whether native or European, being easily controlled by the Managers' ordinary powers of dismissal. Both at Obuassi and at Abbontiakoon there were excellent hospitals. The former was, it is understood, originally constructed by the railway contractors as a temporary structure, which probably accounts for the fact that it might be greatly improved by the provision of better arrangements for bathing, though the accommodation is, in many respects, admirable. That at Abbontiakoon is, in many ways, one of the best tropical hospitals I have met with anywhere, and a trained nurse is included in its staff.

Although corrugated iron is the material of the roof, the inadequacy of this material as a protection against the heat of the sun has been neutralised by a wide and freely ventilated space between roof and ceiling, and the doors and windows are all protected with wire gauze. Against mosquitoes the protection afforded is but relative, as the doors are only single, and are not self-closing ; but this is a great advance on no attempt at protection whatever. The addition of a gauze-protected verandah, in which convalescents might sit out during the cool of the evening, without risk of being bitten, would be a great improvement.

General Conclusions.

The managing authorities of most of the mines appear to thoroughly recognise, and, as far as means allow, to utilise our knowledge of the methods of the propagation of malaria, and of general sanitation ; and, owing to the more compact and manageable character of the communities with which they have to deal, have in many cases rendered their settlements far healthier places of residence than found elsewhere in the colony. There can be little doubt that the amelioration already effected can be more than maintained by a policy of steady improvement. It appears that the points that now require most attention are the drainage of marshy ground, the clearance of jungle, and attention to the details in the standard of comfort, which contribute so much to health in trying climates such as this.

Part II.

A COMPARISON BETWEEN THE CONDITIONS OF EUROPEAN RESIDENCE IN THE GOLD COAST COLONY WITH THOSE EXISTING IN INDIA.

The European nations have engaged in trade, and made attempts at settlement in both the above regions ever since a greater mastery of the sea has made long voyages possible; but whereas, in the case of India, these attempts have resulted in the almost complete political domination of the entire peninsula, it is only lately that anything more than a precarious footing on the coast has been gained in Africa.

From this it results that, from the European point of view, our African colonies are still new and undeveloped countries. In both fields of enterprise, the same men have been engaged in the same task, but while India proved from the first to be fairly habitable to the new comers, in Africa they have been beaten back, again and again, and even now, keep their footing only at a heavy cost of life and suffering.

Broadly speaking, the reasons for this are not far to seek. The India opened up by the early navigators, was at least as civilized as the countries whence they came, and what is more, had been so for a far longer period; so that, great as has been the advances of late years, there can be no doubt that could the Anglo-Indian of to-day be transported back to the court of Akhbar, he would find himself in by no means strange surroundings, and far more comfortably situated than he can be, even now, if he move but a mile or two beyond the limits of an Anglo-African settlement. In the one case, centuries of labour on the part of an intelligent, if not very progressive people had gone far to overcome the influences hostile to human life in the tropics, while in the other, a race of savages had left their country practically untouched. The detail of the points of difference, however, require separate consideration.

The Comparative Unhealthiness of the Two Countries.

In the first place, is there any great difference in the morbidity of the regions under comparison? Here we are at once met with the difficulty of the different composition of the two European populations. In India the European population is far more permanent, and includes a fair proportion of children, and even a few old people, while in Africa, prolonged residence can scarcely be said to be attempted, and neither children nor elderly persons are to be met with. Again, outside the great presidency towns, the Anglo-Indian element is almost purely official, and even in Calcutta and Bombay, the traders are mostly important leaders of commerce, who are able to command every procurable comfort, and are very differently placed from the white man engaged in exchanging trade gin for oil nuts in a rickety shanty, on the banks of some muddy African creek. Shift the African trader's shanty to some backwater of the Hoogly and still deny him all the comforts of civilization, and it may be doubted if he would be any the healthier, while he would certainly find the climate even more disagreeable. The number of European troops in West Africa is too small to afford any fair basis of comparison, and the only two at all fairly comparable bodies for which statistics of any sort are available are the civil officials. These are drawn from very much the same class of English society, and in both cases are necessarily prudent and responsible persons, able to take the best practicable care of themselves, and accustomed to do so.

At the same time, it must be remembered that the comparative healthiness of India is a matter of merely recent years, and that even in the earlier years of the 19th century, it held a deservedly bad reputation, so that at that time, service there was regarded in much the same light as that on the West Coast at present. Dickens, for instance, disposes of Mr. Bob Sawyer by "passing him over to Bengal, accompanied by Mr. Benjamin Allen, both gentlemen having received surgical appointments from the East India Company. They each had the yellow fever fourteen times," etc.

As to the serious danger involved in West African service, there can be no doubt, but neither in India nor in Africa are there any available statistics as to the exact character of sickness affecting officials. In the former an official is treated at his home, and unless so ill as to involve his appearing before a Medical Board, does not figure in any official return. Moreover, even if invalided by such a board, it is as likely as not that the leave when granted, appears as "on private affairs" in the official gazette. In fact, unless an officer have exceeded his authorized proportion of leave, it is unlikely that he will appear otherwise. As a matter of fact, indeed, owing to the impecuniosity resulting from a depressed rupee, an officer usually serves as long as he can, and only takes his furlo' when compelled to on account of failing health; but even taking all Indian furlo' as equivalent to invaliding, it would not approach the combined leave and invaliding roll of West Africa by a third.

Up to recent years the death rate of our West African colonies has been very heavy. In an official paper, kindly supplied to me by H. M. Colonial Office (African (West) No. 727, dated June, 1903), the deaths among officials are subjected to actuarial investigation, with the following results.

Colony	Number of Persons	Number of year's service	Average length of service in years	Number of deaths during service	Death rate per thousand per annum
Gold Coast ...	554	1,307	2·4	99	75·8
Lagos	258	522	2·0	28	53·6

Colony	Average age at entering service	Number of persons on which average is based	Average age at death if during service	Number of persons on which average is based*
Gold Coast ...	nearly 30	390	$34\frac{1}{2}$	83
Lagos	" 32	153	nearly 42	6

The column headed "Number of years' service" contains the totals of the periods from the date on which each European arrived in West Africa to take up his employment under one of the two above-mentioned Governments to the date on which he ceased to be in the Government's employ. In the case of persons whose employment falls partly outside of the years 1881 to 1897, the part before 1881 or after 1897 is not taken into account. Leave of absence to England has been regarded as incidental to the employment, and is included. Since 1883, and except in cases of invaliding, such leave of absence would ordinarily be for six months after every twelve months' service, voyages to and from England being included in the six months.

Three women were employed in the Gold Coast, and four in Lagos. The remainder of the persons employed were men.

Dates of birth were only available for 390 persons in the case of the Gold Coast and 153 in the case of Lagos, of whom two, both in Lagos, were women.

PERIOD 1881—1897 INCLUSIVE.

The statistics have been compiled by Mr. T. E. Young, a former President of the Institute of Actuaries, from data collected from the records of the Colonial Office by Mr. C. D. Turton, a former Treasurer of the Gold Coast, and are as follows :—

In the case of the Gold Coast the 83 deaths during service in which the dates of birth were known were distributed according to age as follows—

Age.	Deaths.
20—30	27
30—40	39
40—50	9
50—60	8
Total	83

* Note by Mr. Young.—The persons here mentioned include only those where some definite evidence existed of the age at death, but it seems not improbable, from a general examination of the returns, that as regards the Gold Coast the age at death here furnished may be regarded as fairly representative of the age in the cases also where no specific evidence appeared; while in respect of Lagos it may be reasonably assumed that the age at death of persons not included in the average was somewhat younger than 42.

In these and following comparisons, it should be borne in mind that the death-rate for corresponding ages in England is about 9 per 1,000, and this, too, in spite of the fact that it necessarily includes the maimed, halt, and blind, of all classes of the community, whereas both in India and on the West Coast, the official is carefully selected by medical examination, and almost without exception, is drawn from the well-to-do classes. On the "Coast," indeed, even the non-official community is very generally selected by medical examination.

These figures represent the state of health of the community previously to the introduction of antimalarial sanitation, and there is no blinking the fact that they are appalling, and this rate persisted right up to the date of the first attempts in that direction, the rates for officials in 1901 being :—

Number	Deaths	Invaliding	Death rate per 1,000	Invaliding rate per 1,000
188	15	18	80	95

The improvement between 1901 and 1902 is so considerable that it clearly can hardly be due to ordinary variation, still less to any sudden change in the habits of life of the community, as neither of these is likely to bring about a fall to less than half the previous mortality, as is shewn in the subjoined table taken from the Gold Coast Report for 1902.

Table of sickness and invaliding among Europeans for 1902 :—

How employed	Number	Deaths	Invalided	Death rate per 1,000	Invaliding rate per 1,000
Officials	286	10	24	35·0	83·9
Mercantile Firms, etc. ...	373	21	38	56·3	101·9
Mining Companies ...	778	18	98	23·1	126·0
Gold Coast Railway ...	297	6	20	20·2	67·3
Missions	96	2	1	20·8	10·4
Total	1830	57	181	31·1	98·9

Moreover, when a further, almost equally striking improvement takes place in the succeeding year, it is clearly out of all probability that the incident is due to the fluctuations constantly found in any series of figures, and still less to any sudden change in the habits of life of the community. I allude to this, because one very commonly hears the reply to the deduction that antimalarial measures have brought about this improvement, "Ah ! the real reason is that a better and more temperate class of men are now taking service on the coast." Now social improvements of the kind suggested can hardly be other than gradual, and the improvement has been a sudden one and an immediate sequel to the introduction and development of anti-malarial measures. The corresponding figures for 1903 are as below.

Table of sickness and invaliding among Europeans in 1903.

How employed	Number	Deaths	Invalided	Death rate per 1,000	Invaliding rate per 1,000
Officials	326	5	25	15·3	76·7
Mercantile Firms, etc. ...	335	12	18	35·8	53·7
Mining Companies ...	1,043	20	92	19·2	88·2
Missions	92	2	2	21·7	21·7
Total	1,796	39	137	21·7	76·3

Still great as has been the improvement, the health of the European in India, as will be seen, compares very favourably with that of his brother-officer on the West Coast, and the difference is all the more striking, because it is not fair to compare Indian figures with the comparatively light mortality of the last two years. These years are the result of the systematic adoption of all such measures of anti-malarial sanitation as can be carried out without considerable capital expense, but in India for all practical purposes the possibilities of anti-malarial sanitation have been absolutely ignored. Up to 1903, at any rate, the futile so-called experiment at Mian Mir, was all that had been attempted in this direction, so that a fair comparison can only be instituted with West Africa previously to the adoption of anti-malarial measures.

The only branch of the Indian services for which information is available is the Covenanted Civil; and even of this only for certain provinces, which happen to publish the casualties occurring in that service in their Quarterly Civil Lists.

From these have been collated the casualties of the five years ending with 1903, on a total average strength of 607. For the reasons already mentioned no reliable information as to invaliding is obtainable for comparison. The results are as follows :—

Table of mortality of the Indian Covenanted Civil Service, based on the five years from 1899 to 1903 inclusive.

Province	Average strength	Died	Death rate per 1,000
Bengal	233	17	14·4
United Provinces... ...	217	10	7·4
Madras	157	8	12·7
Altogether ...	607	35	11·3

If available, it would probably be found that Bombay and Central India would not differ greatly from Madras, and that the Punjab would equal Bengal, while Burmah and Assam would be much higher than either, but it is perfectly certain that neither of these would show a mortality at all approaching to that obtaining on the West Coast, up to the last few years. It should be further explained that the death-rates of other branches of the service would certainly run higher, as the Covenanted Civil Service enjoys more favourable leave rules than any other branch of the service, and, what is even more to the point, are so much better paid that they can never be prevented from taking their full proportion of leave through impecuniosity. On this account, the circumstance that this service in the United Provinces has a death-rate lower than that of England is not so surprising, as the only fair comparison with the English data would be those relating, e.g., to clergymen of the Church of England, or the Bar, whose sheltered lives afford them a death-rate much lower than that of the community generally.

The general European death rate in India is difficult to compare with that of almost any other community, without laborious actuarial investigation, because it includes so small a proportion of children of school-going age, but an enquiry undertaken in the Bombay Presidency gives figures that confirm the impressions yielded by the records of the Civil Service.

Out of a total population of 18,804 (including soldiers) the death rate in 1901 was 13.5, and the birth rate 14.4, while in 1902 the birth rate fell to 13.4, and the death rate rose to 16.1. Amongst Eurasians the birth rate was 21, and the death rate 24 per thousand. For the native population, it need hardly be said, the rates, alike of births and deaths, are very much higher, their mortality in some years quite equalling that of Europeans on the West Coast, when at its worst, in some of the more unhealthy Indian towns.

The constantly sick rates, however, would certainly not work out so favourably to India, as, for malaria alone, about a third of the entire strength of British troops is admitted once to hospital yearly, although a considerable proportion of the men are kept out of harm's way by being sent to the hills, while in specially malarious stations, such as Mian Mir, there have been years when every man was admitted, on the average, three times each.

Character of the Diseases Responsible for the Mortality.

In India, the special causes of death that raise its mortality above that of England are Typhoid Fever, Cholera, Dysentery, Abscess of the Liver, and Bubonic Plague. As has been seen, malaria is responsible for an enormous amount of sickness, but is rarely directly fatal, although much of the malaria is of a very virulent type. As to West Africa, very little detailed information is available in a documentary form, but conversations with a considerable number of medical men, possessing experience of the Coast, elicited almost universally the same information, viz., that Typhoid, Cholera, and Plague were unknown, and dysentery and abscess of the liver comparatively uncommon. All were also agreed that the ordinary cases of malaria are by no means serious, involving, as a rule, only a day or two's confinement to bed. Further, it was difficult to hear of instances of death from any other cause than either what is called Black-water Fever, or another, equally inexplicable and rapidly fatal condition, spoken of simply as hyperpyrexia. It is quite useless searching for information as to the commonness of these two conditions in hospital returns, as both of them have hitherto been included in malaria. Another point equally striking is that almost unanimously my informants were agreed that all these cases, or, at any rate, Black-water, showed no seasonal prevalence. The exceptions were the men who served in Sierra Leone, some of whom were inclined to claim a prevalence for black-water parallel to that of malaria. Now, if black-water and hyperpyrexia be simply malignant malaria, it is, to say the least, strange that they are not met with in India or elsewhere where malaria is an excessively common disease. That the symptom of haemoglobinuria is occasionally met with I am quite aware, though personally 20 years of Indian service scarcely enables me to recall more than one or two, but where is there to be found a similar form of malaria killing one out of every three victims? That the malarial parasite is usually found in the earlier stages of the majority of cases proves nothing to anyone who has practised in a malarial country, as in such places the whole population carries about with it dormant parasites, which start into activity when favoured by any shock, or other depressing influence, so that it is exceptional rather than otherwise not to find the parasites in the epidemic pneumonia of India, and child birth and amputation of the leg might be demonstrated to be malarial in their causation by the same argument, for nothing is commoner than to have such cases complicated by the reappearance of malarial parasites in the blood. If "Black-water" be really malarial, its prevalence should coincide with that of mosquitoes, as otherwise it is clearly to no purpose to attempt to check it by measures directed to the diminution of their numbers. It must be admitted that the hypothesis of the malarial origin of Black-water Fever fails to cover the circumstances of the case, and as the discovery of its true etiology and prevention will solve at once the problem of the unhealthiness of the greater part of Africa, it appears to the writer that a strong case has been made for a special investigation of this mysterious malady.

It will thus be seen that the causes of increased mortality, as compared with those of temperate climates, differ entirely on the West Coast of Africa from those met with in India.

Comparison of the Climate of the Gold Coast with that of India.

In speaking of climate, it must be clearly understood that the salubrity or otherwise of the places compared is not considered, but simply the records of the thermometer, hydrometer, and rain-guage. In the first place, however, it must be pointed out that India extends over so many degrees of latitude that almost every variety of tropical and sub-tropical climate is to be found within its limits, and on this account the climates of Southern India, Lower Burmah, and Ceylon alone resemble at all closely that of West Africa. In the next place, it may be well to consider what constitutes a "bad climate." Individuals differ greatly as to the discomfort experienced from damp or dry heat respectively, a few finding the dry heat the more intolerable, but, for the majority, damp heat is undoubtedly the more trying.

Fortunately for mankind, dampness is never found associated with really excessive air temperatures, that is to say, such as considerably exceed the temperature normal to the human body; but it is not a question of whether a dry heat of, say 90, is more harmful than the same temperature combined with dryness, but as to whether such a damp heat is or is not a more serious matter than a dry heat of 100 or over. The answer in all probability depends on the continuousness or otherwise of the unfavourable condition; in other words, on the diurnal range of temperature. Whether damp or dry, heat will be well borne provided that the nights are cool enough to permit of healthy and refreshing sleep, but unremitting heat extending over several weeks or months will undermine the resisting powers of the strongest, from lack of sufficient sleep, even if such serious direct results as heat stroke be escaped. Another point to be remembered is that for temperatures that approach the normal body-heat, every degree of closer approach or excess becomes increasingly serious.

As compared with India, the weather conditions of our West African Colonies are very uniform, all of them, with the exception of Bathurst, being in much the same latitude, the Gold Coast Colonies, Lagos, and Southern Nigeria all having a coast line that coincides pretty closely with 5 deg. N., while Sierra Leone is in 8 deg. 30 m., and even Bathurst only about 12 deg. N. All of them are, therefore, well within the tropical zone, and hence present the phenomenon of double rainy seasons. The meteorological returns for India are the results of many years' skilled observation, and may be said, therefore, to represent the actual facts. Those of West Africa, on the other hand, bear unmistakable signs of being the work of amateurs, and have been in some cases so obviously fallacious that Government has refused to publish them, with the result that no adequate series is available.

In some cases the instruments are wrongly exposed, as thermometer screens should never be placed absolutely in the open in a tropical climate, but should be installed under the shelter of a thatched hut with open sides. When placed in the open, the result is to exaggerate the shade maximum, and to disturb the correct readings of the difference between the wet and dry bulbs. Another result of amateur weather recording is to exaggerate the degree of relative humidity, through its constant tendency to forgetfulness in the matter of keeping filled the receptacle of the wet instrument.

No carelessness in the management of these instruments can result in recording too low a relative humidity, and every neglect to keep the water receptacle properly filled must give rise to too high readings.

An inspection of the detailed monthly returns, published in the Government gazettes, shows plenty of obvious instances where the wet instrument has been allowed to become quite dry, or nearly so. On this account, the records of relative humidity given below require to be discounted somewhat.

MONTHLY RAINFALL OF GOLD COAST STATIONS

Place	January	February	March	April	May	June	July	August	September	October	November	December	Year	Number of years' observations
uri ...	1·20	2·88	4·01	5·55	6·72	6·67	3·06	2·74	2·74	8·01	3·89	2·21	49·68	11
vitta ...	...	0·69	1·51	...	7·93	12·45	0·30	2·93	0·05	0·32	...	...	2[illegible]·18	1
mbaga ...	...	0·43	0·12	2·31	3·19	4·56	8·65	10·22	6·08	3·05	0·23		38·56	2
im ...	13·42	1·09	1·11	12·30	7·35	23·64	7·62	1·76	2·34	11·90	7·86	1·82	99·16*	1
kondi	2·73	1·06	2·30	2·37	5·87	8·40	2·74	0·58	1·23	3·4[illegible]	1·12	0·86	31·98	2
uassi Mine	0·86	0·14	2·54	4·54	7·33	13·47	5·86	5·13	5·65	6·90	4·09	3·16	61·11	2
ean of Eight Stations ...	2·45	1·57	2·09	4·61	5·50	9·48	4·58	3·75	3·89	5·49	2·51	1·37	48·58	...

* 99·16 as a second years' *total* rainfall only was available; the two years are included in the annual average.

The only at all continuous records available are those of Accra, and though misprints and other obvious inaccuracies are fairly numerous, such mistakes have a tendency to correct each other, and the following averages of the results of ten years' observations, with a slight discount on those of relative humidity, may be taken as a pretty close approach to accuracy. For the other localities, the series are too short to be considered as more than approximations to the truth, but they generally confirm the results of Accra.

Let us now compare the principal data for Accra with those of different parts of India.

Mean Monthly Maxima (Temperature) of West Africa compared with those of India and other Oriental Stations.

Month	Accra Gold Coast	Port Blair Andamans	Singapore	Moulmein Burmah	Madras	Bombay	Hoshangabad Central India	Sibsagar Assam	Calcutta	Allahabad	Jacobabad	Bathurst Mean 10 yrs.	Lagos Mean 10 yrs.	Old Calabar Mean 6 yrs.
January ...	86·3	86·4	85·6	88·4	84·7	82·6	86·3	70·1	77·1	74·4	73·6	83·6	87·6	86·4
February ...	87·8	88·1	87·1	91·5	86·9	82·6	85·4	73·1	82·0	86·2	77·9	86·2	87·7	89·6
March ...	88·7	91·1	88·0	94·1	90·0	85·7	95·7	79·1	90·8	93·0	91·1	83·4	89·5	89·7
April ...	88·3	92·5	89·0	94·6	93·1	88·5	104·8	82·5	96·6	103·8	163·1	85·5	88·8	90·2
May ...	83·9	89·0	88·9	89·3	98·5	90·7	107·6	85·9	94·5	107·6	111·6	83·7	86·9	91·0
June ...	83·0	86·0	86·7	84·6	98·5	87·6	98·1	89·3	91·1	101·7	112·7	86·6	85·0	86·8
July ...	81·4	85·4	87·5	83·0	95·7	84·4	86·7	90·0	86·0	91·6	107·8	85·6	81·6	83·5
August ...	80·3	85·3	86·3	83·0	93·8	84·0	85·0	89·2	87·1	89·8	103·8	85·4	81·0	82·7
September ...	83·7	85·1	86·9	84·8	93·0	84·5	88·1	88·1	87·7	91·5	103·5	86·3	82·8	84·2
October ...	84·0	86·9	87·1	88·4	89·0	87·5	89·6	84·8	86·7	90·5	98·6	87·7	84·6	86·1
November ...	86·9	86·8	86·1	88·4	85·1	86·9	84·3	78·3	81·4	83·1	86·8	86·8	87·5	87·2
December ...	87·2	85·9	83·2	87·2	83·3	84·5	79·3	71·5	76·5	77·7	76·7	83·0	88·1	87·2
Year ...	85·1	87·4	86·9	88·1	91·0	85·8	90·4	81·8	86·5	89·8	95·6	85·3	85·9	87·0

Judged by the maximum thermometer, it must be confessed that Accra has no claims whatever to any unenviable distinction. Next to Accra have been placed the records of the Andaman Islands and Singapore, which are, by common consent, recognised as two of the most pleasant of all tropical climates, and yet it is undeniable that one may find oneself a trifle hotter in either of them, while tropical India, and Burmah suffer severely in comparison. At the same time it is obvious that the dwellers in any of these localities must travel to Northern India should they desire to form any idea of the suffering involved in the endurance of a prolonged spell of really excessive heat. Taking the other side of the page, where have been placed the figures of some other West African localities, it will be seen that the climate of Lagos follows close, and though Bathurst can show some fairly respectable figures, an inspection of the following table of minimum temperatures shows that, owing to an enormous diurnal range, the nights are always singularly cool for a place so near the Equator. Old Calabar, on the other hand, is pretty steadily warm, having the same mean annual maximum as Madras, but, at the same time, it will be noticed that it has no month as hot as May, June, and July in the South Indian town.

Mean Monthly Temperature Minima of West Africa compared with those of India and other Oriental Stations.

Month	Accra Gold Coast	Port Blair Andamans	Singapore	Moulmein Burmah	Madras	Bombay	Hoshangabad Central India	Sibsagar Assam	Calcutta	Allahabad	Jacobabad	Bathurst Mean 10 yrs.	Lagos Mean 10 yrs.	Old Calabar Mean 6 yrs.
January	71·8	75·6	71·7	65·2	67·4	67·9	52·3	49·5	55·3	47·9	43·3	62·9	73·6	73·9
February	73·8	74·9	71·6	67·7	68·0	68·7	56·0	53·3	60·4	51·8	48·5	64·4	76·0	74·5
March	73·8	76·6	73·3	72·7	72·2	73·4	64·6	60·0	69·5	62·1	59·6	65·1	77·6	74·6
April	72·2	78·8	74·8	76·4	77·1	77·7	73·8	66·5	75·7	72·4	69·7	66·6	76·1	75·0
May	73·5	78·4	76·4	75·8	81·1	80·7	80·3	71·7	77·4	79·5	78·2	69·6	75·8	73·3
June	71·1	77·8	75·6	74·8	80·7	79·5	79·0	76·4	78·5	82·5	84·4	73·5	73·9	71·9
July	69·0	77·4	75·4	74·2	78·7	77·5	75·2	77·9	78·5	79·4	84·3	73·8	73·1	72·1
August	68·0	77·2	74·9	74·1	77·3	77·0	73·8	77·7	78·3	78·6	81·4	73·4	73·6	71·5
September... ...	70·9	76·5	74·2	74·5	77·0	76·5	73·3	76·2	78·0	76·9	76·0	73·3	74·3	71·4
October	71·8	77·3	74·1	74·7	75·1	76·5	66·9	70·8	74·3	67·6	62·5	73·6	75·1	72·1
November ...	73·2	77·2	73·6	71·1	72·3	73·3	57·3	59·6	64·5	55·1	50·8	71·4	77·1	72·3
December ...	73·8	76·7	73·5	66·9	69·7	69·8	51·7	50·7	56·0	47·8	44·0	64·5	76·3	71·5
Year	71·9	77·0	74·0	72·3	74·7	74·9	67·0	65·9	70·5	66·8	65·2	69·3	75·2	72·9

An inspection of the above table shows even more convincingly the less uncomfortable character of the climate of West Africa as compared with either India or the other places tabulated for comparison, as it demonstrates that really hot nights are quite unknown in any part of the Coast, while everywhere in India there are prolonged periods of excessive heat unrelieved by any sufficient fall during the night. Fortunately, where the heat is most excessive, as in Northern India, some compensation is to be found in the existence of a more or less prolonged "cold weather," which in the far Punjab, may amount to as much as four months of really bracing weather.

A continuous year of the conditions of the "hot season" in those regions would be almost beyond human endurance, so that the excellent winter months are most dearly paid for. The only place within Indian limits that possesses a climate at all as mild as that of the West Coast is, indeed, Sibsagar in the Upper Brahmaputra Valley, and one of the wettest of our stations, but even there the nights are much hotter than anywhere on the "Coast" for several months together.

Let us now consider the relative moisture of the compared places.

Monthly Rainfall of West Africa compared with that of India and other Oriental Stations.

Month	Accra Gold Coast	Port Blair Andamans	Singapore	Moulmein Burmah	Madras	Bombay	Hoshangabad Central India	Sibsagar Assam	Calcutta	Allahabad	Jacobabad	Bathurst Mean 12 yrs.	Lagos Mean 12 yrs.	Old Calabar Mean 6 yrs.
January	1·39	0·90	10·30	0·17	0·83	0·12	0·33	1·14	0·29	0·82	0·26	drops	0·60	1·47
February	0·96	0·96	6·18	0·13	0·28	0·02	0·21	2·16	1·02	0·48	0·27	0·01	1·62	2·91
March	1·99	0·34	8·41	0·23	0·37	0·01	0·21	4·74	1·14	0·38	0·25	...	2·79	7·21
April	5·13	2·94	8·39	3·12	0·65	0·05	0·01	9·88	1·54	0·14	0·17	0·04	5·92	11·45
May	6·43	16·73	5·58	20·33	1·96	0·55	0·53	11·47	5·60	0·29	0·15	0·36	8·90	12·83
June	3·11	17·95	6·37	37·68	2·06	20·56	6·82	14·14	11·04	5·09	0·10	3·38	16·68	19·43
July	1·15	15·46	7·74	44·45	3·80	24·56	15·42	15·89	12·31	12·24	1·21	13·15	11·20	21·36
August	0·92	14·81	6·83	42·74	4·66	14·91	13·58	16·29	12·69	10·88	1·25	19·78	3·68	18·19
September ...	1·25	18·85	5·83	29·65	4·84	10·93	9·59	11·77	10·40	6·32	0·19	9·50	6·18	12·10
October	2·95	11·68	8·61	7·90	10·93	1·76	1·31	5·17	3·87	2·40	0·01	3·99	8·30	12·20
November... ...	0·93	8·58	9·24	1·44	13·30	0·47	0·39	1·11	0·62	0·25	0·12	0·29	1·93	9·43
December... ...	0·72	5·55	10·84	0·03	5·25	0·05	0·44	0·59	0·31	0·23	0·15	0·04	0·82	2·86
Year	26·93	114·70	93·99	187·85	48·93	73·99	48·0	94·35	60·83	39·52	4·13	50·55	57·10	131·38

It will be seen from the above that the rainfall on the Gold Coast is very small for a littoral climate so close to the Equator, while that of Lagos is very much the same as that of Southern India. The rainfall of Southern Nigeria is, of course, heavy, rather exceeding that of the favourite tropical stations of Singapore and Port Blair, but not markedly so, while it sinks into comparative insignificance beside that of the Burmah coast.

It now only remains to consider the question of the relative humidity of the atmosphere, which cannot, however, be as definitely compared, as the data available for West Africa must, as already explained, more or less exaggerate the degree of moisture, and are noted at different hours.

The relative humidity of the air in West Africa compared with that of India and other Oriental Stations.

Month	Accra Gold Coast	Port Blair Andamans	Singapore	Rangoon Burmah Coast	Madras	Bombay	Hoshangabad Central India	Sibsagar Assam	Calcutta	Allahabad	Jacobabad	Bathurst Mean 10 yrs.	Lagos Mean 10 yrs.	Old Calabar Mean 5 yrs.
January	77	76	79	64	75	69	54	86	69	66	49	68	81	80
February	79	76	79	63	74	68	45	81	65	56	42	67	78	77
March	78	76	80	64	74	72	35	79	66	42	37	72	76	82
April	77	77	79	66	74	74	28	81	68	31	32	72	75	80
May	79	83	79	78	68	74	32	83	74	37	30	78	78	82
June	84	86	81	89	65	82	62	84	83	56	40	80	82	84
July	82	85	76	90	67	87	83	84	87	81	52	89	83	87
August	85	86	78	89	72	87	85	85	88	83	57	89	81	87
September ...	83	87	77	84	73	85	79	85	86	79	52	89	80	86
October	85	86	79	78	80	80	62	86	81	66	47	81	82	84
November... ...	80	82	82	72	81	70	54	84	73	62	44	75	81	83
December... ...	77	79	89	71	79	69	55	85	70	66	47	69	80	82
Year	81	82	80	76	74	76	56	84	76	60	44	77	80	83

A comparison of the above data again shows the superiority of the climate of West Africa with that of the regions under comparison, for it will be noticed, taken in conjunction with the tables of temperature, that the damp seasons of the year in West Africa are the coolest months, whereas, in such places as Rangoon and Port Blair, the highest humidity coincides with the severest heat. Even Old Calabar, in August, with a relative humidity of 88 per cent. and a mean temperature of 78 deg., can hardly be as uncomfortable a place of residence as Rangoon in July, with a relative humidity of 90 per cent., and a mean temperature of 80 deg., especially at night, when there is a difference of 6 degrees in the minimum temperatures in favour of the West African Station.

Sufficient evidence has certainly been adduced to make it clear that whatever may be the cause of the greater morbidity of West Africa, it can have no connection with climate, in the proper sense of the term, as that of India is undoubtedly much the more severe.

As the available climatic data of West Africa do not appear to have been hitherto collated, it may be well to conclude this section with the results obtained from drawing the averages of such records as are available.

The table for Accra is probably, except, perhaps in the matter of relative humidity, fairly accurate ; that for Kumassi, on the other hand, may be, it is to be feared, none too exact, but is given in full, as it is the only place situated at all far inland, for which information is available.

Month	ACCRA						KUMASSI			
	Mean Solar Maxima	Mean Terrestrial Minima	Mean Shade Maxima	Mean Shade Minima	Mean Rainfall Inches	Mean Relative Humidity per cent.	Mean Shade Maxima	Mean Shade Minima	Mean Rainfall Inches	Mean Relative Humidity per cent.
January...	131·6	68·6	86·3	71·8	1·39	77·5	84·8	66·9	Nil	88
February	138·9	69·9	87·8	73·8	6·96	79·2	88·2	72·7	5·29	78
March	141·6	71·9	88·7	73·8	1·99	78·5	88·5	73·3	3·18	82
April	144·0	71·3	88·3	72·2	5·13	77·5	88·2	71·0	4·68	91
May	141·9	70·4	83·9	73·5	6·43	79·0	87·4	73·2	5·16	83
June	137·0	70·2	83·0	71·1	3·11	84·0	86·6	73·0	3·51	76
July	136·4	68·6	81·4	69·0	1·15	82·0	80·2	70·2	7·30	85
August	136·1	6·55	80·3	68·0	0·92	85·5	82·0	70·6	5·74	Wanting
September	139·5	68·3	83·7	70·9	1·25	83·0	83·0	70·7	11·79	85
October	141·5	68·5	84·0	71·8	2·95	85·0	84·2	70·8	7·33	83
November	141·6	69·0	86·9	73·2	0·93	80·0	86·6	71·5	1·93	75
December	135·4	68·5	87·2	73·8	0·72	77·0	85·2	68·9	2·16	72
Year	138·8	69·3	85·1	71·9	26·93	80·8	85·3	70·8	61·0	82
Number of Years included in Average	10	10	10	10	12	10	2	2	2	1

The readings of the sun thermometer run several degrees lower than in India, a fact that is explained by the veiling of the sun, during cloudless weather, by a peculiar haze, which is undoubtedly one of the factors of the comparative coolness of the climate, and is the more effective because it is most apparent during the dry season, when otherwise the power of the sun would have its full sway. It is said that, during a strong "harmattan" the darkening may rival that of a London fog, but if not an exaggeration, anything approaching such a density is very rare. The presence of more or less haze, however, appears constant, during the Southern Solstice, so that during our few weeks' stay I doubt if on any occasion the sun shone with absolutely unobstructed power. The cause of this peculiar haziness is undoubtedly suspended mineral matter, brought by the wind from the great deserts of the hinterland, and extending to great heights, as the deposition of the sandy matter is often heavier far out at sea than on the shore.

It is nothing uncommon for literally bucketsful of sand to be swept up from the decks of a large steamer several times a day when steaming along the coast at this time of the year, and almost universally all varnished work is left with the wood almost stripped, and looking as if it had been sand-papered.

The dust that falls on shore appears to be much finer, and, though annoying, does not appear to occasion any irritation of the mucosa. The influence of this dust haze appears to extend at least as far south as the Congo.

The temperature records of the other G. Coast stations are too erratic to be worth preserving, though they confirm those of Accra, as far as they go. Those of the rain gauge are, however, given, as neglect of punctual examination of this instrument does not much affect monthly totals.

Considering the close proximity of Axim to Sekondi, and the absence of any great mountain masses to account for a local difference of rainfall amounting to more than double, the only possible conclusion seems to be that through some inadvertence the Axim rain-gauge must have been supplied with a measuring glass intended for an instrument of smaller diameter, or that there be some other source of fallacy. All the sets of record, however, show that the rainfall is somewhat capricious in alike its local and seasonal distribution. It will be observed that the two maxima of rainfall occur in June and October, but that, between the two, there is no sufficient period of dryness to affect the continuous breeding of mosquitoes. Thunderstorms appear to be rare, but small circular storms, of moderate severity, occur rather often. Though apparently of more frequent occurrence, they do not appear to approach in dimensions and severity the cyclonic disturbances met with in India and other parts of the tropical world.

The local observatories are, as already remarked, not too well installed, and, on the other hand, have a rather too ambitious equipment. It is doubtful if the information derivable from the solar and radiation thermometers is worth the extra trouble of observing them, except in observatories of the first grade, and these might be very well done away within the out stations, in which, on the other hand, the addition of self-recording aneroids might furnish a source of useful information. In any case, the appointment of a specialist to supervise the colonial weather records is a very obvious desideratum which it may be hoped will receive attention as funds become available.

A Comparison of the Conditions of European Life in India and West African Housing.

As a general rule, except from the point of view of the prophylaxis of malaria, Indian houses are well suited to the climate for which they are designed. They are nearly always constructed of materials available on the spot, and, though not unfrequently in deplorable repair, owing to the conditions of tenure, are usually of rational original design. Their commonest fault is that of not being sufficiently elevated from the ground, but for the most part the rooms are lofty and well ventilated, and the materials chosen are of a character suitable to the exigencies of the climate of the part of the country in which they are situated. As a rule, however, Government buildings are not so well adapted to climatic needs, owing to the subjection of all other considerations to technical excellence in workmanship. Now, in an excessively hot climate like the Punjab, a thick wall of sun-dried brick forms a far better protection than a thinner one, even if built of the best burnt brick, laid in cement, and finished in the finest fashion ; while in the milder, but damp climate of Burmah, the more porous the walls are the better, and the old-fashioned European bungaloes, with most of the walls formed of split bamboo matting, always provided that adequate verandah protection be allowed, are much healthier and cooler than one formed of tongued and grooved planking or other impervious material. Fortunately for them, however, the number of Europeans who have to live in the cramped and uncomfortable structures, known as officers' quarters, is but small, as both civil and military officers have to hire accommodation for themselves, and have, indeed, to pay rent, even for a Government quarter.

The early Europeans, it must be remembered, had excellent models of the most suitable materials and type of building to construct in the dwellings of the native gentry, and even now some of the best houses available were built back in the time of the earlier European pioneers. In Bombay, and some of the other large towns, where there has been a tendency to make the houses look "so nice and English," the results have been deplorable to comfort, and doubtless to health.

In West Africa, on the other hand, the native does not rise above a beehive hut in architecture, and hence the European has had to evolve a tropical residence, like the German artist's camel, from his inner consciousness.

There appears to be an inexplicable reluctance to make use of any material obtainable on the spot, and the result is that structures formed of corrugated iron and wood, designed and framed up in England, form the bulk of the accommodation whether official or otherwise. Where more permanent materials have been adopted the result is usually simply an English house, with or without some apology for a verandah. There can be no doubt that the native hut, especially with a few obvious modifications, forms a far more comfortable residence than the best of these constructions, as, indeed, every West African officer who has tried both will tell you. It is, of course, quite possible to build a roof well suited to tropical climates even of corrugated iron, by constructing it double, with a wide and well-ventilated space between the two planes of metal, but, short of this, it is absolutely the most unsuitable material that can be chosen for the purpose. In the verandahs there is often the simple metal sheet, with the result that they are quite untenable as long as the sun is up, while in the rooms the metal may be, at best, supplemented with a layer of planking, separated from the iron by only the thickness of the joists, and absolutely unventilated between them. The only really scientifically constructed bungalow I met with was that of Mr. Dawe, at Obuassi, the roof of which was formed of shingles, supplemented with wooden ceilings, separated from the roof by a ventilated loft. The district officers' quarter, at the same place, was, on the other hand, of the usual faulty plan, and though better placed, was, I found, no less than 7 degrees hotter on the same afternoon. Now a difference as large as this means ease and comfort in the one case, and discomfort and nervous prostration in the other. No one seems to have realised that the object of a verandah is not so much to afford open air accommodation as to protect the walls from the direct rays of the sun, and from the reach of any moderately driving shower. On this account, verandahs should be wide, and the lower border of the roof should reach fairly near the uoor level, say within six feet, in domestic architecture.

The verandahs of most of the houses examined were but 5 or 6 feet wide, with the eaves eight or nine feet from the floor, and the result was, that if one wished to rest during the heat of the day one often had to drag the bed about the room until one found a place to which the sun could not reach. Not infrequently, some of the walls have no verandah protection whatever, and, added to all this, the rooms are usually small, and so low-pitched that it would be impossible to swing an efficient punkah within them. The number of rooms, too, allotted to officers is very small in relation to the standard of comfort universal in the class of English society from which they are drawn, and this alone, quite apart from other considerations, makes it very difficult for a married officer to be accompanied by his wife, as, if she do so, she must resign herself to accommodation that would be considered barely adequate for the humblest of working couples by the least progressive of English municipalities. The one redeeming character of these structures is that they are usually well raised from the ground, being better in this respect than the majority of Anglo-Indian houses, out of Burmah and Assam.

The main reason of the unsuitability and inadequacy of the housing on the coast is the heavy cost involved in the importation of the whole of the materials. There is nothing whatever in the character of the materials available on the spot to prevent the building of houses exactly like those in universal use in Burmah and Assam, and there can be no doubt of their perfect suitability to the climate of West Africa.

As has been shown, there is very little difference between the climates, though that of Burmah is a trifle hotter, wetter, and subject to severer wind storms. In the hills in India we find that thatch resists wind better than corrugated iron, and though I am aware that thatch is said to have been tried in West Africa, and found wanting, the reason is very obvious, and lies in the fact that neither the natives nor the Europeans are expert at thatching. If, however, the negro be capable of being educated up to erecting tin houses, he can surely be taught how to thatch, besides which, there seems no reason why tiles should not be manufactured locally, and there are many other materials none of which could be as unsuitable as a mere film of metal, as a protection against a tropical sun. To conclude, there can be no doubt that in the matter of housing, the Anglo-Indian is infinitely better off than the white resident of West Africa.

Much as is the case with his house, the West African resident relies mainly on importation for his provisions, and as a general rule, very little that appears on the table is produced in the country. In the case of meat, this is hard to be avoided, as there are but few localities where cattle can live, but even where they can do so, no attempt seems to be made to fit them for the table by feeding them. For the same reason, the poultry is extremely inferior. On the coast, the fish is excellent, but one is very apt to be offered tinned salmon, and in the same way, though there is abundance of excellent fruit, it is rare to find anything but Canadian apples put before one, and the writer has actually been regaled on preserved tomatoes in a place where a small but delicious variety of that fruit grew wild, within a few yards of the house. In the absence of cattle all dairy produce are necessarily imported, in the form of condensed milk and tinned butter, though it is difficult to see why, if aerated waters can be imported at as high a price as 7d. per bottle, milk should not be imported sterilized in bottles. Good milk and butter are so essential to all good cookery, that it is easy to see how the absence of the fresh articles must render catering difficult. The supply of fresh vegetables, too, is none too good. At the same time, it is probable that this absence of fresh milk and butter is one of the reasons of the absence of typhoid fever, as there is no doubt that, in India, these articles are among the commonest vehicles of the germs of that disease, as well as those of cholera and dysentery.

In India, on the other hand, except in Assam and Burmah, cattle flourish, and good meat can always be obtained, at any rate with a little management. For many years, those who desired a good and safe supply of milk were obliged to keep their own cattle, and have the butter made on the premises, but during the last few years European dairies have been springing up in all the principal centres, which supply excellent milk, fresh for local consumption, and sterilized for those at a distance, so that the necessity of running a private farmyard has become a thing of the past, except in a few isolated stations. In the same way, the old "mutton clubs," for the supply of grain fed mutton, are ceasing to be necessary, as the native butchers are beginning to realise that a good profit can be made by undertaking this business. The supply of vegetables is abundant and excellent, and that of fruit fair. There is great room for improvement, however, in the article of bread, which strange to say, is generally excellent on the West Coast of Africa, but on the whole, with good house-keeping, the European ought to be able to live almost as well in India as he can at home. Another great drawback of Africa, as compared with India, is that in the latter ice is abundant and cheap, whereas on the "Coast" a few pounds, begged from the weekly mail boat is regarded as a great treat, and inland it is quite unobtainable; besides which, methods of cooling water and other beverages which are familiar to every Indian servant, seem to be understood neither by the African "boy" nor his employer. Now whatever may be the virtues of the fashionable hot water, there can be no doubt that the consumption of luke warm beverages is a great provocative of dyspepsia, and as a matter of fact, ice is for the European, almost a necessity of life in tropical countries.

The difficulty in the matter of aerated waters has already been alluded to, though it may be well to add that Indian experience shows that the size of bottle best suited to the exigencies of the case is one that holds a pint.

A proper supply of good and well-cooked food is no mere luxury, but is one of the first necessities of health in any climate, and is doubly so in tropical countries, where the appetite and digestive functions are seldom at their best ; and here, again, there can be no doubt that the Anglo-Indian is far better off, though it is undoubtedly the case that much might be done in Africa in the way of improving and utilizing local products, by the introduction of gardens, the setting up of factories for ice and aerated waters, and for the cold storage of imported meat. That the prolonged consumption of large quantities of tinned provisions is extremely deleterious is amply proved by the experience of every Arctic and Antarctic expedition, in spite of the most elaborate care in the selection and preparation of supplies of this sort. There can be no doubt that it is far better to put up with even inferior fresh provisions than to be enticed into consuming more than the irreducible minimum of tinned goods.

Domestic Service.

As is well known, Indian servants are very fairly efficient, but I must confess I was agreeably surprised by the African " boy." I have had far better servants in India than the " boy " who served me for a few weeks, but have also had more who were worse. Though said to be thievish, they seem generally cheerful and willing, and are far more generally useful than any single Indian servant, being quite willing to turn their hands to anything in a manner quite refreshing to one accustomed to have to consider whether or not the performance of any odd job would be against the caste prejudices of this or that attendant. They seemed very teachable, and as the degree of intelligence required to make a good servant need not be very high, it is probable that any superiority there may be in the average Indian servant is due to the fact that the latter has, for several generations, had the advantage of being trained by English ladies, for it is certain that the most domestic of men is a mere second class amateur as a housekeeper, compared with the average lady.

Condition of Life.

A very large proportion of Anglo-Indians are married, and are able to keep their families around them, at any rate until they become of school-going age, and it is needless to point out how greatly this conduces to health and comfort. If the British man has conquered India, it is his wife that has made his conquest habitable, and so much is this the case that it may be doubted if a bachelor is really much more comfortably placed there than if he served in West Africa, unless he be able to live at a mess or club. On the " Coast," ladies are only just beginning to make their appearance, and it is to their absence that the want of so many of the comforts and amenities of life is certainly due.

Conditions of Service, Accessibility of Health Resorts, etc.

In each of the countries compared, the European, especially if he belong to the public service, has much travelling to perform, but, though trying, at the present day in India, well appointed railways and good roads, available for wheeled traffic, have done much to diminish the fatigues, while in the more backward parts of the country one can at least ride, and, if sick, can be moved in comparative comfort in a *duli*. Where there are no hotels, there are often Government rest houses, and, when on inspection off the main lines of road, the tenting allowances are sufficiently liberal to enable an officer to secure comfortable and safe accommodation at night.

The West African officer, on the other hand, still travels under practically the same conditions as those faced by the pioneers who have performed the work of exploration, the fatal character of which is too well known to require further comment. Putting aside the few miles of existing rail, there are no good roads, and as horses cannot live in the greater part of the country he must needs actually trudge the whole of the long marches, or at best ride in an uncomfortable contrivance known as a hammock. Moreover, the transport allowances are so scanty that the amount of the simplest necessities of civilised existence that he can take with him, if he have to travel or serve in the back country, is so small that it is impossible for him to enjoy even the most moderate degree of comfort, judged by European, or even Indian, standards.

Worse than all, owing to the entire absence of rest houses, to say nothing of hotels, it is actually the custom for officers to have to sleep in native huts, from which the inmates have been evicted for the night. Now, a native hut, in actual occupation, must necessarily swarm with infected mosquitoes, and it is difficult to understand how the greatest care and precaution can save the European who has to pass the night in such quarters from infection, to say nothing of the inconvenience to the native, at having to give over his house, which cannot fail to make the visits of officers unpopular, instead of, as they should be, a small event to be anticipated. The cost of erecting and maintaining huts of the ordinary native pattern along the more frequented routes would be trivial, and, if strictly reserved for European use, and placed at a safe distance from the huts of the village from which it is proposed to draw supplies and carriers, would do away with one very common method whereby officers become infected with malaria, to say nothing of tick fever. So obviously suicidal, indeed, is the custom of occupying native dwellings, that it ought to be absolutely prohibited, and the carrying of tents should be made compulsory. An 80lb. Kabul tent and the necessary camp-bed and furniture can easily be transported by three carriers, and there can be no doubt that the extra cost to Government for this small amount of transport would be repaid over and again in diminished invaliding. The substitution of some form of *duli* for the hammock is also very desirable. The Indian contrivance is so simple that it might be constructed easily enough by the ordinary workmen of an African village, and as one familiar with the difficulties of jungle paths, I have no hesitation in saying that the *duli* is far more suited to the country, for on account of its unwieldly length the hammock is as awkward a contrivance for the bearers to manœuvre through a narrow bush path, as it is uncomfortable for the unfortunate passenger. For the injured the hammock is absolutely dangerous, while for the sick it must be little short of torture, and added to this it would be difficult to elaborate a contrivance for transporting his fellow man, more needlessly fatiguing to the bearers. The stalwart African bearers are of a physique that would enable them to walk off with an ordinary Indian kahar under each arm, and yet, it appears that they can only accomplish about two thirds of the distance that can be compassed by the latter, with his slightly heavier, but far more convenient, contrivance. The obvious fault of the hammock is that it cannot be rested on the ground without the passenger getting out, and this results in the bearers being kept in continuous muscular effort for too long a spell. The *duli*, on the other hand, can be rested on the ground without inconveniencing the passenger, and the kahar avails himself of this to frequently relax the strain on his muscles, and so is able to travel a greater distance, at quite as good an average speed as the African. A further advantage of the *duli* is that it does away with the necessity of carrying a camp bed, as on arrival, the pole can be instantly withdrawn and the frame carried into any tent or hut, while a large ground sheet, stretched over the pole *in situ*, converts it into a very passable shelter for the night. In the case of serious cases of illness, the advantage of it being unnecessary to disturb the patient on arrival at the end of a stage, is obvious. For persons in ordinary health, especially in close jungle paths, the ordinary "hill *dandi*" would probably be more convenient, and *a fortiori*, less awkward than the hammock.

The method of carrying the *duli* and *dandi* is practically the same as that of the African hammock.

At the present day in India, it is rare for anyone to be stationed more than two days' journey from a hill station, and there can be no doubt that this facility results in the saving of many lives every year, which would otherwise be sacrificed; but on the other hand, the dreaded Red Sea lies between us and Europe, so that the more thorough change to Europe is cut off during the hotter months of the year for really serious cases, though not a hot weather passes without a melancholy list of deaths of invalids in the Red Sea, who have either been imprudently sent home by their medical advisers, or more probably have started in defiance of his warnings.

In Africa, on the other hand, over immense tracts of country, no sites sufficiently elevated above the sea-level are to be found, and even where they exist, they have not as yet been utilised. Moreover, travelling is so slow that a hill-station could in any case serve but a limited area, and hence there is no possibility of change for anyone too ill to bear a long hammock journey. The accessibility of the Canary Islands is, however, a great counter-balancing advantage, for those stationed on the coast.

In the matter of leave rules, the West African officer is certainly the better off, as he can take about a third of his service on furlo' in England, while the Anglo-Indian is entitled only to one-fifth, in the case of the favoured covenanted civilian, and to much less under the varying rules of other branches of the public service. In both countries the conditions of private employ have a tendency to be modelled on those of the Government, but are naturally usually less liberal. In view, however, of the much more serious rates of sickness and death, to which he is exposed, it is certain that liberality in this matter to Europeans working in Africa is the only policy consistent with real economy, as any retrograde step in this direction would certainly spell inefficiency in a very costly way.

Segregation.

The custom of the country in India ensures this, practically speaking, in as thorough a manner as is likely to be secured in any mixed community, and there can be little doubt that this is one of the main factors in bringing about the better standard of European health in India as compared with West Africa.

So much is this the case that when first the idea of the segregation of Europeans in Africa came before the professional public the writer was inclined to throw ridicule on the proposition, as he naturally read the word in its usual sense of absolute separation, because it never occurred to him that any Europeans would consent to live closely intermixed with the native population in the way that has grown to be the custom in Africa. In India the European quarter is commonly at least a quarter of a mile from the native town, and no one would dream of settling within the bounds of the latter, or even of taking shelter in a native house for the night, as, except perhaps in the case of heavy rain, everyone would prefer bivouacking in the open to running so heavy a risk.

A considerable number of natives are, of course, employed about the civil and military "lines" of an Indian station, but the great size of the ordinary Anglo-Indian's "compound" affords a very fair amount of segregation even from his own servants. There can be no doubt that caste prejudices on both sides have been the main cause of this satisfactory state of things.

Attitude of the Native Population with Respect to Sanitation.

Here, at least, the advantages are all on the side of Africa. No one who has not had to deal practically with the problems can form the least idea of the obstacles to every form of sanitary improvement which result from the tangled mass of caste prejudices and resulting habits of the natives of India. The mere fact that only outcasts can be employed on the most ordinary sanitary work, even of a domestic character, results in the universal fouling of the ground round every inhabited site, and converts the neighbourhood of every pool of water into a surface reeking with filth. For reasons of a similar kind, the Indian will only use a latrine under compulsion, and, in spite of his reputation for cleanliness, and usually fair niceness of person, he is very commonly unclean in his clothing, and generally so disagreeable a neighbour that it is in no way surprising that the Anglo-Indian has been led to "segregate" himself from him, without ever having heard of the system as a sanitary measure. Like, I suppose, most people who had never visited Africa, I had the idea that, from his lower grade of civilisation and intelligence, the West African native would be an even more unpromising subject for sanitary reform. Much to my surprise, however, I found myself among a population singularly cleanly alike in their persons and clothing, and far surpassing the lower class European in these respects. Added to this, pit latrines are an indigenous institution in the native villages, and there is, therefore, no barrier of prejudice to prevent the West African making use of the better planned European appliance when it is provided for him.

Without entering into needless detail, it suffices to say that Sekondi is far cleaner than any Indian town of its size and resources with which I am acquainted, and that I further doubt if a whole battalion of police would keep the banks of the lagoons there as free from the offence as is the case, were its negro population exchanged for a similar number of caste-ridden Indians.

Only the Anglo-Indian does not live in close contiguity with the Indian, and the Anglo-African certainly does so with the negro, not because there is any particular difference in the necessities of the cases, but probably simply because the negro is not so obviously a bad neighbour as is the Indian.

Conclusions.

I have entered thus at some length into the details of European life in the two countries under consideration, because my visit, short as it was, has led to the conclusion that the greater sickliness of Africa is by no means as mysterious as it at first sight appears, and that it certainly is in no sense due to differences of climate, in the proper sense of the word ; as though the meteorological conditions of West Africa closely resemble those of parts of India, they are, all considered, not as trying as those of that country. It must be remembered that the European in the tropics is an exotic, and can only maintain a precarious existence by close attention to a number of alleviating details that need scarcely be taken into consideration in his native climate, and that this will continue to be the case however thorough the sanitary condition of his surroundings. For example, to take a simple illustration, no amount of sanitary reform, anti-malarial or general, will enable the European to venture abroad bare-headed in either India or Africa, and for the same class of reasons, the European cannot resist the influences of bad housing and bad feeding. To put it briefly, the main reasons for the better health of the Anglo-Indian are that he has made himself more comfortable in his novel surroundings, and that the very unsanitariness of the habits of Indian natives has led to the European's living quite apart from the native, and to his being less seriously affected as a sharer in the diseases of the native, in consequence.

Ask any Anglo-Indian to reside in a tin shanty, such as those I have described, in the middle, for example, of the Black-town of Madras, and to subsist mainly on a diet of tinned provisions, without either ice or punkahs, and I doubt if double pay and leave rules as liberal as those enjoyed by the Anglo-African will induce him to close with the offer, nor do I believe that he would be at all healthier than the Anglo-African were he to attempt to do so. Given close proximity, the European obviously cannot avoid sharing in the diseases of the native, and as he is living under exotic conditions, must necessarily suffer more seriously than the latter. The rates of native sickness and mortality are probably higher in India than in Africa, but the European, who there lives apart from the native, actually keeps freer from sickness than the natives themselves. If he lived in close proximity with them it cannot be doubted that, like the European in Africa, he, too, would be more unhealthy than the natives around him, instead of less so.

These conclusions, assuming them to be correct, must be considered in the main satisfactory and hopeful, as it is obvious that apart from formal measures of sanitation the *desiderata* of comfortable living and segregation from the native depend mainly on individual initiative.

There remains the problem of Black-water fever, which, however, though it does not appear to affect him seriously, is also probably conveyed to the European by the native. The consideration already advanced constitutes, it is thought, a strong case against that disease being merely a severe form of malarial fever, and it is hoped may lead to renewed investigation and reconsideration of the problem, with a free mind as to the possibility of its having a distinct and specific causation.

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TRYPANOSOMES, TRYPANOSOMIASIS, AND SLEEPING SICKNESS

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XVI

REPORT

ON

TRYPANOSOMES, TRYPANOSOMIASIS, AND SLEEPING SICKNESS

BEING

AN EXPERIMENTAL INVESTIGATION INTO THEIR PATHOLOGY AND TREATMENT

BY

H. WOLFERSTAN THOMAS, M.D., McGill

J. H. TODD MEMORIAL FELLOW

AND

A DESCRIPTION OF THE TISSUE CHANGES

BY

ANTON BREINL, M.U. Dr. (*Prag.*)

J. W. GARRETT INTERNATIONAL FELLOW

Dutton, J.E.
Todd, J.L.

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Jacob Hunter Todd

Died, August 10, 1899, Victoria, B.C., Canada

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The report is not so complete as wished for, but the immediate departure of Dr. Breinl and myself on an expedition to Brazil has compelled us to give our results in the manner here presented. We hope to fill in the omissions at an early date.

In conclusion I wish to acknowledge, on behalf of the research workers, the courtesy and interest which so many have evinced in the work. In particular Professors Boyce, Ross, Sherrington, and Moore, Dr. J. W. W. Stephens, Dr. J. Hill Abram, Dr. Lloyd Roberts, Professor Grünbaum, and Dr. Ernest Glynn, Dr. Lauder, Medical Health and Port Sanitary Officer, Southampton, his assistant, Dr. McCulloch, and the Matron of the Southampton Isolation Hospital.

I cannot close without expressing my indebtedness to Dr. H. E. Annett, who has done everything possible to aid the research department, to him and Professor Boyce the numerous worries and difficulties associated with the work have been left.

To the gentlemen on the committee and the Hon. Secretary of the School, who have endeavoured to meet all the requirements of the division, our thanks are tendered.

On behalf of the workers

H. W. THOMAS

CONTENTS

ERRATA AND ADDENDA

Page 4, line 12, *read* 'especially right inguinal and left cervical.'

Page 4, line 20, 'electrical reaction,' *read* 'electrical resistance.'

Page 7, Early history of Banja, Memoir XIII, L.S.T.M., p. 41.

Page 13, reference to Dutton and Todd, p. 97 of this volume.

Page 17, line 35, *read* 'small quantities of blood from an infected animal failed to produce infection.'

Page 30, Horse ; this is the animal referred to as 'HORSE VI.'

Page 48, line 16, 'evidences,' *read* 'evidence.'

Page 49, line 4, 'Governors,' *read* 'Governors'.'

Page 49, line 8, 'Laver,' *read* 'Laveran.'

Page 49, line 10, 'potassium, and,' *read* 'potassium and.'

Page 50, line 14, 'Fowelri,' *read* 'Fowleri.'

Page 53, line 39, '889,' *read* '839.'

Page 59, line 4, 'are seen after,' *read* 'are seen but after.'

Page 60, line 20, 'subjects,' *read* 'substances.'

Page 62, line 24, '*P. rodigosus*,' *read* '*B. prodigiosus*.'

TRYPANOSOMES, TRYPANOSOMIASIS, AND 'SLEEPING SICKNESS'

BY

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AND

ANTON BREINL

I. DESCRIPTION OF CASES OF SLEEPING SICKNESS IN MAN

OPPORTUNITY was afforded for study by the arrival in England of natives from the Congo Free State suffering from 'sleeping sickness' or 'Trypanosome Native Fever.' It is due to the courtesy of the authorities of the Congo Free State that facilities were given to the members of the Congo Expedition of our School to send to England selected cases of the disease. Special importance was placed on observations being made for a prolonged period in England where the change of climate, the regular life, and the general attention given to strengthening their systems might produce some effect on the disease. The cases observed were :—

Of 'Sleeping Sickness'	Of 'Trypanosomiasis' ('Trypanosome Fever')
Boyo	Mpangila
Kitambo	Disasi
Tomi	Banja
	One European Capt. 'S. B.'

It is not our purpose to discuss clinically whether 'Trypanosome Fever' cases are cases of early sleeping sickness or represent a distinct disease—this is left to the members of our Congo Expedition who have had opportunity of comparing several hundreds of cases. All the sleeping sickness cases died, the native 'Disasi' succumbed to pneumonia. Clinical histories of cases of trypanosomiasis in man have been so frequently recorded that a minutely detailed report of each case would serve no purpose.

Kitambo. Male, *aet.* 23. A native of Nyangwé.

History : Three years in Leopoldville. Was ten days in prison before coming to hospital. In prison felt ill and had pains all over the body. Could do no work, because of giddiness, headache, and weakness.

Condition. March 28, 1904 : Nutrition fair. Eyes heavy. Intelligence fair. Complains of frontal headache. Tremors of lips and hands. Gait steady. Skin moist. Glands, except epitrochlear, enlarged. Oedema of feet and shins.

Heart : Pulmonary second sound accentuated, rough and reduplicated ; apex in nipple line in sixth interspace.

Spleen enlarged.

Liver normal.

Lungs normal.

Nervous System : Knee jerks normal. Cremasteric reflex increased. Pupil reacts to accommodation and light. Tongue very unsteady.

April 15 : Sleeps a great deal in daytime. Unsteady gait. Very weak : cries for very little. Eyes sluggish to accommodation and light, pupils small. Tremor of legs when standing. Knee jerks and superficial reflexes increased. Nystagmus marked. During the voyage to England patient continued in about the same state. During the two days in Southampton he dozed most of the day. On arrival in Liverpool, May 24, he was able to walk to the cab. The man was placed in Dr. J. Hill Abram's Ward at the Royal Infirmary.

The following notes are taken from the hospital records by permission of Dr. J. Hill Abram :—

Present condition : Drowsiness and tremors. Lies on his back : not well nourished. Rash all over body. Sleeps a great deal. Slight glandular enlargement in left axilla and neck, and considerable in inguinal regions.

Alimentary System : Teeth good. Tongue tremulous and coated white. Abdomen slightly distended. No enlargement of liver, spleen, or stomach.

Circulatory System : Pulse frequent, soft. Apex beat just perceptible and palpable in fifth space, three inches from middle line. Sounds normal and no hypertrophy.

Respiratory System : Respiration frequent, tenderness and slight oedema over chest.

Urinary System : 2674 grammes, sp. gr. 1025, alkaline, deposit of phosphates, no sugar, no albumen, Ehrlich reaction negative.

Skin : Papular rash (scabies).

Nervous System : Very sleepy, general tremulousness. Pupils small. Knee jerk and plantar reflexes lively.

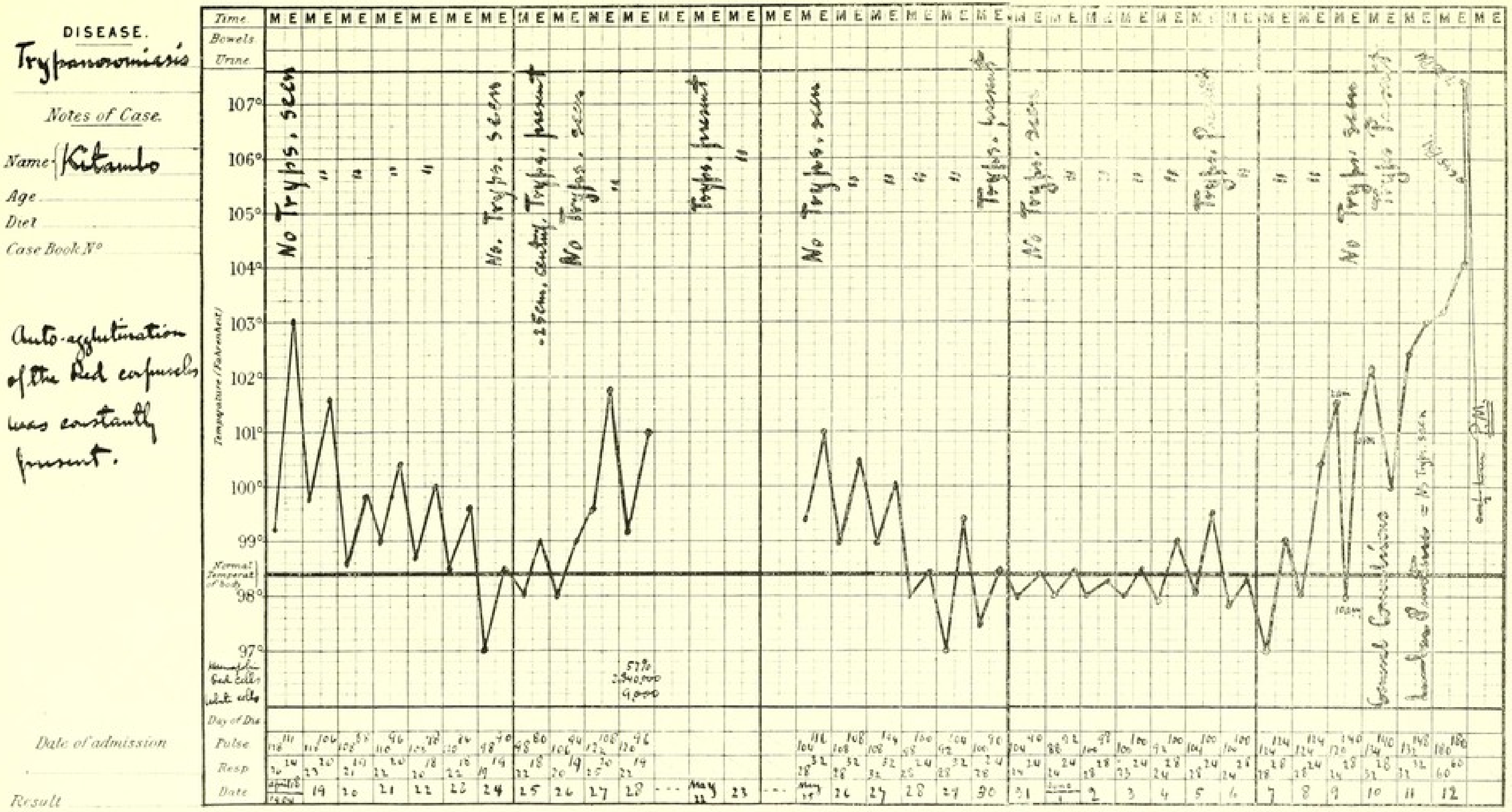
On June 3, 4, and 5, profuse sweating at night.

June 7 : Last three or four days seemed weaker. Cannot now feed himself nor walk. Cannot raise himself in bed. Urine and faeces passed involuntarily. Knee jerks present. No increase in drowsiness. Heart and lungs clear. Pulse, 108, softer. Occasional twitchings with considerable asthenic tremor in hands. Pupils small ; takes food readily, but has to be fed. Blood, haemoglobin, 65 per cent., red blood cells, 3,720,000, white blood cells, 7,812. Eosinophiles in comparison with the rest, not nearly so numerous as on May 25.

June 9 : Conjunctivae injected and muco-purulent discharge.

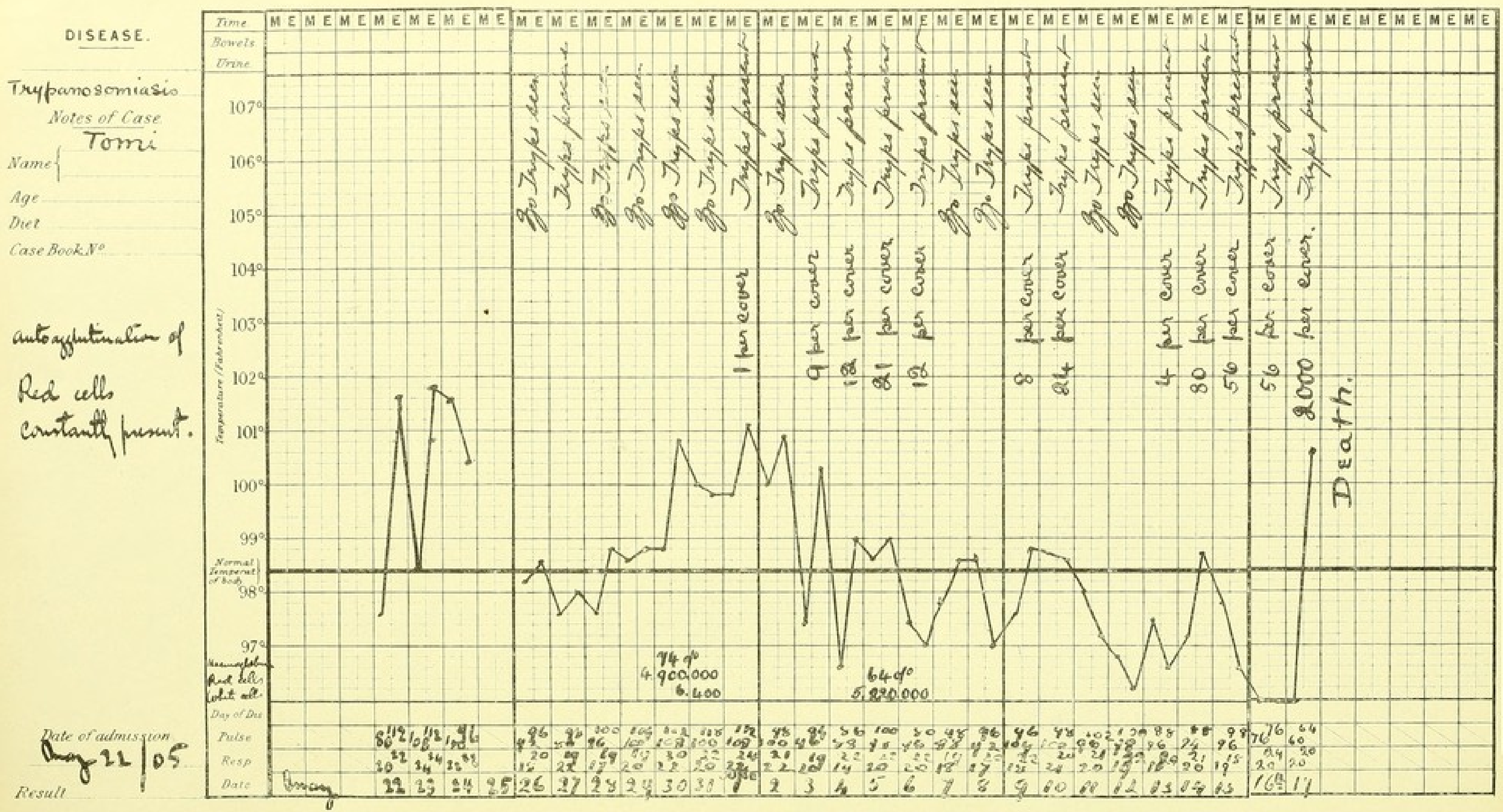
June 10, 2.50 to 3.15 a.m. : General convulsions, three fits, last fit continued for about ten minutes. Conjugate deviation of eyes and head to right. Both arms and legs worked, but right arm seemed to work more than the left, and movement was flexion and extension at elbow. Pulse 170.

CHART I



to face p. 2

CHART II



to face p. 3

7.30 p.m.: Unconscious most of day. At times seemed to hear when spoken to, but most of the time no response. Bowels moved from enema 2.30 p.m. and acted several times since. Croton oil, mid-day. Just had two general convulsions, lasting about three minutes each. Last fit, head and eyes first to left, afterwards to right. Arms and legs worked too. (Whilst writing a third fit came on). Conjunctivae much injected, good deal of muco-purulent discharge.

June 11, *midnight:* Semi-comatose during last twenty-four hours. No fits; takes milk and whiskey when given. Corneal reflex present. Winced slightly when needle pierced skin for lumbar puncture to-day. No fluid ran out, a little drawn out by syringe, but mixed with blood. Profuse sweating on face, forehead, and neck. Past forty-eight hours, not much sweating on trunk. Pulse, 145, full, low tension. Respiration, 32; urine and faeces passed involuntarily.

June 12, 6.45 *p.m.*: Temperature getting higher all day and now 105·6. Pulse, 200, small volume, poor tension. Head and neck sweating still, trunk not. Respiration, 48; alae nasi working; Cheyne-Stokes in type at times. Not been able to swallow fluid food to-day.

7.30 *p.m.*: T. 107·4 (thermometer seen).

7.45 *p.m.*: *In extremis;* face covered with cold perspiration. Corneal and knee jerk reflexes gone. T. 105·8. Heart beats 168 at apex, every third or fourth only reaching wrist. Respiration, 24, jerky (chin could be made to touch sternum).

7.55: Respiration, 8 per min. Heart, 56. Violent last inspiration. Heart and respiration failed together. No P.M. rise of temperature, but fall (see chart).

For autopsy and morbid anatomy see Part II, Kitambo.

Tomi. *Aet* 18. Male.

He had been employed as cook to the Rev. Mr. Gordon at the Kinshasa Mission of the Baptist Missionary Society, Stanley Pool. As he was only seen a couple of times by the members of the Expedition, no detailed history is procurable. Mr. Gordon first noticed the boy to be careless, disinterested, and quarrelsome in December, 1903. In January, 1904, he complained of pains in one eye, which became inflamed. It improved for a time, but by the end of February both eyes were affected. This, coupled with the increasing irritableness and his being found sleeping at odd times in the cook house caused the missionaries to fear he had 'manimba.'[1] In April he was examined by Dr. Dutton, and parasites found.

On his arrival at Southampton, May 22, he was able to walk, but was extremely nervous and hysterical, laughing and crying without cause. Marked tremor of the upper and lower limbs when in a sitting or recumbent posture was observed. This condition was accentuated if the boy noticed anyone looking at him. On his arrival in Liverpool, May 24, he was very excited, and homesick, but became quiet on being given light work to do.

General Condition: A rather emaciated averaged-sized boy. Muscular development poor. Skin soft and clean—chiggers in both feet. Glandular enlargement general but not so marked as in other cases. Gait unsteady and very irregular, this is due to the chiggers. On standing still with the eyes closed he remains motionless for a few minutes and then starts to sway; power over the knees suddenly appears to be lost and he will fall; he can stand motionless if allowed to keep his eyes open, but after a while sways from weakness. At times, if seated, a violent tremor commences in the lower limbs, and heels rap the floor; the knees, especially if the toes are resting on the floor, shake sideways and a little forwards. The hands and arms may remain quiet or start twitching spasmodically. The head usually moves sideways, the lips tremble, the eyelids twitch and the eyes roll. Plaintive sounds are emitted but no coherent words. These symptoms may cease after a few minutes, or a crying fit terminate the attack. If spoken to he can usually rise and appear quite well again, at other times, the trembling, etc., is not interrupted and the general vacant expression continues. Much is due to hysteria. If taken into a dark room and

1. A native name for 'sleeping sickness.'

his attention engaged, no swaying or falling occurs even if the heels are together. At night he will sit quite motionless without trembling. He is fanciful in his wishes and tastes, and very quarrelsome with his companions.

Respiratory system : Lungs normal ; expansion good.

Circulatory system : Heart, normal size and position. Slight accentuation of pulmonary sound. Pulse variable, often markedly irregular, quick, without tone, and soft, at other times of high tension with a slow but regular rhythm.

Digestive system : Teeth good ; faeces contain ova of *Ankylostoma duodenale.*

Liver not enlarged nor painful.

Spleen moderately enlarged, not painful on palpation.

Genito-urinary system : Urine normal, sp. gr. 1020. No albumen. No sugar.

ANALYSIS OF URINE MADE BY MR. EDIE, LABORATORY FOR BIO-CHEMISTRY

Date	c.c. Urine	Sp. Gr.	Reaction	Gram Total Nitrogen	Gram Urea	Gram Uric Acid	Gram NH_3	
June 17	325	1014	Neutral	3·14	5·82	·11	·05	Albumen and Sugar absent

Glandular system. All groups enlarged, especially right. Inguinal and left cervical freely moveable, not painful.

Aural and nasal systems normal.

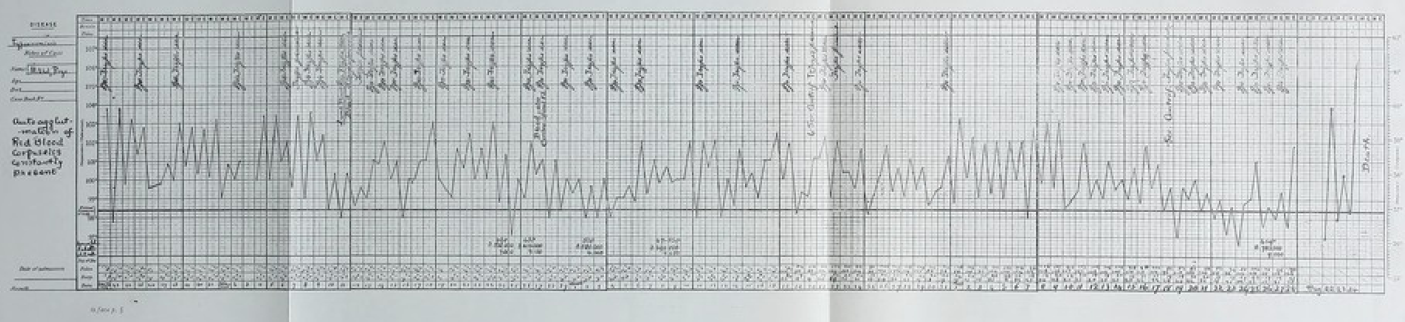
Pupil not dilated. Reaction to accommodation and light normal. Small opacity on cornea of left eye about 1 mm. in diameter.

Nervous system : Knee jerks increased. Cremasteric, epigastric, and anal reflexes not accentuated. Jaw clonus normal. Ankle clonus very accentuated at times.

Electrical reaction of skin normal. Some of the peripheral nerves reacted very slowly to the galvanic and faradaic currents. Some evidenced the degeneration reaction. The majority reacted normally.

From May 25 to June 11 the boy continued in the same state, seemed to gain in strength and became less excitable. The tremors became less accentuated and he learnt rapidly. At times he would become depressed and say he had 'manimba' and was going to die. *Sleep symptoms were not noticed.* During this period the parasites were always scanty, but appeared to be increasing on the 12th. On that day he finished his work and went to dinner ; at 2 p.m. the attendant came and said he could not wake him. He was found lying on his side with his knees drawn up, apparently asleep and perfectly motionless. On being shaken and shouted at he would open his eyes and utter a word and then relapse into the somnolent state. The temperature *per rectum* was 96·2° F. The cremasteric and epigastric reflexes normal, the anal much less. The knee jerk was much lessened. Respiration, 22, full and regular. Pulse, 100, soft, low tension, and irregular. After four hours he woke up and appeared to feel as usual, though somewhat dazed and unsteady in his gait. For the next two days he was kept in bed, but was always getting out and sitting on a chair. Parasites were increasing in numbers. The temperature continued sub-normal. On the 15th, 30 c.c. of cerebro-spinal fluid was drawn off by Dr. CHRISTY without difficulty, the fluid welling out when the needle entered the canal. The clear fluid, not contaminated with blood, contained trypanosomes, as many as five to a field. The blood at this time contained 700 to a cover, irregularly distributed, groups of two, four, and six being

CHART III


DISEASE
Auto agglutination of Red Blood corpuscles constantly present
Death

seen. Part of the cerebro-spinal fluid was inoculated into a monkey, two rats, and a rabbit. The boy was kept in bed, though he said he felt well. The next day he was found in a semicomatose state. Temperature, 96·4° F.; respiration, 19; pulse, 108. Deviation of the eyes was noted. He was taken to the Royal Southern Hospital, and placed under the care of Dr. Lloyd Roberts. Until he died, on June 17, he remained in a somnolent state. At first nourishment in the form of soup could be given, but later total unconsciousness intervened. There was incontinence of urine and faeces. The temperature was sub-normal, but started to rise on the evening of the 16th, registering 100·6° F. at death. The reflexes were all decreased: sensations dulled. The pupils reacted to accommodation and light. The parasites continued to increase in numbers—a few hours before death two to three to a field were seen.

The differential blood counts made on two different days gave the following results:—

	June 11	June 16
Polymorphonuclear neutrophile ...	77·63	76·00
Large mononuclears	4·15	2·8
Lymphocytes	10·77	11·2
Eosinophiles	4·71	5·1
Transitional forms	2·14	4·2
Mast cells	0·60	0·7
	100·00	100·0
Trypanosomes	Absent	1 to 2 to a field

For autopsy, etc., see Part II, Tomi.

Boyo Mitchel. Male. *Aet.* 14. Coquilhatville.

First seen January 21, 1904. Came to Leopoldville two years ago. First felt ill coming down the Kasai river two or three months since, when he had headaches.

February 5: Thin and wasted. Gait slow, unsteady, and shuffling. Expression dull, apathetic, and vacant. Answers questions slowly and in a weak voice. Very drowsy.

Physical condition: Skin dry and scurfy. Glands enlarged. No oedema. Slight puffiness about eyes and puffy appearance of whole of face. Mouth full of sores.

Heart and Lungs normal.

Spleen not enlarged.

Liver apparently enlarged.

Knee jerks normal. Epigastric and cremasteric reflexes normal.

Faeces contain anchylostoma and ascarides.

Up to time of departure for England the boy remained in about the same state. Tremors being marked at times.

May 13: He walked with difficulty to the steamer. Temperature, 104 for two days; patient in state of collapse; could eat nothing. Urine and faeces passed in bed. After two days at sea he revived a little; the temperature fell and he was able to sit on deck. Mouth very foul. Later he was unable to get out of his bunk. Could only take soup and water if fed with a spoon

May 21 : Condition much worse. Emaciation very marked. Motions passed in bed. Bedsores over sacrum, others commencing on ankles, knees, and scapulae. Pulse extremely weak. Extremities cold. Gums ulcerated, teeth loose, mouth very foetid. Treatment of no avail.

May 22 : Taken to Isolation Hospital, Southampton. Condition after two days improved, but death took place May 24. Patient was lumbar-punctured six times, on three occasions parasites were present in the cerebro-spinal fluid. A rat injected with some of the fluid shortly after death, developed the disease in a mild form thirty-five days after inoculation.

For autopsy and morbid histology, see Part II, Boyo.

Mpangila. Male. *Aet.* 17.

Arrived in Liverpool, December 27, 1904. Parasites had been found in the blood in November, 1904, by Dr. Dutton.

Physical condition : A well-developed boy ; muscular development, fair. Thin, but not emaciated. Intelligence, above average. Easily tires ; no tendency to somnolence. Glandular enlargement general. Skin soft. No oedema. No eruptions on skin.

Respiratory system normal.

Circulatory system : Heart sounds, normal. Pulse, 96-104, soft and regular, at times becoming more rapid and irregular, without cause or relation to the temperature, rising to 110 and falling again to 96. This occurred when at rest or during work ; heavy labour did not appear to affect it.

Spleen : Slightly enlarged ; not tender on palpation.

Liver normal.

Genito-urinary system normal. Urine, sp. gr. 1018. No albumen ; no sugar ; chlorides ; no bilirubin.

The following analyses were made by Mr. Edie, Laboratory of Bio-Chemistry :—

Date	c.c. Urine	Sp. Gr.	Reaction to Litmus	Grams Total Nitrogen	Grams Urea	Grams Uric Acid	Grams NH_3	Grams NaCl	Grams P_2O_5	Albumen	Sugar
July 9	1100	1015	Neutral	10·1	20·1	·46	·51	15·1	1·42		
,, 14	940	1015	Acid	10·9	21·6	·56	·49	8·4	1·15		
,, 17	1160	1018	Alkaline	11·4	22·8	·69	·41	13·4	1·25	Absent	Absent
,, 22	860	1024	Acid	12·3	24·8	·69	56	10·4	1·1		
Aug. 1	1300	1019	Acid	14·4	29·0	·71	·36	13·2	1·29		
,, 5	1700	1022	Acid	25·2	45·8	1·4	1·0	17	1·9		

Faeces contained ova of *Ankylostoma duodenale*.

Ocular, oral, and nasal systems normal.

Nervous system : Knee jerks normal. All superficial reflexes normal. No tremors. Pupils react to accommodation. Electrical reactions normal.

Sensations : Pain, temperature, taste, and smell normal.

Glands : All enlarged, especially cervical and inguinal regions. Easily palpable, freely moveable, firm, not painful ; some of cervical were as large as a hazel nut.

From December 27, 1904, to August 17, 1905, the boy was under observation. He was given work in the laboratory and animal houses. No evidences of the progressing of the disease could be determined. The boy grew taller and stronger and put on weight, learnt English rapidly, and his intelligence improved. During the winter he contracted several colds, but was otherwise well. Rheumatic pains in the knee, shoulder, and wrist joints were complained of, but quickly disappeared. Somnolence was never observed. Easily excited and naturally irritable. Outbreaks of passion occurred at times; during such an outbreak he became frenzied and incapable of controlling himself. On one occasion severe frontal and occipital pains were complained of. At the same time it was noticed that the parasites were then starting to increase in number. The temperature also rose, but after two days the trypanosomes lessened in number, and coincident with this the headache disappeared and the temperature began to fall. A trial of subcutaneous injections of arsenic having proved too painful, liquor arsenicalis was given, but he quickly complained of headache and nausea. A varied treatment of Blaud's pill with arsenic, alternating with a nux vomica tonic and then liq. fowleri alone, was given. The blood counts still further improved; the parasites became scantier, and were often absent from the peripheral blood. The temperature, which at this time was irregular and sub-normal, became more regular, though very often sub-normal. Owing to his illtemper and homesickness he was sent back to the Congo in August, and the missionary authorities were given a supply of trypanroth tabloids for him. No news[1] has been received as to the boy's progress. Lumbar puncture was performed several times, but no parasites were found in the cerebro-spinal fluid, nor was such fluid infective to animals. The fluid possessed the normal characters; it did not agglutinate trypanosomes.

Blister fluid: Serum obtained from a small blister proved negative on two occasions. Mice inoculated with it, failed to become infected. Under the chapter headed Periodicity, tables shewing the presence and absence of the parasite in the blood are given. During the last twenty-two days, the parasites were hardly ever present, and were absent for the last eleven days before he left England, apparently due to the arsenical treatment.

	Differential Count	
	March 4	June 15
Polymorphonuclear neutrophile ...	53·98	61·81
Large mononuclears	6·78	5·63
Lymphocytes	10·32	8·36
Eosinophiles	25·69	20·91
Mast cells	0·68	0·48
Transitional	2·55	2·81
	100·00	100·00

Banja. Male. *Aet.* 26.

Under observation from January 18 to April 1, 1904. Arrived in England, May 22, 1904. The early history of the case has been recorded.

Physical condition: A large, strong, very obese man. Intelligence poor. Skin soft. General enlargement of the glands. Spleen just palpable, not tender. Liver not enlarged. Urine, sp. gr. 1018, no albumen, no sugar, no bilirubin.

1. On May 18, 1905, news was received that this patient was, in the middle of April last, in the last stage of Congo sleeping sickness. 'He was not always sleeping, but greatly emaciated, talks rubbish, and seems to have lost his reason.' Further details not yet to hand, July 20, 1905.—H. E. Annett. Aug. 30, 1905, patient dead.—J.L.T.

The following analyses were made by Mr. Edie, Laboratory for Bio-Chemistry :—

Date	Amount of Urine in c.c.	Sp. Gr.	Reaction to Litmus	Grams Total Nitrogen	Grams Urea	Grams Uric Acid	Grams NH_3	Grams NaCl	Grams P_2O_5	Albumen	Sugar
June 27	860	1014	Acid	10·5	21·3	·43	·26	3·62	...		
,, 30	1440	1019	Alkaline	17·9	34·1	1·29	·6	12·2	2·5		
July 13	1500	1017	Acid	14·2	28·2	·52	·76	19·6	1·5		
,, 16	1380	1011	Acid	9·5	19·0	·51	·4	11·3	1·4		
,, 17	1480	1013	Neutral	12·6	25·3	·65	·34	10·8	1·35	Absent	Absent
,, 22	1060	1020	Acid	10·5	21·4	·58	·34	11·1	1·2		
Aug. 1	2450	1014	Acid	20·7	41·9	1·2	·82	24·8	3·0		
,, 7	2800	1018	Acid	24·7	49·2	1·5	·97	23·1	3·4		

Nervous system : Knee jerks, cremasteric, epigastric, and anal reflexes normal. Electrical reactions normal, no tremors. Sensations, temperature, taste, and smell normal. No symptoms of drowsiness. No oedema, no skin eruption. The temperature ranged between 98° F. and 102·2° F., somewhat irregular ; sudden rises occurred which did not correspond with days on which an increased number of parasites was observed.

The pulse was as usual rapid, 94-108, once or twice rising without apparent cause to 128, usually regular and of good volume ; after climbing or work, irregular and dicrotic.

The man worked in the laboratory and animal houses. During the period of observation, from May 22 to August 15, no symptom other than the presence of parasites in the blood was noted. His appetite was inordinate and he grew extremely fat. No mental symptoms shewed themselves other than masturbation, which he had practised before arrival, and which he continued, despite all efforts to prevent it.

Lumbar puncture performed once by Dr Christy, and twice while under observation, never shewed any parasites in the cerebro-spinal fluid, nor were animals infected by injections of the fluid.

Lumbar puncture was performed three times in the Congo. Once trypanosomes were found but the notes record blood being mixed with the fluid at a period when eighty parasites to a cover were present in the peripheral blood.

Gland examination : One cervical gland was removed and examined on a day when there were only a few parasites in the blood. The juice did not contain so many trypanosomes as did the blood. Glands were punctured on two occasions. On a day when the blood was negative no trypanosomes could be found in the fluid withdrawn from the gland. On the other time both gland and blood preparations contained the same number of trypanosomes.

Blister fluid : The fluid contained no parasites, but successful infection of two mice out of four inoculated is recorded after a somewhat lengthened incubation period. This case was tried with injection of sodium arseniate, but as so much pain was complained of liquor arsenicalis was given by the mouth only to be discontinued and trypanroth grs. V in tabloid form substituted. To commence with one tabloid, later two tabloids a day were employed. No inconvenience appeared to be caused. The urine became pinkish twelve days after commencing treatment. A slight reddening of the conjunctivae appeared on the eighteenth day. The saliva appeared to have a faintly pinkish hue. The trypanosomes had decreased in numbers apparently due to the action of the dye. As the man returned to the Congo on the twenty-second day of treatment the administration of the substance had to be discontinued. The temperature had fallen somewhat and the patient appeared to have experienced no ill effects from it. The patient arrived at Leopoldville in September, 1904, and was at once put to work. Through an unfortunate misunderstanding treatment was not continued. Four months later the patient entered hospital with evident signs of 'sleeping sickness,' and died there in June, 1905.—J. L. T.

Disasi. Male. *Aet.* 26. Lower Congo.

Arrived in Liverpool, December 27, 1903. He and his wife had been found to be suffering from trypanosomiasis. His wife died on the voyage to England.

Physical examination: A well-set-up sturdy man. Muscular development good, but inclined to obesity. Intelligence good; no signs of being drowsy. Skin soft. Few chiggers in feet. General glandular enlargement.

Respiratory system: normal.

Circulatory system: Heart sounds not accentuated. Pulse, 98-101, of high tension, but regular.

Spleen and Liver: Enlarged, not tender on palpation.

Genito-urinary system normal. Urine, sp. gr. 1020. No albumen; no sugar; chlorides; no bilirubin.

Faeces contained *Ankylostoma duodenale.*

Nervous system: Knee jerks normal. Epigastric, cremasteric reflexes not increased. Pupils reacted to accommodation and light.

Ocular, nasal, and aural systems normal.

The blood at first contained no trypanosomes—but *Filaria perstans*, often twenty-six to forty to a cover. Later, trypanosomes were very scanty; the examination was often negative. On January 26 an attack of malaria occurred, the temperature reacting to quinine.

February 6: Thirty trypanosomes to a cover preparation were found; these increased to eighty to a cover, and after four days decreased to seventy; they then disappeared, to reappear again later and remain more constantly present, though in small numbers. From that time until May 7, except for slight colds and an occasional headache, nothing abnormal was remarked. Glandular enlargement had not become more pronounced. On May 8 he had coryza, and complained of pain in the right ear; this increased in intensity. Examination revealed no mastoid tenderness or discharge from the ear. Signs of pneumonia appeared on May 10, and he was removed to Dr. J. Hill Abram's Ward in the Royal Infirmary. The disease progressed, and death occurred from pneumonia, May 14.

For autopsy and morbid histology, see Part II, Disasi.

Capt. S. B. *Aet.* 25. Italian.

Patient was employed in the Congo Free State River Service. As he was suffering from trypanosomiasis and was leaving for Europe, Dr. Dutton recommended him to come to Liverpool. No definite history as to the date of infection could be ascertained: he had had several attacks of malaria. The first symptoms of irregular temperature, not reacting to quinine, and slight oedema of the legs were noticed about the end of 1901. Trypanosomes were found in his blood by Dr. Broden, in September, 1903. Patient was under the care of Dr. Lloyd Roberts in the Royal Southern Hospital from May 31 to June 18. Our notes of the case record nothing abnormal in the physical examination other than a very slight enlargement of one or two inguinal and cervical glands. The liver and spleen were slightly enlarged and palpable. No tenderness was evinced. There was no purpuric eruption, nor could oedema of any part be found while he was in Liverpool. The parasites were very scanty in the blood. The temperature was of the usual type.

On *June* 5 an epileptiform attack occurred, he became unconscious for about ten minutes, the pupils were dilated, there was slight frothing at the mouth with loud stertorous breathing.

June 6 : Another slight convulsion, the pupils were very small. These fits were the first he had had. Before admission to the hospital he had been taking tabloids of some arsenic preparation. The drug was discontinued, but as he was not doing well liq. arsenicalis fowleri was prescribed. As he wished to go to his relations in Italy he left, promising to return but never did so.

Trypanosomes were only demonstrated in the peripheral circulation on June 4 ; a monkey, rabbit, guinea-pig, four rats, and four mice were inoculated with blood on a day when parasites were present and developed the infection.

Periodicity of the Parasite in Natives[1]

Below are given the number of parasites found in fresh coverslip preparations of blood from the peripheral circulation. These columns read downwards show the periodicity of the parasite.

Mpangila			Disasi			Banja	
3	1	4	0	0	0	46	10
2	4	1	0	30	0	32	0
1	2	0	0	50	0	14	0
0	4	0	0	70	0	300	0
2	3	3	0	0	0	4	0
1	6	2	0	0	0	16	1
0	1	5	6	2	2	40	0
0	2	2	0	0	2	40	0
1	0	1	2	4	0	0	0
0	3	2	0	2	0	0	0
2	6	7	0	0	0	8	0
0	8	5	0	2	0	2	0
0	6	2	0	2	0	0	0
0	0		0	0		16	0
0	2		0	0		16	0
1	2		0	4		4	0
0	4		0	2		0	0
1	0		0	0		0	0
0	0		0	0		12	0
0	2		0	0		0	1
1	2		0	2		0	90
0	0		0	0		0	21
0	0		0	2		0	2
5	2		0	0		48	0
0	6		0	0		6	0
0	8	rise of temp.	0	0		0	5
0	34	100·6	0	0		0	11
0	54	103·4	0	4		0	
0	12	101·4	0	0		3	
4	8		0	0		0	
5	2		0	0		1	
0	6		0	0		0	
0	14		0	0		7	

1. In a later report, periodicity of the parasite in animals as compared with other trypanosomes will be discussed.

Periodicity of the Parasite in Natives—*Continued*

	Mpangila	Disasi	Banja
Days present	113	22	26
Days absent	104	78	33
Longest period present—days ...	12	3	8
Longest period absent—days ...	7	25	13

These figures show that periodicity is very marked in some cases. The charts of these cases do not record any very marked rise of temperature coincident with an increase in the number of parasites. Mpangila had the parasites more constantly present but in smaller numbers than in the other two cases. From the periodicity columns the case of Disasi shows well the difficulty in making a diagnosis without daily examinations continued for a long period.

II. INOCULATION EXPERIMENTS WITH *TRYPANOSOMA GAMBIENSE*

Strains of Trypanosomes Derived from Man

In May, 1904, a preliminary note was published on a comparison of the animal reactions of various strains of trypanosomes derived from sleeping sickness cases in Uganda and the Congo Free State, strains from native fever cases from the same regions, with the original strains of trypanosomes brought back by Dutton and Todd from the Senegambia. Two Gambian strains were derived from natives suffering from the so-called 'Trypanosome or Native Fever'; the third was from a European who had died from trypanosomiasis. The strain obtained from the boy at Gunjur has been the principal Gambian strain employed, though the other two have been used to some extent. It is the 'Gunjur' strain which was sent to Professor Laveran, and also to Colonel David Bruce; from the latter we obtained Uganda sleeping sickness strain and Uganda native fever strain. From our expedition in the Congo Free State we have secured a large number of strains. We have been able to obtain fresh strains of trypanosomes from two cases of sleeping sickness and three native fever cases which had been sent from the Congo Free State to Liverpool for observation and treatment. We have also been able to procure a strain from a European who had returned from the Congo suffering from trypanosomiasis. It has been of great assistance to us to be able to compare strains derived from so many sources, and especially to be able to procure strains in their first passage through an animal and to compare them with those strains which had been through several hundreds of passages, and finally to compare them all with the parasite in the blood or cerebro-spinal fluid of a case suffering from the disease. In our report in the *Lancet*[1] we gave in detail the results of the inoculation of many of these different strains. Dutton and Todd have already published their results with the Gambian strains, also a short account of the animal reactions with various strains from the Congo Free State. Laveran and Mesnil have published their findings. Drs. Brumpt and Wurtz have recorded the results from strains derived from French Congo cases. All groups of observers have come to the conclusion that the trypanosomes found in cases of sleeping sickness are identical with the trypanosome found in the blood of a European, and described by Dutton in 1902. It would, therefore, seem unnecessary to reiterate any of the findings were it not for the publication by Plimmer of a comparison of the Gambian fever strain (Gunjur) and the Uganda sleeping sickness strain,

1. *Lancet*, May 14, 1904, p. 1337.

both obtained by him from Col. BRUCE. A reply to the publication by PLIMMER has already been made.[1] In correspondence with Professor LAVERAN, who has also experimented with both of the strains used by Mr. PLIMMER, he writes that his results are equally opposed to PLIMMER's. In order that Mr. PLIMMER's findings may be compared with our results, a synopsis of his report is printed.

Further experiments and comparisons have been made with the various strains of trypanosomes. We have been able to successfully inoculate four baboons, one *Cynocephalus sphinx*, three *Cynocephalus babuin*, with strains of *T. gambiense*; these animals have all died. The baboon is certainly the most resistant animal with which we have experimented. From our baboon experiment, No. 747, a highly virulent strain has been recovered by passage through a rabbit.

BABOONS (*Cynocephalus babuin*)

Experiment No. 709. Inoculated intraperitoneally July 24, from Rhesus, 672. Mixture contained two to six trypanosomes to a field. The monkey, 672, was a direct inoculation. On August 10 a temperature of 104·6° F. was registered; no parasites were seen. The animal lost weight, and the blood counts showed a diminished number of red corpuscles and of haemoglobin. No parasites were seen up to death, October 7. During the ten days preceding death the animal became very emaciated, and for the last thirty-six to forty-eight hours weakness was marked. Baboon lying down and almost unconscious. A rabbit inoculated with nearly ten c.c. of heart blood after a greatly prolonged incubation became infected. Up to date it has never shown parasites in large numbers.

Experiment No. 747. Inoculated intraperitoneally August 21, the temperature rose on the sixteenth day and after that date continued very irregular—104·2° F. being frequently registered. Death occurred on October 10, being hastened by a severe dysentery which commenced five days before. Parasites were first seen on October 1 and again on October 4, each occasion a high temperature was registered. In this case, as also in the other two, though the blood was so often or always negative still the characteristic clumping or autoagglutination[2] of the corpuscles was pronounced. This phenomenon occurred gradually but was easily determinable about the eleventh to fourteenth day after inoculation; it persisted to the end. At the autopsy, which was done immediately after death, a rabbit, 823, and two guinea-pigs were inoculated with large amounts of blood which was negative even when centrifuged. The rabbit littered on October 25, at the same time the temperature rose, the autoagglutination of the corpuscles was present but no parasites were seen. On November 1, 105·1° F. was registered; the next day, the twenty-third after inoculation, parasites were seen; these increased very rapidly so that thirty to forty to a field were present. From this rabbit

1. *Proc. Roy. Soc.*, 1905. 2. Dutton and Todd.

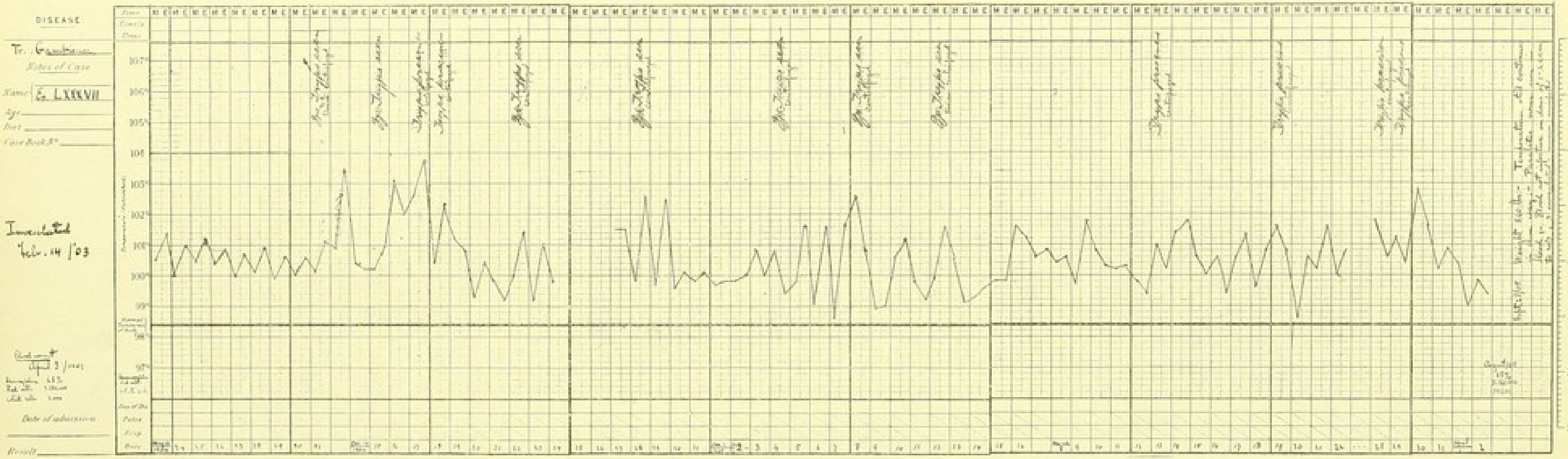
a series of animals have been inoculated. The incubation period and duration of the disease is much less than with the ordinary strain of parasite. One of the guinea-pigs has since shown parasites in its blood. Whether the parasite from this guinea-pig is as virulent as that from the rabbit is not as yet determined. The animals died four-and-a-quarter weeks after the appearance of parasites, there being over one hundred to a field at death. Further experiments in progress.

Experiment No. 890. Inoculated intraperitoneally with 9·0 c.c. pure blood from rabbit 877. Mixture contained one parasite to a field. This rabbit was inoculated in the third passage from rabbit 823 (see above). On the tenth day the temperature rose to 103·4° F. No parasites were seen. Two days later a trypanosome was discovered. From that time until the baboon's death on the forty-first day the organisms were present at nearly every examination. Death took place suddenly. A pup inoculated with heart blood from this baboon developed the disease after a prolonged incubation, the parasites were present in only very small numbers up to its death.

All three baboons showed a rise of temperature to 103°-104° F., and following on this an irregular temperature which persisted, usually becoming lower and often being sub-normal before death. Parasites were found in the blood of only two of the baboons despite repeated centrifuging of the blood, but though the parasites were hardly ever present, and then only one to two to a cover, still animals inoculated with large amounts of their blood have developed the disease. Loss of weight and anaemia, though gradual, was present in all three cases. The autopsies, especially of 747 and 709, showed an enlarged and firm spleen, slight enlargement of the lymphatic glands. Dr. Breinl has included the brains, cords, and organs of these animals in his report on the histo-pathology.

The strain derived from baboon 747 and passed through rabbit 823 has been inoculated into a great number of animals. In all the incubation period has been greatly shortened. Rabbits very often show parasites in their blood in two to four-and-a-half days, and death may occur as early as the fifth to eleventh days after inoculation. In many cases the parasites augment from day to day until there will be one hundred and fifty to two hundred or more to a field. The animal will very often suddenly die. The number of trypanosomes will frequently decrease, they usually commence to increase in numbers again in three to eight days, and continue to do so until the blood actually swarms. A very severe anaemia occurs, loss of weight is marked. Coma may develop a few hours before death or the animal may die while in the act of eating and apparently quite strong. The temperature is usually very high, the incubation rise being often to 104°-106° F. It usually continues high, hardly falling at all in the acute fatal cases. The *post-mortem* of these acute cases shows a multitude of parasites in every organ and in the blood and serous exudates, acute swelling of the spleen, enlargement of the glands—some of these may be haemorrhagic.

CHART IV



to face p. 15

Rats, mice, dogs, cats, guinea-pigs, and monkeys develop the disease in equally short incubation periods. Death occurs early: in the dog in nine days; cats, twenty days; rats, twelve to eighteen days; mice, twelve to sixteen days; monkeys, ten to twenty-four days. Guinea-pigs may die in twelve days to three weeks after the appearance of the parasites in the peripheral blood. The guinea-pig may resist, and after an incubation of three to five weeks acquire a more chronic form of the disease.

Monkeys

Various species have been used, *Macacus rhesus*, *Cercopithecus callithricus*, *Cercopithecus ruber*, *Pithecia satanas* (*Jew* and *Sooty* monkeys). All react to inoculation with almost the same sensitiveness. The *Sooty* appears to be somewhat less so, the parasites are rarely seen but autoagglutination of the corpuscles, anaemia, fever, and loss of weight occur as in the others. Monkeys, though reacting so well and the parasites often showing in large numbers, are, unfortunately, extremely liable to digestive disturbances, their vitality is not great and they quickly succumb to the complication. As they usually harbour large numbers of intestinal parasites the blood counts cannot be absolutely depended on. The monkeys infected with sleeping sickness strains have not shown any more symptoms of 'sleep' than others inoculated with 'Gunjur,' etc., strains. Monkeys infected with *T. dimorphon* and non-infected ones dying from dysentery, etc., have sometimes exhibited even more pronounced symptoms.

It is of interest to record the progress of the disease in large animals infected for a long time.

Horse VII

Experiment No. 87. Inoculated by Dutton and Todd, February 14, 1903. Strain 'Mr. Q' (European, Senegambia). Parasites appeared March 16. Up to May, when it was sent to England, the organisms were fairly constant in the peripheral blood. From August 31, 1903, the blood was negative to microscopical examination, but still infective if inoculated in large amounts. On numerous occasions, the blood was centrifuged, but no parasites could be found. The blood when inoculated in amounts of 0·5 c.c. into rats and mice, formerly proved infective, such a quantity is at present of no use; 2·5 to 3·0 c.c. or more is now needed to produce an infection. Moreover, it is necessary to use more than one animal, as the animal may only acquire a mild chronic infection with very few parasites to be seen in its blood. The horse, shortly after the infection, lost flesh but improved after arrival in England. It is now in excellent condition, weight, 510 pounds, no oedema. The blood count: reds, 5,600,000; whites, 17,600; haemoglobin, ninety per cent. Urine normal. The autoagglutination of the blood corpuscles is still present. Its temperature has been recorded for nearly the whole period (see chart); glandular enlargement has not been noticed since the animal arrived in England.

Donkeys

Two were inoculated, one with 'Gunjur' strain (*Lancet*, May 14, 1904), the other with Uganda sleeping sickness strain, between February and March, 1904. These animals became infected, and showed the parasites in their blood. The parasites have always been extremely scanty in numbers, even after centrifuging the blood. The occasions on which the blood examination has been negative have gradually become more frequent, but they are still occasionally seen. The autoagglutination of the corpuscles is marked. Few symptoms have been observed. For about two months after infection, the animals appeared to be losing flesh and were less lively, they have now regained their normal weight. Anaemia has been present from the commencement but it is not marked. The temperature has continued irregular, varying between 98·6° and 100·4° F., occasionally it rises to 101·8° to 102·4° F. about every ten to fourteen days or so. This rise continues for about forty-eight hours, when the temperature drops to normal or sub-normal. The urine is negative. Glandular enlargement is present in both these animals, it was noticed about a month after infection, and still continues, though much less marked. The blood is infective to rats in amounts of 0·5 to 1·0 c.c., formerly a few drops of blood were sufficient.

Cow

This animal was inoculated, April 28, 1904, the temperature rose to 103·6° F. eight days later, but no parasites were seen until May 17. A rat inoculated on the day of the rise, developed the disease. For the first month no symptoms were noted, the animal then began to lose flesh, and became quite thin, but in July it commenced to put on weight. The yield of milk decreased, the parasites were extremely scanty, and have been present in less numbers and at longer intervals than in the case of the donkeys and the horse. Anaemia was not marked. The blood count at present is, reds, 6,220,000; whites, 16,200; haemoglobin, eighty-five per cent. Autoagglutination of the corpuscles has been present from May 20—it still persists, but is not so marked. The temperature has shown the same irregularity, rising gradually but irregularly for ten days to remain high for about one-and-a-half to three days, and then commencing to fall. Glandular enlargement was present up to August, 1904. The coat which had become rough and dull looking is now smooth and glossy. The blood is still infective though larger amounts are now necessary.

A peculiar condition has been noted in the milk. About two-and-a-quarter months after infection, it was noticed that the milk was very poor in fat, and watery. Dogs fed with it developed in about twenty-four to thirty-six hours a very profuse diarrhoea, which continued so long as the milk was given. Pasteurising or autoclaving at 120° C. appeared to make no difference, as pups and kittens developed diarrhoea in two to four days. Bacteriologically, the milk has been proved to be free from pyogenic organisms. Guinea-pigs inoculated with it have not developed any lesions.

Chemical analyses have failed to detect any changes other than a low percentage of fat. Tried on human beings, nothing is noted other than a tendency to cause biliousness and diarrhoea. The possibility of antibodies being formed in the milk has been recognised, but no proof has been established.

Sheep

A wether, Experiment No. 560, became infected ten days after inoculation. On the twenty-seventh day one parasite to a field was noted. The numbers gradually decreased, and five months later, the animal appeared to have recovered. Blood in amounts of ten to forty c.c. was non-infective. Slight anaemia was present for a time. Autoagglutination was fairly well marked until the end of the third month.

Goats

The animals inoculated with the various strains have all died. One, No. 480, inoculated with Uganda sleeping sickness died on the fifty-eighth day. The anaemia was somewhat marked. The parasites were present fairly constantly, usually four to twenty-four to a cover preparation being seen. Autoagglutination of the corpuscles was not very marked. The temperature remained irregular. Loss of weight was the only symptom noted. The *post-mortem*, twelve hours after death, showed a slightly enlarged spleen and glands, none of them haemorrhagic. Decomposition was advanced.

Dogs

These animals, though easily susceptible to inoculation, survive for many months. Laveran records one dog still living, six months after infection. A bitch, No. 738, inoculated with 'Gunjur' strain lived for over nine months. The parasites were at first hard to find, but for the last three months became more and more numerous. For the first two months emaciation was not marked; a progressive decline then became evident, and this continued up to death. Towards the end a profuse discharge from the eyes occurred; the conjunctivae were inflamed and infiltrated.

The blood count of this animal is interesting (p. 18).

Some dogs have died in three weeks, others have lived for varying periods up to nine months. A bitch, Exp. 45, brought back by Dutton and Todd, recovered from the disease. This animal had been inoculated when a puppy; it developed a chronic form of the disease and at the end of four months no parasites could be found in its blood. Autoagglutination of the corpuscles gradually became less marked, and ten months after inoculation the blood appeared perfectly normal. In amounts of 2·0 to 10·0 c.c. it was non-infective. Reinoculation of small quantities of blood failed to produce infection, although a control dog developed the disease.

Experiment 738

Day of Disease	Red Corpuscles	Leucocytes	Haemo-globin	Parasites
4th	5,240,000	12,000	85	8 to cover
5th	6,500,000	12,600	86	40
6th	5,430,000	15,800	75	228
7th	5,610,000	17,000	65	400
8th	5,850,000	18,600	64	2400
9th	5,540,000	13,600	79	24
15th	4,270,000	18,400	60	56
58th	5,260,000	10,000	69	28
69th	7,820,000	11,800	92	2
166th	4,310,000	14,000	70	680

It appeared to be immune. Its serum did not possess protective properties. Infection and progress of the disease occurred in all animals treated with this serum. Its agglutinative properties were infinitesimal. Pups born of this bitch were as susceptible to the various strains as the control ones. The temperature varies. Usually, in the long continued cases, exacerbations of fever with apyrexial periods of eight to ten days occur ; sometimes the fever is high and irregular during the whole course of the disease. A subnormal temperature is usually recorded before death. One animal developed fits eight days before death, and unconsciousness became marked eighteen hours before the end. Owing to absence from the laboratory no *post-mortem* was done. Anaemia may or may not be pronounced. Autoagglutination is usually pronounced.

Pups are very susceptible and usually show large numbers of parasites in their blood. Periodicity is sometimes very pronounced, the parasites often diminishing from ten to forty to a field to only a few in a coverslip preparation. This may occur in the course of a few hours.

Cats

As shown by us, these animals are susceptible to inoculation. The disease runs a course of three to ten weeks ; a few have lived for a longer period, six-and-a-quarter months. Parasites are generally hard to find, but can be usually found if properly looked for. The temperature is irregular, sometimes passing 104·5 F., apyrexial intervals usually occur. It is often subnormal about twenty-four hours before death and there may be a steady and regular fall for some days preceding death.

Anaemia may be a prominent feature. The blood count of one cat was, reds, 8,600,000; whites, 6,000; haemoglobin, seventy-eight per cent.; on the twenty-ninth day of infection, reds, 3,470,000; whites, 14,400; haemoglobin, thirty-eight per cent. Its weight had decreased three hundred and twenty grammes during this time. The parasites in this animal were numerous, at times three to a field were seen. Auto-agglutination is a noticeable feature both in the acute and the chronic types of the disease.

Kittens are very susceptible, the parasites appearing early and generally persisting in large numbers until death. The anaemia is severe. Loss of weight and stoppage of growth occurs. A high temperature is noticed. The duration of the disease is from three to seven weeks. Purulent conjunctivitis is common.

Rabbits

The incubation period has not varied markedly; from the figures given in the preliminary report five to fifteen days. Some of the rabbits have lived one hundred and fifty to two hundred and seventy-three days; these have had a chronic, mild infection. Average duration fifty to one hundred and twenty-eight days.

Guinea-Pigs

The disease varies, many of the animals have only shown the parasites after one to three months or more. The trypanosomes have then continued present in large numbers, death occurring fourth, ninth, and sixteenth weeks after the appearance of the parasites in numbers. Rupture of the spleen has caused death in four cases, in every instance the blood was full of trypanosomes and the spleen acutely swollen.

Morphology of the Parasite

Dutton and Todd, Laveran and Mesnil, Bruce, and others have described the parasite. Both Dutton and Todd, Laveran and Mesnil, and Bruce have had opportunity of comparing the trypanosomes found in the blood with those parasites found in the cerebro-spinal fluid and those present in the blood of inoculated animals. All groups of observers have agreed that they can determine no marked differences. All agree that the parasites in the cerebro-spinal fluid are often vacuolated. As Laveran and Mesnil point out and illustrate in their work (Fig. XLII, Nos. 1, 2), and Dutton and Todd (Pl. I, Fig. 1), the trypanosome may contain large vacuoles. Laveran and Mesnil ascribe it to the parasite being poorly fixed, and show that with very serous blood such a condition is common. Such being the case it is only natural that films made from the cerebro-spinal fluid will contain many of these vacuolated forms.

We have compared the trypanosomes in the same way as these observers and can find no difference between the parasite present in the cerebro-spinal fluid and blood of patients, or in the blood and exudates of infected animals. Plimmer claims that the parasite of 'Gambia Fever' differs from the sleeping sickness trypanosoma: the former being longer, generally larger, and more easily stained than the stumpy, larger-vacuoled, badly-staining trypanosoma of sleeping sickness. After the examination of many animals infected with the various strains of *T. gambiense* the distinctions which Plimmer notes appear to be artificial. Both long and short, large and small forms are seen in their blood; on comparing these with the parasite in the blood of a native the same forms are seen. No differences have been noticed in the staining reactions. The parasites in serous blood require longer staining than do those in less anaemic blood.

Comparisons were made by injecting animals both with a sleeping sickness and a 'Gambian Fever' strain. It was impossible to detect any difference whatsoever either in the control films or films made from the animal. Animals were injected with blood containing a majority of short stumpy-formed parasites, these animals have shown as many or more longer forms than stumpy ones in their blood. Careful measurements have not shown any difference between the sleeping sickness or 'Gambian Fever' or any other 'Trypanosome Fever' parasite. These comparison slides were made from the same species of animal, and, with two exceptions, the number of passages of the parasite was the same. Chromatic granulation is common both to the long and short forms. Parasites appear to possess these granules more often if the infected animal is dying or if large numbers of parasites are present in the blood. They have also been prominent in the trypanosomes undergoing degeneration in the blood of an animal treated with arsenic or trypanroth. In some cases they have almost filled up the whole body of the trypanosome, making it difficult to distinguish the micronucleus and interfering with the macronucleus. These granules may form in clusters or may be ranged in comparatively regular rows, they may vary from a pin-point to a size equal to or larger than the macronucleus in size. Trypanosomes containing such granules may be run through several passages and still possess granules. One mouse, Experiment 692, had enormous numbers of trypanosomes containing these granules; all the subinoculated animals became quickly infected, and though this strain was run through eleven passages the parasites still contained the granulations. The granules were present in both single and divisional forms of the micro-organism. These granules were present in the trypanosomes of the subinoculated animals—rabbits, rats, mice, and pup. In a monkey a less number of granules were seen. The twelfth passage into a guinea-pig infected the animal, but the trypanosomes had almost lost the granules. In the blood of this animal granular trypanosomes were noted from time to time; it died from broncho-pneumonia; its subinoculated rats have never shown granular forms of the parasite.

CHRONICITY

The artificially produced disease in animals may pursue an acute or chronic course. With the ordinary strain all the animals show a more or less chronic and lengthened infection as compared with Nagana and other pathogenic trypanosome infections. It appears more virulent for kittens, pups, and monkeys (*Rhesus*) than for cats, dogs, rabbits, guinea-pigs, rats, and mice ; in some of these animals the parasites, after appearing almost constantly for a time, disappear and are then found only at rare intervals. Such animals usually show an increase of parasites a short time before death. The large animals, goats, sheep, cows, donkeys, and horses, though susceptible to the infection, with the exception of goats, appear to be able to withstand the disease. It is interesting to note that a horse still shows infection twenty-seven months after inoculation.

VIRULENCE

In the majority of animals infected with the various strains of *T. gambiense* the disease pursues a normal course, and the animal dies with a fair number of parasites in its blood. Occasionally the numbers of parasites increase enormously, and such an animal quickly dies. The subinoculations, even with very diluted blood containing no more parasites than control blood, may show that it is extremely virulent, the incubation and duration of the disease being shortened. Such virulency has been noted in baboon 747, rabbit 823, and in rabbits, rats, and mice. Though parasites are numerous in guinea-pigs, in no case has an increased virulency of the parasite been observed. As noted elsewhere if a strain be repeatedly and quickly run through animals of the same species it will acquire a certain virulency for such a species, but this continues only so long as the strain is not run through other species of animals.

IMMUNITY

Certain species of animals appear to possess a more or less stable resistance to infection with trypanosomes. Baboons are peculiarly hard to infect, the immunity is not an absolute one as they have been on occasion infected with *T. gambiense* and *T. dimorphon*. In every case the incubation has been lengthened, the parasites have been scanty but the animals have succumbed to the disease. Certain species of monkeys, as the *Jew* and *Sooty*, are somewhat more difficult to infect than the *Rhesus* and *Calothrix*.

All attempts to infect birds and fish with *T. gambiense* and *T. dimorphon* have failed. Goats[1] and sheep, though susceptible to infection with various pathogenic trypanosomes, do not easily succumb. Some species of animals, ordinarily susceptible

1. As Bruce suggested it is with such animals that the histo-pathology of the disease ought to be investigated. In our report a comparison of the lesions found in animals dying after lengthy period from a chronic type of the Gambian Horse disease has been made with those found in sleeping sickness. A comparative study of a large number of goats, etc., infected would be of great aid in determining if the various trypanosomes pathogenic for animals produce lesions akin to those found in natives dying from sleeping sickness.

to infection, show occasional resistance. One rat, 285 (see p. 25), was difficult to infect with *T. dimorphon*, and then only showed the parasites for a few days. It recovered and was able to withstand inoculations of enormous quantities of virulent blood. In the preliminary note on *T. gambiense* it was shown that sometimes, of two rats inoculated at the same time the one acquired the disease the other did not, the resistant animal even having received the greater amount of the virulent blood.

With these resistant animals and those in which the disease pursues a markedly chronic course experiments have been made to see if an exacerbation of the disease could be produced. Such animals have been daily, weekly, or monthly reinoculated with small quantities of virulent blood. In a few cases a rise of temperature corresponding to the incubation period has been observed. In a couple of cases the parasites have somewhat increased. Various experiments in breeding infected and healthy animals together have been done. The progeny of such unions have not shown any immunity or resistance.

Endeavours to protect animals, or to at least mitigate the disease by injection of attenuated parasites or large quantities of blood from which the parasites have been freed or killed off, have proved of little value. The same applies to injection of animals with sera from animals which have recovered from the disease in which the chronic type prevails, or from animals naturally immune. Here again very meagre results have been obtained. Efforts to produce an immunity by the administration of drugs is of little value. Arsenic, which has an effect on the parasite, is of no use when attempts are made by first treating the animal with the substance to render it later proof against inoculation of virulent blood. Ehrlich and Shiga in their work on 'Trypanroth' were able to protect[1] animals by preliminary treatment with the dye. If large enough amounts are administered a certain amount of protection is afforded.

Toxicity

All efforts to isolate a toxine have proved negative. The various procedures which Plimmer and Bradford had used were employed. They had found that animals could be inoculated with large quantities of blood from dogs infected with Nagana, the blood being filtered through porcelain bougies, without producing any effect. As much as 150 c.c. of filtered serum have been used without producing any toxic effect.

On one or two occasions the injection of blood containing trypanosomes has seemed to us to possess toxic properties. A rabbit infected with *T. gambiense* showed this. The blood as long as there were few parasites present could be inoculated into rats with impunity. Later on, as the parasites became numerous, it was noticed

1. Such a line of investigation with this and other substances ought to be tried on large animals. The history of punitive expeditions, etc., in the past has shown how handicapped man is when a trypanosomic disease breaks out amongst the transport animals. If this dye were administered before passing through a fly-belt, and the animals carefully examined ano tested before and afterwards, valuable data would be available.

when the blood was inoculated that rats which received 0·5 to 0·8 c.c. of pure blood died in twenty to twenty-eight hours, while controls injected with a weaker solution, 0·1 to 0·5 c.c., survived. On three consecutive days batches of four rats were inoculated intraperitoneally; the two animals which received the higher amounts were killed, the other two survived. A repetition of these experiments gave the same results. Cultures made from the rats remained negative, and films from the inoculation mixture, peritoneal cavity and heart blood of the rats, showed no bacteria. This rabbit died a week later. Maceration of its organs and treatment in the usual manner failed to reveal a toxine. The organs of animals dying or killed when numerous trypanosomes were present in the blood and in the juices of the organs, or at any time when the parasites have almost disappeared, have been used. The precipitates obtained from them have neither produced any effect nor afforded any protection against infection. The organs of the two cases of sleeping sickness were tried with like negative results. Peritoneal and pericardial exudates and fluid from oedematous tissues containing parasites have been ground up and injected also with negative results. It is possible, if they could be procured in large quantities, that some substances might be obtained which would cause a reaction, but the quantity of fluid ordinarily obtainable is limited. Centrifugalization of large quantities of blood renders it possible to collect enormous numbers of trypanosomes, but they are mixed with leucocytes. Efforts to get rid of these latter have not been successful. Inoculation of these parasites after they are killed by heat or cold or kept for a sufficient time have failed to produce any effect. From the products of culture tubes no toxine has been found, and animals inoculated with such contents have shown no evidences of intoxication.

Agglutination

The possibility of the agglutination of the parasite acting as an adjunct to the diagnosis of the disease has been realised. The results are not satisfactory. Blood, from an animal showing parasites, when defibrinated and mixed with serum from a native or animal suffering from the disease has been used. The parasites do not agglutinate. Serum from an animal continually injected with living trypanosomes shows the same negative results. In both cases there is a certain agglomeration of the parasites, but this is also usually obtained if normal serum be used. The serum from a native or animal added to defibrinated blood from the same case shows a slight agglutination. The exudate from a bleb causes no definite agglutination. If the trypanosomes be rendered immobile by the addition of weak formol before the serum is added, a partial clumping of the parasites may occur. Brumpt and Wurtz added potassium citrate solution to blood containing parasites to prevent coagulation, and then added serum from a sleeping sickness case. A rapid agglutination of the trypanosomes occurred. As they point out citrated blood containing parasites shows agglutination of the trypanosomes in a short while. In our opinion blood, to which citrate is added, must of necessity be of no value for agglutination diagnosis on account of spontaneous agglutination of the parasites. With defibrinated blood the objection is that the agglutination of the blood corpuscles seen so often in animals or man suffering from trypanosomiasis renders it impossible to say whether a true agglutination of the parasites is produced.

Serum from the horse, cow, donkey, sheep, or goat, if added in large quantities, produce an agglutination; it is perhaps a trifle more marked if the animals have been infected[1] or cured. Baboon serum agglutinates the parasites to a certain extent, the action seems to increase and remain, as far better agglutinations are observed some hours after the commencement of the experiment.

Conclusions

1. The further comparison of the trypanosomes found in (*a*) the cerebro-spinal fluid of Uganda sleeping sickness cases; (*b*) the cerebro-spinal fluid and blood of the Congo Free State sleeping sickness cases; (*c*) the blood of Congo Free State 'Trypanosome Fever' cases; and (*d*) the blood of Europeans infected in the Congo confirms the previous observations that all these trypanosomes are identical in animal reactions and morphology with *Trypanosoma gambiense* (Dutton).

2. There is no acquired immunity against infection nor transmission of immunity to offspring.

3. That baboons, *Cynocephalus babuin* and *Cynocephalus sphinx*, are susceptible to infection with *T. gambiense*. That usually a chronic type of the infection develops but a fatal termination occurs.

4. That in many of the animals, especially the horse, cow, donkey, sheep, and goat, the infection is of a mild character, but their blood is still infective to susceptible animals one year after the infection. That in the case of the horse the parasites are still occasionally seen and the blood infective twenty-eight months after inoculation.

5. That periodicity of the parasite is a prominent feature both in man and beast.

6. That the passing of a strain from a susceptible into a very resistant animal does not attenuate the organism.

7. That the parasites in an animal may sometimes become more virulent. The numbers increasing enormously, the subinoculated animals become more rapidly infected and death occurs. That such a strain may be particularly virulent for one species of animal. That the more rapid infection is not due to the inoculation of a greater number of parasites than usual.

8. That the parasites, after being passed through many hundreds of animals for nearly three years, still retain its morphological characters, and animals inoculated with it react as described by Dutton and Todd.[2]

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1. The sera from animals infected with other trypanosomata usually cause almost as much.
2. Liverpool School of Tropical Medicine, Memoir XI.

III. *TRYPANOSOMA DIMORPHON.* GAMBIAN HORSE DISEASE

This strain was brought back by Drs. Dutton and Todd from the Senegambia. Our results in general coincide with those of Dutton and Todd and Laveran and Mesnil.

Rats—White and Black

The incubation varies; in the case of the more attenuated strains the incubation period may be as long as twenty days; with the ordinary strain, which has been passed through many rats, the incubation period is from three to twelve days, the average being from four to seven days. Duration of infection, seven to forty-two days; average, eighteen days. Periodicity in some of the rats is fairly well marked. A white rat in the course of thirty-three days showed almost daily an irregular number of trypanosomes in the blood—after amounting to thirty to forty to a field they would diminish to one to thirty to forty fields, and then gradually rise. Each time when the parasites commenced to disappear a marked leucocytosis was present. On account of the smallness of the animal no blood count could be made.

One rat showed a marked resistance to the parasite:—Experiment 285, rat (white), one hundred and eighty-five grammes weight. Inoculated intraperitoneally January 5, 1904, with 0·75 c.c. of blood containing three trypanosomes to a field. Up to February 5, this animal never showed parasites in its blood. It was then reinoculated intraperitoneally with the whole blood from a rat (Experiment 242), there being two parasites to a field. Five days later four parasites were seen to the cover-slip preparation. These continued present for three days; its blood then became negative. On February 22, nine days later, it was once more inoculated intraperitoneally with 3·5 c.c. of pure blood from a dog (Experiment 314), there being twelve trypanosomes to a field in the mixture. It never became infected, nor was its blood infective to small rats when inoculated in quantities of 0·5 c.c. to 0·75 c.c. If some of its serum was added to blood containing the parasites a marked and permanent agglutination occurred. Up to May 10 it was repeatedly inoculated with large quantities of virulent blood, it then succumbed to an epidemic of broncho-pneumonia. Unfortunately, very little serum could be obtained for agglutination and other work. Artificially a certain degree of resistance to this parasite can often be established by injecting a mixture of blood and citrate solution attenuated by preserving in the incubator at 35° C. for four to six hours. Out of seven white rats so treated five of them were able to withstand at the end of eighteen days inoculations of 1·0 to 3·0 c.c. of virulent blood. Their blood, however, caused very slight agglutination. If these animals were bled very freely, a new inoculation of virulent blood would cause them to become infected, and after that the disease pursued the normal course. The spleens of rat 285 and some of the five others not showing the infection were small and normal looking, the glands were not enlarged. The spleens of rats dying after a duration of more than two weeks are very markedly enlarged, as pointed out by Laveran and Mesnil. The glands are also enlarged and many, especially the retroperitoneal group, are haemorrhagic. The pleural surface of the lungs is very often spotted with small petechial haemorrhages. Oedema has only been noticed on two occasions. Paralysis has never been noted in rats dying from the acute form. Two rats suffering from the chronic form developed a partial paresis of the left-hind leg. Haemorrhagic nephritis has been noted in two large rats suffering from the chronic type, the urine contained a few trypanosomes, the kidneys showing numerous small haemorrhages on their surface and in their substance.

Mice—White, Black, and Grey

The incubation varies from two to five days. Death may occur in the acute cases within sixteen to twenty-three days. In the more chronic cases the duration may be from thirty-seven to one hundred and thirty days. In the acute cases the parasites appear and continue to augment almost up to death. In the chronic phase of the disease there is very often a marked periodicity, the parasites being absent from the blood for intervals of eight to fourteen days. Subinoculations at such a time into young rats or mice are negative if small amounts of blood are used.

Two mice inoculated intraperitoneally with blood from Horse VI (p. 30) in amounts of 1·5 to 2·0 c.c., the blood being negative to microscopic examination, never showed parasites until the fourteenth and fifteenth days, the parasites then began to increase and the disease terminated eight days after the appearance of trypanosomes. Two mice were inoculated from the horse at the same time and never became infected, but were later on shown to be immune.

As Laveran and Mesnil note, the spleens of mice infected may become enormously enlarged. The organ often being six times as large as normal, causes a most noticeable tumour and almost completely filling the abdominal cavity compresses the other organs. In mice treated with arsenic the splenic tumour has lessened at the same time as the parasites have temporarily disappeared from the blood.

Guinea-Pigs

Over twenty-five have been used. The incubation has varied between four to fifteen days, the average being four to six days. The duration of the disease is from nine to sixty days. The acute cases showing parasites in large numbers in the blood very often die in thirteen to twenty days. Young guinea-pigs succumb sooner than do adults. There is usually a slight rise of temperature on the appearance of parasites ; after which the temperature may vary very little from the normal. Loss of weight is usually a feature of the disease. Anaemia is present but is not so marked as in rabbits infected with *T. dimorphon*. Paralysis of the posterior limbs has been seen in two cases about thirty hours before death. The parasites after the first appearance usually continue constantly in the peripheral blood, gradually increasing until there may be forty to sixty to a field. These high numbers may continue for ten days before the animal dies, or diminution in the number coincident with an increase in leucocytes can be noted.

Periodicity in some cases is a prominent feature, the parasites at times almost completely disappearing and remaining so for some days. This feature is observable in the more chronic cases. Rupture of the spleen has occurred in seven cases. Five of these cases were of the very acute form in which, after the incubation period, a continuous and rapid increase of the parasites had been noted. In the remaining two cases the disease was more prolonged. One death happened on the ninth day of the disease ; numerous parasites were present in the blood, and the animal died suddenly. The abdomen contained a large quantity of fluid blood, no lesion of the spleen or other organ could be detected, but the peritoneum was studded with small pin-head sized haemorrhages. One case of haemorrhagic nephritis conducing to the death of the animal occurred. Enlargement of the glands is not marked. If a very attenuated parasite be injected infection may not take place ; the animal is not protected by such an inoculation.

Rabbits

The parasite has gradually become more virulent for these animals. The incubation period after subcutaneous inoculation is longer than after intraperitoneal or intravenous inoculation. An incubation as short as four days and as long as fifteen days has occurred. The average after intraperitoneal injection is nine days, after intravenous four to seven days. Some animals have died in twenty-six to thirty-five days after intravenous inoculation, showing parasites in large numbers in their blood. The more chronic form of the disease can last from seventy-eight to one hundred and fifty-seven days.

These animals show a pronounced periodicity, the parasites being often absent from their blood for four to nine days at a time, to reappear in small numbers and gradually increase to one to ten to a field. Large numbers of trypanosomes to a field, as in the guinea-pigs, are rare. In acute cases the number of parasites is somewhat increased, and they are almost constantly present. In both the acute and chronic types of the disease anaemia is a very marked symptom. Soon after the appearance of the parasites in the peripheral blood the anaemia is noted, this rapidly advances, so that the blood is of a very pale serous character. At the same time a marked loss of weight occurs. In the chronic cases the animals may become mere skin and bones ;

a loss of four hundred to six hundred grammes is not uncommon in these cases. The coat becomes rough. Oedema of the posterior limbs and base of ears may occur to a certain extent. Discharges from the eye, nose, and genital orifices are rarely seen, and the animal never presents the wretched appearance so often seen in rabbits infected with Nagana, Caderas, etc., diseases. Coincident with the appearance of the parasites the temperature rises, and after continuing so for twenty-four hours falls, after that it may become irregular, being often very elevated, and towards the end becoming subnormal. The spleen is enlarged, but not more so than in rabbits dying from Caderas, etc. The glands may be somewhat enlarged, a few are often haemorrhagic, congestion of the organs is often seen.

Monkeys

A *Cercopithecus callitrichus*, a *Macacus rhesus*, a *Jew monkey*, and a baboon, *Cynocephalus sphinx*, have all been successfully inoculated with the disease. The incubation in the *Calothrix* was four days, the duration lasting over one hundred and sixty days. The *Jew* monkey developed the disease on the sixth day, and died seventy-five days after inoculation. In both these animals the parasites were never present in very large numbers until a few days before death. The *Calothrix* showed more parasites and exhibited more symptoms than did the *Jew* monkey. Anaemia, loss of weight, and irregular temperature were noted in both these cases. A baboon, *Cynocephalus sphinx*, ♀, was inoculated intraperitoneally with a large quantity of virulent blood from a dog which had died from the disease on February 22, 1904. On April 18 a rise of temperature was noted, but no parasites could be found. On May 12 eight parasites were found. Unfortunately a daily examination of the blood could not be made, therefore no definite incubation period can be given. From that time the animal rarely showed parasites in the blood until July 4, when they were nearly always present, though in small numbers, up to its death on September 13. The temperature was irregular. Loss of weight was very marked, especially when the parasites were first seen. Anaemia was not a prominent feature of the disease. A *Rhesus* inoculated with some of the baboon's blood developed the disease on the seventh day. Parasites were hardly ever seen, and it finally died from dysentery. A rabbit inoculated intravenously developed the disease after an incubation of eleven days, it is still living, and appears to have recovered from the disease. Two guinea-pigs inoculated at the same time became infected, but never severely, and died from an epidemic of broncho-pneumonia. The serum of this baboon was slightly more agglutinative to the parasite than ordinary baboon serum. Its serum was not protective.

Post-mortem.—The autopsy of the *Calothrix* showed an enlarged firm spleen, glandular enlargement was general, but not very marked. The baboon showed a slightly enlarged spleen and a little enlargement of the glands. The microscopical examination of the brains and organs is referred to by Dr. Breinl.

Cats

Four cats and two kittens have been inoculated. The disease in the adult cat is of a chronic nature. The incubation, after intraperitoneal inoculation, is from twelve to fourteen days. The duration of the disease in three of the animals was nine to ten months, one slightly smaller cat died at the end of forty-six days. The disease pursues a chronic course, the parasites are present only in small numbers, and often are absent for intervals of two to eleven days. The incubation period and the rise of temperature occur together (in one cat, 105·2° F.), after that the temperature falls somewhat but is exceedingly irregular ; after some time the temperature, though remaining irregular, does not rise so high as it did at first. Before death a fall in temperature to subnormal is usual. Loss of weight occurs but the weight is very often regained temporarily ; a month or so before death the loss of flesh is more marked. Anaemia is present but not very marked or progressive. A discharge from the eyes may occur, and in one case oedema around the vulva was noted. The coat is roughened. Two cats which became pregnant after infection aborted. The foeti were examined but no parasites could be found. Small rats inoculated with blood from them never became infected.

A kitten became infected at the end of seven-and-a-half days and died in twenty-three days, the parasites were more constantly present and in greater numbers. Anaemia and loss of weight were marked. Discharge from the eyes and nose was noted. A seeming partial paralysis[1] of the posterior limbs was remarked four days before death. The temperature rose on the appearance of the parasites and remained high but irregular until death.

Post-mortem.—The spleen in the acute form is enlarged. In the chronic form it is only about one-and-a-half times enlarged. The glands are not very big, some few may be haemorrhagic, all contain much juice.

Dogs

Many dogs and puppies have been used. The average incubation after intraperitoneal inoculation is four to eight days, death has taken place in ten to nineteen days. For puppies the incubation is about the same, but the duration appears somewhat prolonged—nine to twenty-six days. The parasites are continuously present in the peripheral blood and increase in numbers, to diminish for a few days. They then begin to augment and usually continue to do so up to or just before death. Loss of weight and anaemia are prominent features. The temperature, after an initial rise, becomes irregular or sometimes continuous ; before death it is usually subnormal.

Dutton and Todd[2] brought back an adult bitch, Experiment No. 11, inoculated October 16, 1902, from Horse I, and infected six days later. This animal, August 31, 1903, was well and strong, its blood non-infective. It is still living, no parasites are

1. While the paralysis is noted no importance is attached to it as young infected animals of all species exhibit such a symptom.

2. Liverpool School of Tropical Medicine, Memoir XI

seen, its blood in amounts of 2·0 to 3·0 c.c. is non-infective. While in England it has been bred and its pups used to see if they were less susceptible than other pups to trypanosome infection. The results show that they acquire the disease quite as easily as other ones, and succumb in the usual time. The serum from the bitch has no protective properties.

Post-mortem.—The spleen is often two to three times larger than normal, the substance is dark and friable, sometimes it may be almost deliquescent. The glands are enlarged, some may be haemorrhagic. Peritoneal exudate is scanty, the pericardium may contain a great deal of fluid. The exudates usually contain a fair number of trypanosomes.

Sheep

A ram was inoculated intraperitoneally. On the sixteenth day the temperature rose slightly and at the same time parasites were seen in the blood. Ten days later ten to forty trypanosomes to a field were noted. These continued in large numbers for the next seven days. The numbers then fell and remained scanty, though continuously present, to death, which took place eighty-four days after inoculation. The anaemia was constant and the animal rapidly became thin. Appetite continued good. No other symptoms were noted. The animal suddenly died during the night. As it was in the height of summer decomposition commenced quickly. The spleen was small, the glands were not markedly enlarged. No oedema or petechial haemorrhages could be found.

Goats

Goat, Experiment 35, inoculated by Dutton and Todd from Horse I, November 28, 1902, remained infected up to March 20, 1903, it was then sent to England. In August, 1903, its blood was negative to microscopical examination, and non-infective even when injected in amounts of 2·0 to 3·0 c.c. It was reinoculated in October and became infected. The temperature rose and remained irregular. Death occurred after inoculation. The parasites were always very scanty until just before death. The autopsy disclosed enlarged spleen and glands, some few of the latter being haemorrhagic. Anaemia was noted a few days before death.

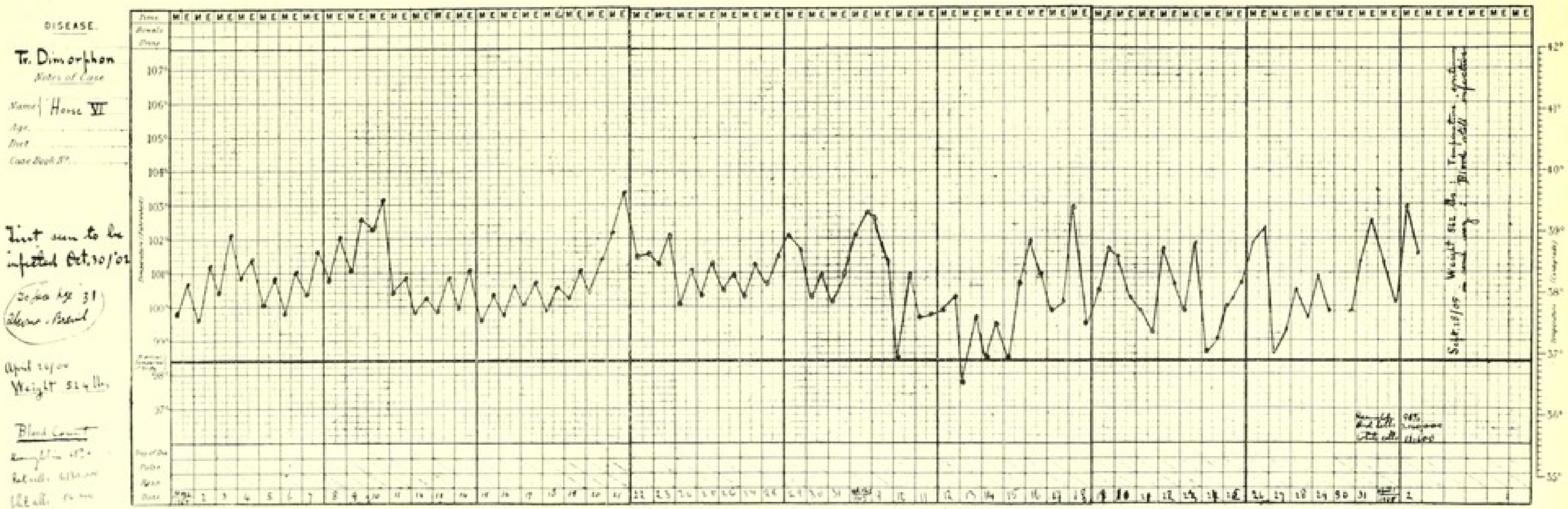
Goat 10, inoculated by Dutton and Todd, October 15, 1902. Appeared to have apparently recovered in October, 1903; in March, 1904, it was killed by accident while being bled. A guinea-pig, inoculated with 100 c.c. of pure heart blood, became infected after a prolonged incubation. The serum from these goats did not cause any permanent agglutination.

Horse

The stallion,[1] naturally infected in the Gambia and sent back by Dutton and Todd, has been under almost continuous observation from October 30, 1902. Since August, 1903, it has been bled at regular intervals, and its blood inoculated into

1. *First Report of the Expedition to Senegambia*, p. 31.

CHART V



to face p. 30

susceptible animals. After two years and five months it is still alive and apparently in good health. *Its blood is still infective to rats and mice*, but the amount necessary in order to secure an infection has had to be increased. Formerly a few drops of blood were required. At present 1·0 to 1·5 c.c. of pure blood is needed to infect a medium-sized rat; rabbits require 3·5 c.c. of blood. The blood still preserves the characteristic agglutination of the corpuscles. Very occasionally a trypanosome has been found after long continued examination. The temperature has lost the markedly irregular type which characterises the disease. The animal has put on weight and has become accustomed to the change of climate. No symptoms of oedema, etc., have been noted. Blood counts:—April 8, 1905, reds, 7,160,000; whites, 17,600; haemoglobin, ninety per cent. Its blood no longer causes any more agglutination than does normal horse serum; the protective properties are nil. The urine is normal.

From the above records it will be seen that observations on the disease are in accordance with the findings of Dutton and Todd and Laveran and Mesnil. The disease in horses can become chronic and the animal may live for some time, probably a cure will result in such a case as the above. From Goat 10 and Horse 6 cases it is evident that animals in which the disease is markedly chronic for some time, will hardly show any evidences of infection. The blood, in amounts of even 1·0 to 1·5 c.c., is non-infective, and when inoculated in larger amounts, 3·0 to 10 c.c., the incubation period is prolonged.

It is not our intention to enter into a detailed description of the parasite as the morphological characteristics have been well pictured and described by Dutton and Todd, Laveran and Mesnil. The parasites have been examined in both fresh and stained specimens from the blood of all the species of animals used in the investigation. In no instance has the long form, described by Dutton and Todd and possessing a long thin body and a long flagellum, been seen; in this we are in accord with Laveran and Mesnil. The long form is known to have been seen in the blood of animals, but it disappeared early in September, 1903, when the research work in Liverpool was begun. From a study of the films the forms described by Dutton and Todd (Pl. I, Fig. VII, VIII), and Laveran and Mesnil (Fig. XX), are those seen by us. Granules have been seen in many specimens, but not so numerous as in other species of trypanosomes. The agglutination of *T. dimorphon* is a very noticeable feature. As pointed out by Laveran and Mesnil it is especially remarkable in the blood of rats and mice shortly before death, it is also well seen in rabbits and guinea-pigs under the same conditions. In making agglutination experiments with serum, etc., it is therefore necessary to avoid such blood.

IV. *TRYPANOSOMA EQUIPERDUM.* DOURINE—MALADIE DE COIT

This disease has been under observation for some time. Two rabbits which had been inoculated from a dog were received. One rabbit was killed, and the whole of its blood used to inoculate a pup and a rabbit. The pup showed parasites in its blood on the eleventh day, and death occurred on the forty-ninth day, many parasites were found in its blood and in the peritoneal and pericardial exudates. Since that time the strain has been kept running through young puppies and rabbits.

Eight puppies have been used. The incubation period has been from four-and-a-half to eleven days, the average being six-and-three-quarters to seven days. The duration of the disease is from twenty-two to sixty-four days, the average period being from five to six weeks. At first it is extremely hard to find trypanosomes in the blood, but after the third week they quickly increase in numbers, and continue to augment so that eight to ten to twenty-five or more to a field are present. Divisional forms at first are very few in number, but soon abound in the peripheral blood. Profound anaemia occurs coincidently with the increase of parasites. Loss of weight is a marked feature. A characteristic feature of this disease is the oedema of the posterior limbs ; an oedema around the genital organs, extending along the abdomen, is also often very marked, and lasts for a few days or remains till death. In some cases the only oedematous areas are about the site of inoculation. Petechial plaques with loss of hair over these areas have been noted in two cases. Purulent discharge from the eyes and nose very often occurs. There is usually a slight discharge from the genital organs. Nervous symptoms have been rarely seen. In only one pup has a partial but true paralysis of the posterior extremities been noted. This pup developed a halting gait, which steadily became worse, due to an increasing paralysis of the right hind leg. The reflexes were lessened, and towards the end almost completely absent. The autopsy on this pup revealed nothing special, its cord and brain have not been microscopically examined.

One adult dog developed the disease in thirteen days. For a period of three weeks the oedematous condition around the genitals was very marked, the sheath being particularly affected. In addition, small unconnected oedematous areas were present on the inside of the thighs. These oedematous patches contained fluid, in which were very many trypanosomes. The dog lost flesh and became very anaemic, but recovered after two-and-a-half months. Four months later it was killed, and a pup inoculated from its blood developed the disease.

Rabbits

Rabbits inoculated subcutaneously develop the disease in six to eleven days and die in twenty-four to one hundred and eight days, some have lived over six months. The parasites are very scanty during the whole course of the disease. Oedema of the ears and genital organs, very often persisting and increasing, is marked. Loss of hair has been noted on one or two occasions, usually at the base of the ears and around the eyes and nose. The genital organs are swollen, the urethra or vaginal mucous membrane is pinkish and covered with catarrhal exudate. The discharge is often pronounced. The discharges from the eyes and nose are not so marked as in rabbits infected with the parasites of Nagana or Caderas. Examination of these discharges always proved negative.

Rats

Twenty-three rats have been inoculated with large numbers of the parasite ; in only two have parasites been found after the fourth day. One died on the eleventh day, the other on the eighteenth. In neither case could the autopsy be done early, and therefore the negative finding is not to be considered. The spleen and glands were small. A rabbit inoculated with the blood and extract of mashed organs of one of these rats never developed the disease.

Cats

One adult female cat was inoculated at the same time as a pup ; on the ninth day the temperature rose but no parasites could be found. The experiment proved negative.

Guinea-Pigs

Four have been inoculated with negative results.

Goat

A goat inoculated subcutaneously with ten c.c. of heart blood and twenty c.c. of peritoneal exudate never developed the disease. Its temperature remained normal, and its blood negative ; a pup inoculated from it never became infected.

Post-Mortem Appearances

The autopsies on the pups showed a moderately enlarged spleen and enlarged glands, some few of which were haemorrhagic, these being found usually in the retro-peritoneal, inguinal, and axillary groups. The blood was very serous and pale, and usually contained numerous parasites. The bone marrow was pale and often very soft. The pericardial sac contained some slightly clouded fluid. The peritoneal cavity usually contained a large quantity of clear watery or straw-coloured fluid.

These fluids contained trypanosomes often in large numbers. The oedematous patches of tissue contained trypanosomes, often present in greater numbers than in the blood. Petechial patches, the size of a pin's head, were found on the pleural surface of the lungs. The brain and cord did not show any marked macroscopic changes, very often there was considerable oedema around the lumbar region of the cord. The cornea was sometimes opaque.

The autopsies on the dog and rabbits and cat showed no special features. An account of the histo-pathology of the nerve tissues and organs will be found in Part II. Divisional forms of the parasites have been found in all exudate fluid, exudates and juices from the organs. If the autopsy is done immediately after death large numbers of remarkably fine divisional forms will be found in the exudates. These forms rapidly lose their contour if the animal has been dead some hours.

TRYPANOSOMA EQUINUM. MAL DE CADERAS[1]

A large number of animals have been inoculated with this parasite.

Rats—White, Black, and Grey

Rats are easily infected. Subcutaneous inoculation causes the parasites to appear in two-and-three-quarters to three-and-a-quarter days. Intraperitoneal, two to two-and-a-half days. The average duration is six to eight days. In some few cases parasites have been found in the tail-blood in thirty-six hours, the blood is infective at this time.

Mice—White and Grey

Mice are infected somewhat earlier than rats. The duration of the disease is slightly shorter.

In both rats and mice the incubation period and the duration of the disease is lengthened if the inoculated fluid is poor in trypanosomes. Sometimes one notes a temporary lessening in the number of the parasites, this usually lasts for one to three days, sometimes longer. The parasites then increase and usually continue to do so until death. Rats and mice inoculated with blood from animals undergoing treatment with arsenic, especially when the treatment has only been in force for a short period, develop the disease after a prolonged incubation. The parasites may appear for a few days and then disappear to remain absent or once more reappear, such animals are not protected. Loss of weight is noted both in rats and mice when showing marked infection. In some of the rats inoculated with the attenuated parasite the loss has been less marked and of only temporary duration.

Rabbits

The average incubation period has been four to five, sometimes six days. The duration has been sixteen to fifty-nine days. In a few of these animals the parasites have been fairly numerous in the peripheral blood, as many as ten to fifteen to a field being recorded. The majority of the infected rabbits duly show the parasites in very scanty numbers. The parasites are usually found in the blood when the temperature rises. Cases are recorded with a preliminary rise on the fourth to fifth day to 106° to 107° F. The fever is irregular, usually not passing 104° F. A few days before death the rise of temperature may be very marked, death occurring usually with a fall in the temperature. Loss of flesh and a somewhat marked anaemia is noted ; this latter symptom is not so marked as in rabbits inoculated with *T. dimorphon* or *T. gambiense.* Oedema at the base of the ears and around the genitals is often marked. Loss of hair around the eyes, nose, and base of ears is usually pronounced.

1. We have been able to study this parasite through the courtesy of Professor Laveran.

The testicles are generally swollen, there usually is a discharge from the penis or vulva. The discharge from the eyes and nose is very severe, causing the animal to present a very miserable state. It has been noted that in treated animals the discharge and oedema quickly disappear, and the hair begins to grow over the bald patches.

Guinea-Pigs

Subcutaneous inoculation causes the parasites to appear in eight to ten days. Intraperitoneal injection takes six to eight-and-a-half days. The duration of the disease may be from twenty-two to one hundred and fifty-three days, the average period being seventy-five to ninety days for adults, and thirty to forty-six days for young guinea-pigs (three hundred grammes). The majority of the animals have shown parasites in their blood almost constantly ; occasionally the organisms nearly completely disappear. This is especially so after a marked increase in numbers. Small guinea-pigs usually harbour large numbers of trypanosomes in their blood. The appearance of the parasites in the peripheral blood is coincident with a slight rise of temperature. The fever then becomes irregular, but not more so than is met with in guinea-pigs infected with Surra, Nagana, etc. Loss of flesh is noted, but is more gradual than in rabbits. Paralysis is rarely observed. Three guinea-pigs showed partial paralysis of the hind extremities, six, three, and one day before death. No guinea-pigs out of forty-three infected and not treated have survived the disease.

Cats

Kittens are more susceptible than adults. The incubation is six-and-a-half to eight days, and death occurs in about thirty to fifty-six days. Adults develop the disease in seven to nine to eleven days, and may die in two-and-a-half to six months. The appearance of the parasites in the general circulation is associated with a rise of temperature. The chart of an infected animal showed an irregular rise and fall with sharp rises to 104° to 105° F. With kittens the temperature usually remains high. The adults rarely show the parasites in their blood, but the agglutination of the corpuscles is often very pronounced. Kittens usually have the parasites almost continuously in the peripheral circulation. The parasites usually are found in the blood at the time of the sharp rises of temperature. Oedema is rarely observed. Discharges from the eyes, nose, and genitals are rare. The autopsy shows a certain enlargement of the spleen. The glands are somewhat swollen. Haemorrhagic glands are rarely seen. In the kitten the gland juice frequently contains many parasites.

TRYPANOSOMA EVANSI. SURRA

This strain was also given by Professor LAVERAN, its origin is from one of the infected animals in the epidemic which ravaged the island of Mauritius.

A guinea-pig showing a severe infection was received, from it a series of animals have been inoculated.

RATS—WHITE, BLACK, AND GREY

These animals are as susceptible to Surra as to Nagana. The incubation after subcutaneous inoculation has been three to four-and-a-half days, after intraperitoneal injection two-and-three-quarters to three-and-a-half days. The average duration is about five to seven days after the appearance of the parasites in the peripheral blood.

MICE—WHITE AND GREY

The incubation after subcutaneous inoculation is about three-and-three-quarters to four days, after intraperitoneal inoculation about three days, duration six to eight days after the infection declares itself. In both rats and mice the parasites usually continue to regularly augment, so that as death approaches large numbers of parasites are found in the peripheral blood. Careful observation has shown that occasionally a decrease in the number of the parasites present in the tail blood is to be noted, it is, however, only transitory, as the numbers quickly increase, so that at death the blood will swarm with the organisms. In rats and mice inoculated with attenuated trypanosomes or with the blood of less susceptible animals, the parasites being fewer in number, the incubation period is lengthened, and the course of the disease prolonged. As in Caderas and the other trypanosomic diseases rats and mice inoculated with blood from animals undergoing treatment, especially where the parasites are still present, though in very scanty numbers and degenerated, may only show a few parasites in the blood. In such cases the parasites are so attenuated that they do not increase rapidly, and the animal acquires a chronic form of the disease. These animals frequently recover, but they are not immune.

RABBITS

The incubation period varies. After intravenous inoculation the parasites appear in three-and-a-half to five-and-a-half days. The presence of the parasites in the peripheral blood is usually accompanied by a slight rise of temperature. Sometimes the rise is marked, being 106° to 107° F., such a high temperature is usually associated with a severe infection. The fever may be marked and of an irregular type, or there may be hardly any noticeable rise during the course of the disease. The temperature may sharply rise, this is usually in conjunction with an increase in the number of the parasites. The parasites may be noticeably scanty, or they may, as we observed in a few cases, be present in large numbers—ten to forty to a field. Death is usually preceded by a fall in temperature, sometimes the parasites are almost absent before death, at other times they are largely increased in numbers.

The symptoms so often associated with Nagana and Caderas are seen in rabbits infected with the Surra parasites. The oedema of the ears, perineum, the swollen testicles, the tumified vulva, the discharge from the penis, eyes, and nose ; all these are present to a greater or less extent. Anaemia is present but not markedly so. Loss of weight is a constant feature of the disease. Young rabbits are easier to infect than adult ones. The duration is lessened, the parasites are generally more numerous.

Guinea-Pigs

Incubation is six to eight days. Duration, forty days to two to four months. The parasites at first are present in scanty numbers, later in the disease they increase. Sometimes they may almost disappear from the blood and remain so for some time to augment once more. The rise of temperature is usually associated with the appearance of the parasites, the temperature is never very high. Anaemia is not a prominent feature. Loss of weight occurs, being especially marked when large numbers of trypanosomes are present in the blood for some time. Oedema has been noted on a few occasions. No animal has recovered without treatment.

Cats

After intraperitoneal inoculation infection takes place in eight to twelve days. The infection is usually long continued, the parasites are scanty in the blood. The chronic form of the disease in this animal may last six-and-a-half to eight months. There is a certain amount of anaemia associated with a slight loss in flesh ; towards the end these symptoms become more pronounced. A discharge from the eyes and nose has been observed. One cat showed quite a pronounced oedema of the perineum. The disease in kittens manifests a severer form, the parasites are usually numerous, and the duration of the disease may be only four to six weeks. The autopsy shows in these chronic cases very little of interest. The organs appear very little changed. The peritoneal and pericardial exudates, if any, are scanty and usually no trypanosomes can be found. Kittens show an enlargement of the spleen and glands, their blood and peritoneal and other exudates usually contain parasites.

Dogs

Several animals have been inoculated. In all cases after subcutaneous injection the parasites have been found in the peripheral blood in seven to nine days. At first the parasites are scanty. After a few days marked exacerbations, persisting for a few days, occur ; or the parasite may be scanty until only four to six days before death. The end can occur in sixteen to thirty days, depending on the virulency of the parasite and the method of inoculation. The animal at first presents very few symptoms, but when once the parasites are increasing rapidly a very decided and rapid anaemia, together with emaciation, occurs. The animal continues to lose strength, death is usually preceded by a subnormal temperature. The usual *post-mortem* lesions met with in dogs dying from acute trypanosomic disease are met with.

V. BACTERIOLOGICAL EXAMINATIONS, MORPHOLOGY, GLAND PUNCTURES, AND BLISTERS

Bacteriological Examinations

Cultures of the blood and cerebro-spinal fluid were made from two of the fatal cases of sleeping sickness and several times from 'Native Fever' cases.

The blood was obtained from one of the arm veins by means of a Roux Syringe —the cerebro-spinal fluid through lumbar puncture. The media used consisted of broth, agar and gelatine of various alkaline or acid reactions. Sugars or peptone, salt, etc., were contained in some media, in greater or less proportions, and were absent from others. Large Ehrlenmeyer flasks containing fifty to two hundred c.c. of nutrient media were inoculated with some of the blood or cerebro-spinal fluid. Anaerobic and aerobic methods of cultivation were employed. The inoculated media were incubated at 18°, 23°, and 35° C.

From Kitambo. Cerebro-spinal fluid, one flask and two tubes showed small growths of *Staphylococcus epidermidis albus*. These were the first cultures inoculated.

From Tomi. All cultures remained sterile. All cultures were kept under observation for two months.

From some of the animals infected with the cerebro-spinal fluid of the two sleeping sickness cases cultures were made at death, the results were negative.

At the *post-mortem* on the two sleeping sickness cases, cultures were made. The blood and cerebro-spinal fluid cultures remained negative. The spleen and liver showed in Kitambo *B. coli communis* and putrefactive bacteria.

From Tomi. No growth.

Variations in the Morphology of the Parasites

From a comparison of stained preparations of *T. gambiense* made during the course of the disease no differences can be made out. The parasites in the sub-inoculated animals seemed somewhat larger. This seemed to be the case with many trypanosomes.

The parasites in the three cases of Trypanosome Fever compared with those found in the blood of the two sleeping sickness cases show no determinable differences. The organisms found in the cerebro-spinal fluid of one case showed a more vacuolic condition, the parasites appeared slightly more rounded at the posterior end. None of the amoeboid forms described by Castellani were seen. The trypanosomes in the blood of the same case did not show the vacuoles so markedly. The observance of many slides of blood, which is often very serous, and of exudates, causes one not to rely on the presence of vacuoles. They often appear to be present in trypanosomes living under unfavourable conditions. In animals treated with arsenic, vacuolic forms can be seen. If non-vacuolated trypanosomes be injected into the peritoneal cavity of a guinea-pig and some of the fluid withdrawn after a few hours, many trypanosomes containing large vacuoles can often be seen. This is especially so with *T. gambiense*. The vacuoles seem more accentuated in stained films than in the fresh specimens. As LAVERAN points out this is especially observed in slides made from the cerebro-spinal fluid or from very serous blood. Films from such fluids take longer to dry even if the slide be warmed to blood temperature beforehand.

If in a heavily-infected animal the parasites seen in its peripheral blood be compared with those met with in the organs, bone marrow, and large vessels, no differences can be made out. A series of animals were killed and the numbers of parasites present in the organ juices, heart, and large blood vessels compared with the peripheral parasites. In all cases the peripheral blood contained more, the average number of parasites in the different organs were the same. The various groups of glands did not contain more. On comparing the numbers found in the organs of animals which had died from the disease, at from one to twelve hours after death, the results have varied. If the blood be very serous more parasites will be found there than in the organ juices. Sometimes the bone marrow or one organ will contain more than the others. The brain and cord contain fewer than do the organs.

GLAND PUNCTURE—PARASITES IN THE GLANDS

A study of the number of the parasites in the glands as compared with those met with in the blood have not confirmed GREIG and GRAY'S observations. From one native superficial glands were removed. Twice were glands taken at a period when the blood was negative to ordinary examination, and once when the blood contained a fair number of parasites. After excision the glands were immediately dried, the surface cauterized, and the gland juice withdrawn. When the blood was negative the glands did not show any parasites ; on the occasion when parasites were observable in the peripheral blood the gland juice contained a less number of trypanosomes. Gland juice was also removed by puncture with the same results. Similar findings are to be recorded with glands excised from or punctured in animals infected with the disease. Unfortunately, monkeys, rabbits, guinea-pigs, and rats do not usually have very enlarged glands, but in the other animals no better results can be shown. Gland puncture of two donkeys infected with *T. gambiense* and with very few parasites in their blood have not proved of use in the routine examination of the animals, though the glands were enlarged and easily palpable. DUTTON and TODD have made use of gland puncture with very satisfactory results.

Glands were removed from lightly infected animals—strains, *T. gambiense*, *T. dimorphon*, *T. evansi*[1]—showing parasites in only scanty numbers in the blood. The glands were immediately mashed up with citrate solution and the extract injected into the peripheral cavity of susceptible animals. Eleven experiments were done. In nine the animals were infected only after a prolonged incubation ; in two cases the animals never showed parasites. Controls inoculated with blood and citrate became infected in a shorter time.

Occurrence of Parasites in Blisters

One of the experimental animals having a blister the exudate from the small bleb was noticed to contain a few trypanosomes. By means of cantharides plasters small blisters were made, and the serum was examined from two of the natives and some of the animals. The results were not encouraging. On occasions when the blood was negative the fluid from the blisters was also negative, and on days when the blood was positive only a very small number were seen in the exudate. Sufficient exudate was collected and mice inoculated. After an incubation period of twenty-one days in two out of four mice inoculated intraperitoneally with 0·5 and 1·0 c.c. parasites were seen in small numbers.

Diagnostic Methods

Much attention has been directed to find some method of diagnosis in cases where the blood and gland-juice examinations fail to show parasites; in cases of failure, and when the centrifuged blood is also negative, resource must be had to inoculation. Dutton and Todd record a certain number of their inoculated rats failing to show signs of infection, even when inoculated with blood verified to contain motile parasites. All the rats inoculated from the natives have shown parasites in their blood, yet in some cases the incubation period has been prolonged to thirty-two days. Rats are in many ways unsatisfactory, as the parasites may be present in only very small numbers. Inoculation of larger animals, rabbits, guinea-pigs, and cats are also open to the same objection. Monkeys are most suitable, since they are easily infected ; then come young pups, kittens, rabbits, and adult dogs. Advantage was taken of the periods when the trypanosomes were absent from the peripheral blood of the natives. If after several days the blood still remained negative, small quantities of blood, ten to thirty c.c., were withdrawn from one of the superficial veins and, combined with citrate solution, the mixture was

1. While experimenting with *T. brucei* in Professor Kitt's laboratory, Veterinary School, Munich, and at McGill University, a series of animals were inoculated with extracts from the mashed up organs, glands, bone marrow, etc., of infected animals. Infection quickest with blood mixture, then bone marrow, spleen and liver, kidneys and adrenals, glands, brain, cord. A repetition of the above with *T. gambiense* and other trypanosomes has given almost the same results. Pieces of organs removed aseptically and inserted whole under the skin or in the peritoneal cavity of rats and guinea-pigs have infected the animals after a more or less prolonged incubation period. Pieces of organs left under the skin or in the peritoneal cavity for some hours and then taken out and examined showed trypanosomes more degenerated and in less numbers than in control pieces examined. Celloidin sacs filled with blood containing parasites and placed in the peritoneal cavities of rats and pigs for a time show the usual degenerating, deformed trypanosomes.

inoculated into the animals. These animals became infected, though the incubation period was lengthened. After the appearance of the parasites the disease ran its natural course, and the animal succumbed to the infection in almost the same time as others which had been inoculated with blood in which the organisms were seen.

Monkeys of 1·5 to 2·5 kilo. weight inoculated intraperitoneally with 5·0 to 8·0 c.c. of apparently negative blood always became infected. Kittens can receive two c.c., pups, two to four c.c. of blood intraperitoneally without untoward symptoms developing, and show parasites usually in nine to fourteen days. The kitten and pup are especially useful for studying the disease as they quickly show the parasites in large numbers, and periodicity, particularly in kittens, is not a marked feature. Dogs are also useful, but the number of parasites observed may for a considerable period be small, and the possibility of the unskilled observer passing them by is enhanced.

The Cultivation of Trypanosomes

Novy and McNeal in a series of papers emanating from Professor Novy's laboratory, have shewn that it is possible to cultivate some of the trypanosomes infecting animals, *T. lewisi*, *T. brucei*, *T. evansi*, and a numerous series in birds. We have been able to cultivate *T. lewisi* and *T. brucei* on the media proposed by these investigators. Our attention has, however, been directed more to the artificial cultivation of *T. gambiense*, *T. dimorphon*, and the other pathogenic trypanosomes. If the results must conform to Koch's postulates, then we must admit we have failed. Various strains of *T. gambiense* are capable of being cultivated in a modified blood agar medium and kept alive for sixty-eight days by transference from tube to tube or through flasks ; after the seventeenth day of cultivation we found it no longer capable of infecting a susceptible animal, no matter what amount of culture was used. The trypanosome loses its form to a great extent, its staining reaction is altered and it finally dies. Numerous trials have been made with various changes in the composition of the media but without success. Guided however by the history of the numerous failures of Novy and McNeal before their efforts were rewarded, we believe that our successors will be able to cultivate these parasites with greater success than we have had. That the task is a difficult one is evidenced by the fact that of the many trypanosome investigators only one in addition to those working in Novy's laboratory has been been able to publish a successful result, and this only a repetition of a former investigator's work.

A synopsis of our attempts is included here in the hopes that they will act as a spur to the investigation of this most important subject. As the result of our experience, we feel that the undivided attention of the research worker is necessary to secure success.

After cultivating *T. lewisi*, attention was paid to *T. brucei*, using blood agar in the proportion 2 : 2 and 2 : 1 ; the third attempt proved successful. This culture was run through five generations before it died out from the effects of contamination. Efforts were then directed to *T. equiperdum*, *T. equinum*, and *T. evansi*. The culture of *T. equiperdum* was difficult, as the parasites were not present in large numbers, but at the fifth attempt two tubes out of nineteen inoculated with blood and exudate fluid from a pup, showed motile trypanosomes on the eleventh day. One tube was infected with heart blood, the other with oedema fluid obtained from the subcutaneous tissue of the thigh. The heart blood tube showed evidences of growth and the formation of reduplication forms, but only one in thirty fields, while at the time of inoculation large numbers of these forms were seen. The oedema fluid on the seventeenth day showed many divisional forms undergoing division. These forms were agglomerated together into clumps, not rosettes, as after the manner of *T. lewisi* in culture ; many single well-preserved forms were seen, but the motility of all was much lessened. Many deformed and motionless, granular, degenerated trypanosomes were seen. At this time a pup used for keeping the strain running in the laboratory died. Resource had therefore to be made to the cultures. The total contents were taken and injected into the peritoneal cavity of a puppy. On the eleventh day after the inoculation a slight rise of temperature was noticed, but no parasites could be found. Nineteen days later, *i.e.*, thirty days from date of inoculation, no parasites having been seen it was killed and the whole of its blood inoculated into another pup. This pup after a prolonged incubation became infected. The medium used in this instance was chicken-broth, in the proportion of meat one to water two with 0·5 per cent. peptone and 0·25 per cent. sea-salt added, and rendered faintly alkaline, agar 2·5 per cent., and defibrinated rabbit blood 2 : 1.

T. equinum.—Many failures with this parasite have to be recorded. Cultures were made on various strengths of beef-broth agar, with different proportions of blood, peptone, etc., with no result. Rats, mice, rabbits, and guinea-pigs were used, the animals being killed at all stages of the disease. The trypanosomes quickly died off. One effort yielded a positive result on a chicken-broth agar tube of similar composition to that used for the *T. equiperdum* culture. It was one tube out of twelve inoculated from a rabbit, which had died about three-and-a-half hours before the inoculation of the cultures. The trypanosomes were in the average about one to eighteen fields. The tubes examined showed no growth, after the twelfth day only dead parasites were found. These tubes were left in the incubator at 22° C., and were not examined till the twenty-ninth day, when the majority were found to be overgrown with mould. One was not and it contained a few trypanosomes, many of them being paired, looking apparently healthy with fair motility. A few transplants were made into fresh blood agar tubes, and the rest of the culture was used to inoculate a rat, which became infected after an incubation of eight-and-a-quarter days. The transplants never grew. Further efforts failed to produce cultures.

T. evansi.—Here, as with the other trypanosomes, numerous cultures from the blood of different animals have been made from time to time. Seven tubes at 22° C. showed growth up to the nineteenth and twenty-second days, but these were contaminated with bacteria. One tube showed a growth on the twenty-ninth, another on the thirty-third, still another on the thirty-seventh day. These three latter were all room temperature cultures, the efforts to transplant the twenty-ninth and thirty-seventh day cultures proved failures, nor did the original tubes show any more growth when placed in the 22° C. oven, all the trypanosomes quickly dying off. The thirty-third day tube was used for inoculating a rat and a guinea-pig without success ; the few remaining drops were used for sub-cultures, but no growth resulted from them. The trypanosomes in these three tubes, especially that of the thirty-third day, resemble the description which Novy, McNeal, and Hare have given of their efforts to cultivate the Surra trypanosome of the Philippines. The parasites were few in number, were all single and actively motile, the majority showed dark granules at their posterior ends, and resembled the first two drawings of Fig. 1 and the lower of Fig. 2 (Novy, etc.) The flagella seemed longer and thinner than in the normal parasites obtained from an infected animal.

T. gambiense.—The difficulties attending the cultivation of this organism are many. The parasite does not as a rule appear in great numbers in the blood. If an animal is infected with the parasites of Nagana, Surra, etc., once they appear they will augment from day to day until the blood fairly swarms. With *T. gambiense*, on the other hand, rats rarely show very large numbers in their blood, and periodicity being a feature of this disease, the parasites present one day will be found to be absent the next day. This feature is constant in all the animals inoculated. Monkeys, pups, and kittens, however, usually have more parasites in their blood than do the other animals. Advantage as far as possible has been taken of this fact. With the ordinary blood-agar medium no growth takes place, and the trypanosomes die off at once. Veal and chicken-meat infusion has been found to be more suitable than beef infusion. One to 1·5 per cent. peptone with 0·25 to 0·5 per cent. sea-salt is added and agar from 2·5 to 3·5 per cent. Various animals have been used for bleeding—horse, goat, sheep, dog, and rabbit. Almost as satisfactory results have been obtained from the blood of the goat and sheep as from that of the rabbit. The blood has been used in various proportions—2 : 2, 2 : 1, 3 : 1—the most satisfactory proving 2 : 1 or 3 : 2.

The trypanosomes for the first few days appear to tolerate the media, but after the fourth to seventh days numerous degenerated and dead ones are seen. In cultures kept at 22° to 23° the tubes will at the fourteenth to sixteenth day either contain dead trypanosomes or a few partially motile ones. These motile ones may present the normal outline of the parasite, but granules are usually present in the anterior portion of the body. The macronucleus of these forms is often of a granular appearance, staining unevenly, and sometimes fissure-like breaks may occur. The flagellum is usually shorter, and it and the undulating membrane when stained appear thinner. The motility of some of the forms is accentuated, but usually the motion is markedly lessened. Many parasites are globular and show whitish areas, apparently vacuoles, in the body, and these sometimes encroach on the macronucleus. The motility of these forms is nearly always lessened. The trypanosomes usually occur singly or in two, three or four to a group, sometimes clumps of twenty to thirty will be found, the flagella facing outwards ; these clumps are not composed solely of parasites, but consist of a mixture of blood cells, fibrin, and trypanosomes. Rarely after the twenty-fifth day have normal looking organisms been seen, though at this time there may be found dead trypanosomes with perfectly formed outlines and flagella. If from the sixteenth day onwards attempts be made to transplant the motile trypanosomes into fresh media the majority of the tubes will be failures. A few, however, may survive, and in these, after a few days, the trypanosomes will appear to lengthen out and become still more normal looking. The motility is normal, but unfortunately no duplication forms will be seen. No evidences of actual growth occur, and usually by the twenty-fifth to fortieth day from the first generation the organisms will be found dead. Such cultures naturally do not infect animals even when the whole culture is used to infect one animal. On three occasions tubes which on the twelfth to seventeenth days had looked hopeless, with the degenerating parasites increasing each day, have on the addition of fresh culture fluid from another tube appeared rejuvenated ; some of the parasites appearing to lose their dark granules and to become less stumpy. Twice the contents of such tubes have been poured into other tubes, and the parasites have continued motile up to the forty-third day. The parasites of a first generation tube which behaved in this manner were transplanted into another tube, and were alive, though badly degenerated, up to the fifty-sixth day. They were once more transplanted, but twelve days later were all dead. The original tube had contained motile trypanosomes up to the forty-seventh day.

Various strains of *T. gambiense* have been used. Some of the cultures were inoculated with blood in which the short flagellated and vacuolated form, though associated with the longer form of the parasite, predominated. It has been noticed later on in such cultures that sometimes more vacuolated short forms remained or *vice-versa*. This, though it may not be definite, goes to refute the idea which some investigators have put forward that the short vacuolated form is typical of the parasite found in sleeping sickness cases. With the very virulent strain 'E' some attempts have been made to cultivate the parasites. No living trypanosomes have been found after the nineteenth day. These cultures were non-infective for animals.

T. dimorphon.—A great deal of work has been done with this parasite. Tubes of culture media of the same proportions as in the experiments with *T. gambiense* have been used and the animals from which the inoculating material has been taken have included rats, mice, guinea-pigs, and rabbits. This parasite has naturally a stumpy form and possesses the peculiarity of a marked tendency to agglutinate in animals near death ; this is especially the case in moribund rats and mice. After inoculation of the culture tubes very little is noted for the first three to four days, and the parasites are usually gathered together in large clumps or several of them are agglutinated side by side or by their anterior ends. The motility is not altered, the form is normal and the parasite stains as usual. Cultivated in the room or at 22° C. changes occur after the fifth day, especially in the tubes incubated at 22° C. The parasites become slower and many show granules. Numerous globular and distorted forms are seen. About the seventh to eleventh days the majority are either motionless or dead. However some very acutely rounded or oval forms, pear-shaped and twice as broad and about half as long as the normal ones, are seen. These latter often recall the 'tadpole' shape, and they may become more rounded. Coincident with these changes larger forms appear, which to a certain extent resemble in size and shape cercomonads. The motility of both these forms is remarkable when compared to the ordinary motion of the parasite ; it is very striking to observe them as they whirl into a field and circle round, often lashing out and going to the side of or leaving the field. Their motion is however, usually circumscribed to the one field. Such forms when stained show a badly staining granular protoplasm, a very small macronucleus and micronucleus. Usually the body of the rounded forms contains small chromatin bodies. The flagellum is thin and only faintly stained, the undulating membrane is hard to make out. In order to stain these forms, longer staining is necessary than with normal trypanosomes. If now, cultures containing these bodies be transplanted, very few of them will survive. Cultures containing these forms are non-infective to animals.

Cultures at 22° C. containing normal-looking trypanosomes have proved infective to animals as late as the twenty-third day, but only when injected in large amounts. By sub-inoculations of the cultures of the very active but degenerated forms, it may be possible to keep the parasites alive to the thirty-sixth day. A second generation tube which had been inoculated with a small piece of the surface of a blood agar flask which had been covered with clotted blood, showed two trypanosomes almost dead, but faintly moving on the seventy-sixth day. This tube was sub-inoculated from a 22° C. flask on the nineteenth day and left sealed up from the thirty-second day. No other parasites than these two could be found.

Summary

1. The parasite *T. equiperdum* in blood agar tubes is capable of infecting a pup up to the seventeenth day, when the tubes are kept at 22° C.

2. The parasite of *T. equinum* is capable of infecting a rat twenty days after the inoculation of the tube. There appears to be an actual growth taking place.

3. *T. evansi* in blood agar cultures at 22° C. is living, but non-infective up to the nineteenth to twenty-second day. Three tubes at room temperature contain motile but non-infective parasites on the twenty-first, thirty-third, thirty-seventh days.

4. *T. gambiense* of any strain is capable of living in a non-infective form in a first culture flask up to the thirty-fifth to fortieth days. Cultures in tubes and flasks, which on the twelfth to seventeenth days contained degenerating parasites, have by the addition of fresh culture fluid regained their vitality. Twice the contents of such tubes by transplanting to a fresh tube have lived to the forty-third day. One lived to the fifty-sixth day, and by a second transplant survived up to the sixty-eighth day.

5. *T. dimorphon* in culture tubes and flasks is infective to animals up to the twenty-third day, when infected in large amounts. Sub-inoculated but non-infective cultures remain alive as long as the fifty-sixth day. In one case, two trypanosomes showing motion were found on the seventy-sixth day.

6. In no case has any evidences of a toxine been noted in the inoculated animals.

VII. THE TREATMENT OF TRYPANOSOMIASIS

Experiments have been conducted under this head on all the various trypanosomic diseases described in the previous investigations, and include *T. brucei*, *T. evansi*, *T. equinum*, *T. equiperdum*, *T. dimorphon*, *T. gambiense* (various strains). In 1902-1903, while Governors Fellow of Pathology at McGill University, one of us (H. W. T.) made experiments with sodium arseniate, etc., on animals infected with *T. brucei* and *T. lewisi*. These tentative experiments have now been carried out on a large scale. As in the case of other workers we have tried a very large number of drugs to find them of no value in the treatment of infected animals. WENDELSTADT, LAVER and MESNIL, MUSGRAVE and CLEGG, all give long lists of drugs and chemicals used without avail. These we have retested, and have tried in addition sodium, potassium, and ammonium fluoride, fluorescene, chrysoidin, and various preparations of silver and mercury, especially the newer compounds. The results have coincided with the findings of other investigators. Up to March, 1904, the only drug of any value was arsenic; EHRLICH and SHIGA then published their results with a new dye named by them 'Trypanroth,' and these two preparations are the only ones found to be of value in the treatment of trypanosomiasis.

As animals have for a considerable period been known to be liable to infection with the various pathogenic trypanosomes, it was only natural to turn to the veterinary profession to see what drugs have in their hands proved of service in the treatment of these diseases. Of the countless drugs tried arsenic is the only one which has given encouraging results. Cases are on record where cures have been reported, but, on the other hand, many cases which have been treated by some form of arsenic and which have improved as long as the administration of the drug was kept up have shown parasites when it was discontinued and have succumbed to the infection. BRUCE records cases in which large doses of sodium arseniate were given, and so long as the treatment was continued parasites were hardly ever found in the blood, the animal retained its strength and weight and was able to work, but on the treatment being discontinued the parasites quickly reappeared and the animal began to fail. MOORE and CHICHESTER report the effect of the intravenous inoculation of cattle, after dosage the animals regained their weight, the yield of milk which had diminished became normal and the parasites disappeared, whilst animals which had not been treated quickly died. We have, therefore, evidence that arsenic is of use in prolonging the life of the animal. LAVERAN, in 1902, reported his results in treating rats infected with the Nagana parasites. The life of the animal was prolonged, the parasites disappeared, and the animal seemed to have recovered. When treatment was discontinued after a varying length of time the parasites reappeared, the disease pursued its normal course, and the majority of the animals died. Some few recovered, but the animals were not rendered immune, as LAVERAN proved by reinoculation.

He had, however, been able to keep infected rats alive for periods many times exceeding those of untreated animals. LAVERAN and MESNIL record very unfavourable toxic effects with the ordinary preparations of arsenic. At McGill and Liverpool, in our hands the experiments showed the same toxicity of the drug, the tendency to cause ulcers and extensive sloughing despite all asceptic precautions. The results obtained as to the prolongation of the animal's life was the same. On the arrival of natives suffering from Trypanosomiasis it was felt that some form of arsenic treatment was indicated. Subcutaneous inoculations of sodium arseniate caused so much pain that this form of medication was abandoned. BRODEN had reported the favourable results obtained by the administration of arsenic in the form of *Liquor Fowleri.* Resource was made to this form of the drug, but the surviving natives were sent back to the Congo before the effects of the different preparations could be determined.

Animals infected with the various pathogenic trypanosomes were subjected to treatment ; it was found that with sodium arseniate, the most useful form of arsenic, sloughing was prone to occur. In such a case the animal very often became so depleted by the ulceration that it succumbed to a secondary affection. Moreover, the use of arsenic in the form of sodium arseniate is all too apt to cause toxic effects. The administration of the preparation may be continued for some time, favourable results occur and then, unfortunately, toxic symptoms appear. If the drug be discontinued on account of the untoward symptoms the parasites very quickly make their reappearance and the animal dies. Moreover, despite medication being continued, the parasites which have disappeared will reappear and continue to be present and even augment. In such cases an increased amount of arsenic will not affect the termination of the disease. We have, therefore, to realise that the ordinary arsenic compounds when administered only produce a temporary, favourable effect, that, if long continued, the animals will die either from the parasite or from the arsenic or from both. Hence, some other compound is indicated. It is for this reason that the newer compounds of arsenic have been experimented with in order to find a preparation capable of being used over a long period and in high doses without producing toxic symptoms. Of the various preparations tried, a meta-arsenic anilin compound, atoxyl, has proved the most satisfactory, but it is not ideal. It is not non-toxic as dogs, kittens, guinea-pigs, and rabbits have shewn toxic symptoms and succumbed, but it is not so toxic as sodium arseniate. It does not produce the sloughing which so often follows the subcutaneous or intravenous inoculation of sodium arseniate, it causes no pain, and its administration can be continued over a period of many months even when used in extremely high doses.

It is the only remedy at present giving any prospects of a cure. In the treatment of cases a rational method of treatment must be adopted. It is useless, for instance, to only administer arsensic for a short period or until the parasites have apparently disappeared from the peripheral circulation. The drug must be administered in as high doses as possible, and it must be continued even after all the favourable signs are present, viz., disappearance of parasites from the blood ; increase of weight, improvement in the blood count and percentage of haemoglobin ; loss of the autoagglutination phenomenon of the blood corpuscles ; decrease in and more regular temperature. From time to time susceptible animals ought to be inoculated with large quantities of the patient's blood at least in amounts of 5·0 to 15·0 c.c. At the same time all aids in building up the physical condition of the individual should be used. If such a *régime* be carried out, and treatment be begun at an early period, the prognosis (based on the experience of treated animals) will be good.

With animals, on the other hand, the question whether treatment with arsenic is indicated calls for some consideration as LAVERAN and MESNIL, BRUCE, and others have pointed out that there is some danger of treated animals becoming a source of infection, by filling the position in these diseases occupied by the native in malaria. The arsenical treatment will cause a temporary disappearance of the parasites from the blood. Some animals may entirely recover, but the majority suffer a relapse, and these latter are then a source of infection for the surrounding country.

On the publication of EHRLICH and SHIGA's results in the treatment by trypanroth of rats infected with *T. equinum*, some of the dye was procured and a series of comparison experiments was made. The results coincide with the findings of the other workers. It is not a very safe drug. Ulceration is very apt to occur, the sloughing is often extensive and persistent. The tendency to cause nephritis is marked and hence its use, when continued, with arsenic is often apt to lead to fatal results, especially in guinea-pigs. High doses of the dye must be employed, and on account of its chemiotoxic properties intramuscular administration is the best method. Very often animals injected with large quantities of the dye appear to be in a stuporose condition which may wear off or persist up to death. Shortly after the injection of trypanroth the tissues commence to turn a bright red colour, and the secretions, urine, etc., are stained. The staining persists for a very long time ; the internal organs may show the staining of the dye for eight weeks or more after injection. We cannot claim to have cured any animal infected with the parasites of Surra, Nagana, Dourine ; the disease, especially in rats and mice, may be greatly prolonged, but the animals eventually die. Larger animals, especially dogs, cats, and monkeys, frequently show toxic symptoms with small doses. On the other hand, a bitch injected sub-cutaneously with fifteen to twenty c.c. of one per cent. trypanroth two and three times a week showed very little toxic symptoms besides a somnolent condition which lasted for about eight hours after each injection. The combination of trypanroth and arsenic has given better results both in the hands of Laveran and ourselves. The animals can live for a longer period; the administration need not be so often repeated. The drawback is that the kidneys quickly become affected. Animals infected with *T. dimorphon* do not seem to react well to arsenical treatment by itself; trypanroth medication only causes the parasites to temporarily disappear; the combination of arsenic and trypanroth causes the parasites to be absent for a longer period. Various methods have been tried. Administration of trypanroth and arsenic together, or the dye first, followed in twenty-four to thirty-six hours by arsenic or *vice versâ*. It is the latter treatment which has given most satisfaction in our hands. Laveran administers high doses of arsenic and follows twenty-four hours later with an intramuscular injection of trypanroth.

Arsenic has been tried in combination with the other dyes but without results.

Arsenic and human serum in the treatment of rats infected with Nagana and Surra have prolonged the life of the animals. A guinea-pig inoculated with *T. Brucei* did not seem to improve, the serum was given in amounts of ten c.c. once a week, but no more serum being obtainable the treatment had to be stopped, and at the end of three weeks the parasites then reappeared. Animals infected with *T. dimorphon* do not show as marked a reaction to serum treatment as do Nagana, Surra, etc.; the employment of arsenic and human serum does not appear to promise well. Human serum and arsenic combined has been tried on animals infected with *T. gambiense*; the control animals treated with arsenic alone showed as much, if not more, improvement as those with the combined treatment.

Arsenic and Baboon serum; very little serum was obtainable, three mice infected with *T. gambiense*, *T. dimorphon*, and *T. Brucei*, respectively, were used. The results were indefinite.

Other sera including horse, cow, sheep, goat, dog, cat, rabbit, and guinea-pig have been tried. The sera were produced from both healthy as well as from infected animals which had the disease in a chronic form or were apparently cured. The sera were used alone or in combination with arsenic, with disappointing results, for in no case could a definite and permanent decrease be ascribed to the action of the sera. Polyvirulent sera have also been tried without success.

Atoxyl Experiments

The trypanosomes and animals used for carrying out the investigation were as follows:—

T. gambiense, in monkeys, dogs, puppies, kittens, rabbits, guinea-pigs, rats, and mice.

T. Evansi, in horse, dogs, rabbits, guinea-pigs, rats, and mice.

T. Brucei, in cow, rabbits, guinea-pigs, rats, and mice.

T. equinum, in dogs, rabbits, guinea-pigs, rats, and mice.

T. equiperdum, in pups.

T. dimorphon, in dogs, pups, rabbits, guinea-pigs, rats, and mice.

The drug was used only upon animals showing the effects of the parasites, such as loss of weight, anaemia, fever, and autoagglutination of the corpuscles, and no animal was used until its blood contained numerous parasites. The numbers of the parasites present differed according to the species of animal and the disease. In the majority of the experiments control animals which were not treated and had been inoculated at the same time as the treated animals were used. In all cases the control animals died.

Intravenous inoculation was used only on rabbits, all other animals were injected subcutaneously. Treatment was continued for one to three months or until increase of weight, diminution of the anaemia and entire absence of parasites from the blood, as far as microscopical examination could determine, was noted. At various periods susceptible animals were inoculated with the blood from a treated animal. When treatment had been discontinued for one to three months or longer, the animal was bled or killed and all the blood available was used to inject susceptible animals. Inoculated animals whose blood has given negative results after three to six months or after longer periods have been inoculated with virulent blood and have taken the disease, thereby showing that no immunity was conferred by the previous inoculation.

T. gambiense.—Rabbit, ♂, weight, 2,010 grammes. Parasites appeared on the twelfth day. On the forty-sixth day, numerous trypanosomes were present; it had lost weight (1890 grammes). A blood count gave reds, 4,980,000; whites, 8,860; haemoglobin, sixty-seven per cent. For three-and-a-quarter months it received 1·0 c.c. of five per cent. solution atoxyl three times a week, gradually increasing the amount to 1·0 c.c. of ten per cent. solution. It then weighed 2,000 grammes. The blood count was: reds, 6,640,000; whites, 6,200; haemoglobin, eighty-eight per cent. The blood in quantities of ten c.c. was non-infective. The autoagglutination of the corpuscles was lost. Thirty-two days later it was very ill; it was therefore bled to death, and the whole of its blood injected into a monkey. This monkey has never become infected. The *post-mortem* showed severe haemorrhagic cystitis, the bladder in parts being almost gangrenous and acute septic peritonitis, especially around the bladder. The spleen showed no congestion, but the connective tissue was slightly increased. The kidneys and liver were normal.

Rabbit, 889, inoculated October 26; weight, 1,760 grammes. Blood count: reds, 6,620,000; whites, 6,700; haemoglobin, eighty-nine per cent. Parasites were seen from November 8 up to January 10; the trypanosomes were always present, but in small numbers; they then increased to eighteen to twenty to a field. The anaemia was pronounced, and loss of weight was noted. It then weighed 1,540 grammes. Blood count: reds, 3,880,000; whites, 11,800; haemoglobin, sixty-three per cent. It could hardly sit up, and remained most of the time lying down. This animal was given 0·8 c.c. of five per cent. solution atoxyl. At the end of eighteen hours the parasites were absent from the blood. Doses were given twice a week, beginning with 0·5 c.c., and increasing to 2·0 c.c. of a five per cent. solution. The blood in large doses is non-infective. The animal is vivacious ; the coat is smooth and thick. Average weight, sixteen hundred grammes. Several guinea-pigs infected for about two months, and showing twenty to forty parasites to a field, have been treated. They were injected subcutaneously with 0·3 c.c. of ten per cent. solution. At the end of the fifteenth hour no parasites were seen. Treatment was 0·1 to 0·3 c.c. of five per cent. solution three times a week for two months. The animals all increased in weight. One died sixty-two days after treatment was discontinued. Three rats inoculated with its blood never became infected. The second and third pigs were killed at the end of eighty and one hundred days after stopping treatment, and the blood used to inoculate controls. No control has shown the parasites. Virulent strain. *Rhesus.*—Weight, 2,815 grammes. Inoculated November 16. Blood count: reds, 5,220,000 ; whites, 12,800 ; haemoglobin, seventy-eight per cent. On November 31 parasites were seen. Two days later, twelve to seventeen to a field were noted. The weight was 2,420 grammes. Blood count: reds, 4,600,000; whites, 7,200 ; haemoglobin, seventy-three per cent. The parasites counted per c.mm. gave 100,000. Oedema of the eyelids and bridge of nose was present. The animal was given 0·8 c.c. of ten per cent. solution atoxyl subcutaneously. Four hours later : reds, 4,450,000 ; whites, 24,800 ; parasites, 40,000 per c.mm. At the eighth hour : reds, 4,740,000 ; whites, 25,200 ; parasites, one to eighty-nine fields. Between the fourth and eighth hours the parasites were seen to become remarkably degenerated and deformed ; many phagocytes were present. At the twenty-fourth hour after injection a count gave reds, 5,050,000 ; whites, 46,000. The blood was negative. The leucocytes remained high for a couple of days, and then fell ; in none of the phagocytes could any remains of trypanosomes be found. Treatment, 1·0 c.c. of ten per cent. solution was given twice a week. The animal increased in weight. The autoagglutination of the corpuscles began to be less accentuated, and the number of erythrocytes and the haemoglobin rose. The local oedema disappeared. On the thirty-ninth day dysentery appeared, and the animal succumbed on the forty-eighth day after injection. The autopsy showed a very severe haemorrhagic and necrotic enteritis, with slightly enlarged spleen. Kidneys normal. Glands small ; inguinal group haemorrhagic. The blood was non-infective in amounts of 1·0 c.c., but infective if fifteen c.c. of pure blood was used. Unfortunately, the arsenic was discontinued on the appearance of dysentery. A second monkey, inoculated from the first *rhesus* just before treatment was begun, was treated with the same doses of arsenic ; the parasites disappeared in the same way, but the animal quickly succumbed to dysentery.

Many rabbits inoculated with this strain have been treated. It was found that unless treatment was started early that the majority of animals died as it was so exceedingly virulent. With these animals treatment was begun earlier and higher doses given than with the standard 'Gunjur' strain. Despite treating the animals early some died. With this strain treatment had to be kept up longer. Some rabbits have survived eight months after injection, while all the controls have died in fourteen to thirty-six days. Guinea-pigs infected with this strain do not react so well to the treatment. Rats must be treated early and with high doses if treatment is to be successful. Mice infected with this strain react if treatment is commenced early enough.

T. brucei.—Guinea-pigs inoculated for two months. Average loss of weight one hundred and fifty to one hundred and ninety grammes. Parasites forty to sixty to a field. Initial dose, 0·4 c.c. five per cent. solution ; parasites absent in about eighteen hours. Treatment, two to three times a week, 0·1 of five per cent. solution. At end of two to three months treatment was discontinued ; the animals had increased in weight. At periods, one to two-and-a-half months after stoppage of arsenic, the animals were killed and their whole blood used to inoculate rats. None of the rats inoculated from these guinea-pigs have ever shown parasites. Some of the control rats inoculated during the first five weeks of the treatment have become infected after lengthy incubation periods. These treated guinea-pigs have shown increase of weight and lessening of the agglutination of the blood cells. Non-treated guinea-pigs have lived on an average forty to forty-five days. One treated pig had lived nine-and-three-quarter months since becoming infected, or five-and-a-quarter months since discontinuation of treatment.

Rats.—Treatment was begun two to three and four days after parasites appeared, when the animals were in the last stage of the disease and showed the semi-comatose condition which is so often met with. Rats of one hundred and twenty-five grammes in this last stage, and showing two hundred or more parasites to a field, have been given 0·5 c.c. of five per cent. solution. The parasites have been absent from the tail blood at the nineteenth hour. If treated twice a week with 0·3 of five per cent. solution, and the amount gradually increased, the parasites remain absent, the blood is non-infective and the animal puts on weight. Some have lived one hundred and twenty-six days from date of inoculation, and fifty-seven days after treatment was stopped ; they have succumbed to broncho-pneumonia or dysentery. The subinoculated animals have remained uninfected. Rats treated only once with 0·5 c.c. of five per cent. solution show parasites in their blood again in six to eleven days, and unless treatment be recommenced, the disease will pursue its natural course.

Cow.—This animal was inoculated subcutaneously from a guinea-pig. Parasites appeared on the sixth day but were very scanty. A severe enteritis occurred on the ninth day, but the animal survived the attack. The parasites slowly increased. Loss of weight and marked anaemia developed. Parasites continued to increase, the animal was then given 1·5 grammes of atoxyl in ten per cent. solution subcutaneously. The parasites disappeared slowly. Leucocyte count increased. Deformed degenerated trypanosomes were seen at the end of a day. The parasites were absent from the blood; 2·0 grammes of atoxyl was given twice a week. The animal was very anaemic, emaciated, and weak. It improved for a time. Unfortunately, our early departure prevented us making a study of this case, and, moreover, as there was no data as to the dose of the drug the administration had to be cautiously proceeded with.

T. evansi.—The results in the small laboratory animals are about the same as with Nagana. The animals have lived as long.

A horse was injected subcutaneously with blood from an infected rat; many divisional forms seen. Incubation four days; temperature rose on fifth day and parasites rapidly increased in numbers; the animal eat little and stood with head hanging down. The numbers increased to forty thousand to the c.mm.; the haemoglobin fell from ninety-five to sixty-three per cent.; no great change was noted in the red and white blood cell count. When definite loss of weight and anaemia had occurred and the parasites were about five hundred to the cover, 1·0 gramme of atoxyl in the form of a ten per cent. solution was given subcutaneously; in thirty hours the parasites had disappeared. A slight leucocytosis was observed; 2·0 grammes were then given and this was continued twice a week. The animal grew fatter and the blood count improved.

T. equinum.—Guinea-pigs react to treatment quickly and for a considerable time, but there is a tendency for some of them to show parasites in their blood one and two months after treatment has stopped. On the other hand, one treated for two-and-a-quarter months survived eight-and-a-half months after inoculation, treatment being stopped for two-and-three-quarter months. This animal was killed, and rats and guinea-pigs inoculated with its blood have never become infected. A rabbit which had been infected for twenty-eight days showed the loss of hair around the eyes and nose, and the purulent discharge from the eyes, nose, and urethra. The oedematous condition of the ears and genitals has by treatment with 1·0 c.c. of ten per cent. solution once every five days disappeared so far that all the external signs are wanting and no parasites are found; it has, up to date, lived seventy-six days.

T. equiperdum.—The work has been entirely on pups; these parasites have reacted in the ordinary manner, but the tendency of young puppies to manifest toxic symptoms has resulted in the experiments only prolonging the disease for one to two weeks longer than their controls. A bitch, inoculated January 14; positive January 20; large number first appeared on the 26th, temperature markedly irregular. Periodicity noticed; usually parasites absent for one to three days, then a rapid increase. Animal became very anaemic and thin. The blood count before inoculation gave 5,860,000 reds; 11,000 whites; and ninety-seven per cent. haemoglobin. On February 25 the reds were 3,780,000; whites, 14,000; haemoglobin, sixty-five per cent.; parasites were six to eight to a field. Trypanroth sixteen c.c. one per cent. solution administered. In thirty-six hours no parasites were seen, but they reappeared six days later. Ten c.c. of one per cent. trypanroth was then given every eighth day; the temperatute lowered. The parasites decreased but the anaemia persisted; March 19, atoxyl 1·5 c.c. of ten per cent. solution subcutaneously given; parasites disappeared to reappear eight days later. Despite large amounts of trypanroth the animal succumbed to the disease. A blood count, March 30, reds, 1,710,000; whites, 6,600; haemoglobin, forty per cent.; trypanosomes, 24,000 per c.m.

T. dimorphon.—This parasite has proved harder to combat with atoxyl or any other form of arsenic than the preceding parasites. LAVERAN also notes this peculiarity. Guinea-pigs showing a severe infection react extremely badly, they appear to manifest a greater tendency to toxicity than do similar animals infected with Nagana or other trypanosomes. The disappearance of the parasites is often less rapid, sometimes they never absolutely disappear, an occasional one being seen in the preparation. In the endeavour to cause the typical reaction a fatal dose may easily be given. One guinea-pig out of twenty-two experimented with survived three months. This animal was only treated once a week with 0·3 c.c. of five per cent. solution. It improved considerably, but towards the last the parasites reappeared, and the animal succumbed. The autoagglutination of the blood-cells never completely disappeared; the animal always exhibited some fever.

Rabbits.—React better to the drug, but the effect is more transient than with other trypanosomes. Higher doses have to be given. The life of the animal can be greatly prolonged, and for one or two months the general condition is improved. After that time parasites once more reappear; by increased dosage they may again disappear. Towards the end larger doses have to be given than at first to produce the effect on the parasites. Here it may be noted as applying to all species of animals infected with *T. dimorphon* that the parasite in animals treated for some time will hardly be recognizable; it presents a deformed appearance, its flagellated extremity is shortened so that scarcely any movement occurs. Blood from such an animal will be declared negative unless each field is gone over thoroughly. All peculiar bodies present must be examined, and over any such object minutes spent to determine if there is any movement. This point seems rather superfluous, but our experience is that the ordinary careful observer usually fails to find these degenerated, deformed parasites, and it is probably for this reason why so many negative diagnoses are made. Dogs and cats infected with this parasite show only a slight retardation of the disease; the numbers are greatly reduced or absent, but tend quickly to reappear.

TRYPANRED

This dye has been mostly used in connection with animals infected with *T. equinum*. The results tally with those of EHRLICH and SHIGA, and the later report of LAVERAN and MESNIL. Some rats injected with this compound have lived as long as one hundred and seven days; in one case sixty-three days without any treatment being given, this rat died from broncho-pneumonia, its blood was non-infective. Mice have also shown the favourable results of this treatment, but they do not appear to be able to withstand large doses.[1] Rabbits and guinea-pigs inoculated with this substance have had their lives prolonged for a considerable time, the parasites disappear completely, and if the administration of the dye be continued the trypanosomes may not be seen for thirty to sixty days; but the animal does not show the favourable reaction which attends the administration of arsenic, the anaemia is very little lessened, very often it is increased, the weight is not recovered, the temperature remains irregular. Very often if high doses are given toxic symptoms appear, these are characterized by more or less somnolence, the animals always appearing 'heavy,' there may be a slight discharge from the eyes. The face is often puffy, the urine in such cases usually has albumen; after a time these symptoms wear off. They are especially marked in rabbits after intravenous injections. Rabbits can withstand intravenous injections of 1·0 to 2·0 c.c. of one per cent. solution, and it appears as if the administration through a vein gives better temporary results, as the parasites, even *T. dimorphon*, disappear more quickly than by the subcutaneous method. The disadvantage is that the anaemia appears more pronounced, and the toxic symptoms severer. No rabbit or guinea-pig has been definitely cured.

Dogs and cats react fairly well to this dye, the life of the animal is prolonged, but no cure has been affected. Towards the last, despite repeated injections of this dye, the parasites continue to increase, the animal becomes a living skeleton, and usually develops a purulent discharge from the eyes and urethra.

T. evansi, *T. brucei*.—Rats and mice inoculated with either of these parasites, and injected with this dye, live longer than infected controls. The disappearance of the parasite is only temporary; after four to six days the parasites reappear, and though they can be caused to disappear once or twice they sooner or later reappear, and the animal dies, sometimes at a time when only very few parasites are present in the blood. With Nagana and Surra, inoculated animals which have been treated have not lived over thirty days, the majority dying in fifteen to nineteen days.

Rabbits and guinea-pigs react for a while, but the action on the parasites is not so marked as with Caderas infected animals.

Dogs and Cats.—The same results as with rabbits and guinea-pigs, only a very short prolongation of the disease is observable.

T. equiperdum.—The duration of the disease is only slightly affected by this dye. If injected early in the disease when the pup shows hardly any parasites a considerable prolongation of the animal's life occurs, but once large numbers of

1. Extreme care has to be exercised in administering th's solution. With rats and mice the preferable method seems to be to inject into the thick muscles of the hind legs. The hair is shaved off and the part disinfected before the injection. Guinea-pigs and rabbits ought to be treated in the same way. Dogs and cats can be injected in the deep muscles of both fore and hind limbs, in the back, or in the loose tissue of the neck. Monkeys are difficult as the skin is extremely sensitive, but the thighs offer the best site for inoculation.

parasites are present in the peripheral blood very little benefit occurs from a continuance of this treatment.

T. dimorphon.—The dye exerts a slight influence on this parasite, the numbers in the blood diminish, and many deformed ones are seen after a few days ; the organisms increase in numbers. In a few instances the parasites are absent from the peripheral circulation for a short time. Dogs show only transient improvement with a diminution of the parasites followed by a rapid increase in their numbers ; this phase lasts a few days only. Rats and mice show a temporary reaction, their lives may be prolonged for fourteen days ; at times the treated ones appear to succumb more quickly than the non-treated controls.

Rabbits and Guinea-Pigs.—The same temporary benefits are derived from injection of this dye.

Testing the action of the dye on the parasite by the addition of some of the solution to defibrinated blood containing trypanosomes, shows that with all of the different pathogenic trypanosomes a slight microbicidal action is manifested. The contact must be for some hours before the action will be noted ; it is, however, a definite action as control tubes show. Ehrlich and Shiga record the preliminary injection of animals with trypanroth, and after a few days injecting the animal with some virulent blood. They believe that the dye forms anti-bodies. A goat was therefore regularly injected with the dye, and after some weeks some of the blood was drawn off ; at first it was noted that the action of the serum did not differ from normal goat serum. As the animal got more under the influence of the dye it was noted that contact of living trypanosomes with this serum produced deleterious effects on the parasites which very often became deformed. If some of this serum was injected into mice with *T. equinum* a diminution in the number of the parasites was noted. Unfortunately, the injection of this dye for a long period caused the goat to become very run down, and the regular injection for a time had to be stopped. On the goat regaining its health it was once more given a course of injections with the dye. The serum had the same effects. In four mice the administration of this serum has prolonged the lives of the animals for thirty-one to forty-eight days. The serum is of a light, clear, fuchsin-red colour after five grammes have been given the goat. The amount of serum necessary is about 1·0 c.c. for a mouse of twenty-two grammes weight. As more of the dye is injected the amount of serum necessary is lessened. The experiments are too few in number to possess any practical worth. As the sodium arseniate and trypanroth had proved of use a combination of these two substances was tried for ten months.

Atoxyl-trypanroth combination has proved of benefit. With animals infected with *T. dimorphon* the results are more promising than in controls treated with either of these drugs separately. The parasites disappear rapidly, remain absent if the administration of the arsenic and the dye is pushed ; the animal increases in weight ;

the anaemia lessens, and the autoagglutination disappears. As mentioned before, trypanroth caused a nephritis, therefore, the combination of these two subjects is fraught with difficulties. In order to obtain results both drugs have to be pushed. It therefore often happens that the animal acquires a severe nephritis and succumbs. The effects of this combination have been noticed on other trypansomes.

The combined treatment offers a promising mode of medication, providing the untoward effect can be diminished or abolished. Very many of the smaller animals, especially guinea-pigs, have died from the effects produced by trypanroth.

Action of Atoxyl and Trypanred on the Trypanosome

The action of atoxyl on the various trypanosomes has been studied, and after numerous observations, continued for the whole period during which the drug was administered, the effect appears to be as follows :—

On administration of arsenic compounds into an animal showing numerous parasites in the blood the following action on the trypansomes will be noticed. For the first three-and-a-half to four hours, depending on the dose used, very little change in the parasites can be noticed. Between the fourth and fifth hour the effect on the trypanosomes is evident. Some parasites appear to be swollen and their movement is less rapid. If now a series of blood specimens be examined at intervals of twenty to thirty minutes the following changes will be seen. The number of slowly moving trypanosomes increases, many parasites will be seen to be almost motionless. The protoplasm takes on a peculiar ground-glass appearance, and dark granules appear in the protoplasm ; very often a whole series of granules one behind the other, sometimes in pairs or all clumped together, are seen lying between the macronucleus and the anterior end or distributed through the whole body of the parasite. At the same time vacuoles are observed, oftentimes very large. The trypanosomes become deformed, assuming various shapes, the most common being a kite-shaped form with fairly long flagellum, and a tadpole-like one with hardly any free flagellum. These forms especially exhibit greatly impaired movements. At the same time a noticeable increase of the leucocytes is discernable ; phagocytes begin to appear, very often groups of five to seven will be seen. Up to this time (sixth to seventh hours) the trypanosomes, though decreased in numbers, are still present in considerable quantities. Suddenly in the course of an hour the numbers may drop from forty to two to three to a field or less ; coincident with this is a very marked increase in the number of leucocytes, especially phagocytes. From the ninth to the fourteenth and sixteenth hours the changes are less pronounced and rapid, the trypanosomes gradually disappear. At the eighteenth hour, provided the animal has been injected with the correct amount, the parasites are absent from the peripheral circulation and, even though the blood be centrifuged, none can be found.

My colleague, Dr. BREINL, and myself have observed a large number of experiments, examining the animals every one-and-a-half hours until the four-and-a half hour, then every half hour until the parasites were almost absent, and continuing the observations hourly until the twenty-fourth to thirty-second hour after starting the experiment. From a series of these observations, we have determined that in hardly any of the forty-six continuously observed animals were parasites to be found after the eighteenth hour. Should, however, the drug be given in smaller amounts the process takes longer, lasting from thirty-six to forty-eight hours.[1]

Phagocytosis has been observed on three occasions. We have witnessed the engulfing of a trypanosome still alive though almost motionless, and on other occasions the ingesting of dead trypanosomes.

Observations on the effect of *Trypanred* on the trypanosomes show that almost the same changes take place, though the process is somewhat slower, usually requiring forty-eight hours or more ; leucocytosis also appears to be very marked in animals treated with this drug.

LEUCOCYTOSIS

In the observations on the action of arsenic and trypanroth on the trypanosomes, it was noticed that a marked increase of leucocytes occurred. Phagocytosis having been seen, it was determined to try the effect of hyperleucocytic agents on the parasites. In the work on the effect of diphtheria antitoxine on trypanosome-infected animals a certain amount of leucocytosis had been observed, but it was not marked. Advantage has, therefore, been taken of such agents as nuclein (this also affects the kidneys). Thanks to Professor SHERRINGTON, we were able to try the effect of colchicine on the infected animals. This substance causes a leucocytosis, but it only produces an increase of some six thousand in thirteen hours. Nucleinic acid acts in the same way. We have been induced to try the effect of administering the atoxyl or trypanred, or the combination atoxyl-trypanred, and following this treatment with the hyperleucocytic agent. Unfortunately, no better effects have been observed. This line of work ought not to be neglected, as it is quite evident that the leucocytes play a rôle in the decrease of the parasites. Animals which have been carefully observed every day show from time to time a decrease in the number of parasites in the peripheral blood. If the decrease be sudden and marked a vast increase in the number of leucocytes is determinable.

THE ACTION OF BACTERIA UPON TRYPANOSOMES

It has been noted in animals suffering from trypanosomiasis that should a localized abscess occur a certain decrease in the number of trypanosomes in that region can be made out. In rats the tail from snipping or pressure may become ulcerated or

1. Blood films were made before beginning the experiment, and at every examination. The results of the examination of these stained films bear out the observations on the fresh blood films. The significance of the granules seen and the phagocytosis will be discussed in a fuller report.

gangrenous, in such a part very few parasites will be found although the blood above the area may be swarming. Moreover, the movements of the parasites are slow and show degeneration and deformity, whilst phagocytes will be found containing the remains of trypanosomes. Acting on these observations experiments have been made with various bacteria. Guinea-pigs suffering from tuberculosis seem to be somewhat more susceptible to trypanosome infection than healthy ones. Mice, already infected with trypanosomes, and then inoculated with *B. anthracis* and the *B. sui*, show at times a certain amount of retardation of the disease. The parasites do not appear to augment so rapidly. Ordinary cultures of pyogenic cocci are too virulent for the animal. If a very attenuated culture of *Staphylococcus pyogenes aureus* is inoculated with *T. dimorphon*, the animals show a marked diminution in the number of parasites, but they persist for some days. Unfortunately, the subcultures never act in the same way and show increase in the virulency. In one of some eight rats infected with *T. brucei* and then injected with *Leuconostoc mesenteroides* there was a lessening in the number of the parasites ; this animal was subsequently injected intraperitoneally with a culture of Klasse's *Gonodiplococcus* of scarlet fever. The parasites disappeared, but the animal died one-and-a-half days later from a septic peritoneal infection due to the wounding of the gut. Cultures of *B. typhi*, *B. coli*, *B. diphtheriae*, so far as we have been able to observe, have proved of no avail.

In connection with these observations it is interesting to record the work of Nissle ; unfortunately, only a review of his preliminary paper is available. He inoculated intraperitoneally a number of rats infected with the Nagana parasites with one-twentieth of a loopful of a *B. prodigiosus* culture grown on potato ; in twenty-four hours the trypanosomes disappeared, and some of the rats died from intoxication in half to three hours after injection. During the disappearance of the parasites he observed all kinds of endo-globular forms. It must be borne in mind that the injection of a culture causes a leucocytosis, and whether Nissle's results depend only upon this or upon the toxic products of the bacteria remains to be seen. It is hoped that this question will not be neglected.

Conclusions

From the experimental work with various therapeutic agents the following conclusions can be made :—

1. That animals suffering from trypanosome infection react favourably to only a few agents, of which arsenic is the only drug which seems to exert a more than transient action.

2. That the greater the amount of arsenic introduced into the system of the animal the greater and more permanent the effect on the parasite.

3. That arsenic medication is indicated in the treatment of individuals suffering from Trypanosomiasis. That the treatment ought to be long continued and regularly

administered in as high doses as the case can stand. That all aids to building up the system should be employed.

4. That in trypanred we possess an agent of some use in the treatment of trypanosomiasis. That certain trypanosomic diseases appear to be more amenable to its action than others. That in the substance at present available there is need for improvement in order to abolish its toxic effects.

5. That a combination of arsenic and of an improved form of trypanred would seem indicated in the further investigation of the cure of trypanosomiasis.

6. That further efforts ought to be made to produce less toxic forms of arsenic suitable for injection.

7. That the action of both arsenic and trypanred causes a hyperleucocytosis and that this condition has an effect upon the parasites. In confirmation of this is to be recorded :—

(*a*) The hyperleucocytosis coincides with the time when the parasites suddenly disappear from the peripheral circulation.

(*b*) There is a smaller number of parasites present in necrotic, bacterially-infected areas than in the general circulation.

(*c*) The effect of certain bacteria on animals infected with trypanosomes.

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SUPPLEMENTARY NOTES

On some Animals still under Treatment on Drs. Thomas's and Breinl's Departure

Nagana cow (page 55), died eleven days later. The haemoglobin was eighty per cent., and the agglutination of the red blood corpuscles remained absent. Death due to extensive hydatids and pulmonary tuberculosis.

Surra horse (page 56), died over three weeks later. The haemoglobin which had at first risen under the atoxyl to eighty per cent. had fallen to sixty per cent. just before death. The agglutination of the red blood cells remained constantly present. In the intervals between the administration of the atoxyl, the parasites would return, and were twenty-five per field on the fourth day after the dose in the last week but one. Two doses per week were therefore commenced. This kept the number of parasites down, so that one per five fields was the highest reached. The animal, however, had become too reduced, and died three days after receiving the third dose at the smaller intervals.

Autopsy.—There was anaemia of all the organs, otherwise (spleen not excepted) there were no striking naked eye changes. Patechial haemorrhages were found in the muscles of the chine. There was a retropharyngeal abscess the size of a child's head communicating with the nasal sinuses, but it appeared to have been of some standing and not to have caused death. The animal was able to swallow readily up to its death.

Rabbit 839 (page 53), kept in perfect health for another month, and as the animal went off its food for a day or two the last dose given was only half the usual one. Two days later, however, the animal died, parasites having been found in the blood the day preceding, twenty per cover, degenerated and almost motionless from the effect of the atoxyl.

Caderas rabbit (page 56), still alive, September 28, 1905. In perfect health. No discharges of any kind ; all hair regrown. No treatment since June 3. Blood negative since May 30 to microscopical examination. Its weight on April 25 was 1,770 grammes, and continued to fall till the end of May, when it was 1,190 grammes. Since then it has gradually increased to 1,795 grammes. It has now lived eight months. The head is usually kept over extended, which may be due to canker of the ears which was always present.

P. A. H. RADCLIFFE, M.B.

PART II. POST-MORTEM EXAMINATIONS WITH DESCRIPTION OF MACROSCOPIC AND MICROSCOPIC CHANGES

I. EXAMINATION OF ORGANS IN MAN (FOUR CASES)

A.—CASE OF THE NATIVE, KITAMBO

Death, June 12, 1904, eight p.m.; *post-mortem* six hours later.

External appearances.—Body of middle height, very emaciated; muscular development poor; no exanthemata; no oedema; rigor mortis marked; configuration of skull normal, markedly dolicho-cephalic. Conjunctivae and sclerae very pale and slightly jaundiced; mucous membranes pale. The cervical and inguinal lymphatic glands were distinctly prominent. Thorax long; intercostal spaces prominent; abdomen retracted. External genitals normal. Superficial ulcers about three c.m. in diameter on the soles of the feet (probably produced by chiggers).

Brain and Spinal Cord.—The under surface of the scalp was very pale. Skull rather thin, the vessels on its inner surface occupied deep sulci. Circumference of skull fifty-two c.m. The dura mater adherent in places to the bone. The sinuses contained dark fluid blood and a few clots. The inner surface of the membrane was smooth and glossy. Cerebro-spinal fluid increased in quantity. The surface of the brain was of normal configuration; the gyri appeared a little flattened. The superficial veins were very large, many were tortuous and they contained dark venous blood. The arteries were also engorged so that the whole surface of the brain was covered with a dark blue network, and greatly congested capillaries (Fig. 1). The leptomeninges were thickened, and in places whitish but not adherent to the brain. The pial vessels of the cerebellum were much congested and could be traced to the finest capillaries. The basal arteries showed no sclerosis. On section the brain substance showed irregularly distributed congested areas; the basal ganglia showed puncta cruenta. The brain substance was doughy, soft, and very oedematous; the ventricles were dilated; the ependyma roughened; the vessels very congested. The pons and medulla showed no macroscopic changes except congestion and some small haemorrhages about the size of pin heads. In the vertebral canal was a fair quantity of cerebro-spinal fluid. The inner surface of the spinal dura mater was smooth and glossy; the pial vessels were enlarged and filled with dark blood; the congestion was not equally distributed, being more pronounced in parts; in others the vessels were only moderately filled. The cauda equina presented a striking appearance; it was surrounded by a gelatinous tissue and its nerves were sheathed in networks of dilated vessels; on section the congested vessels were seen as dark red stripes entering the substance. In the region of the third dorsal segment, at the base of the right posterior horns, were four haemorrhages, the largest being about two mm. in diameter, and extending through two segments of the grey substance. The structure of the cord in the region of the haemorrhages appeared obliterated.

Thorax.—Diaphragm reached to the level of the fifth rib on each side. Both lungs were adherent to the diaphragm, but were free elsewhere ; parietal pleura normal.

Right Lung.—Pleura of the upper lobe normal ; that of the lower lobe showed dark blood coloured patches. The tissue of upper and middle lobes normal ; the lower lobe was congested and of a bright red colour.

Left Lung.—Under the pleura were numerous small haemorrhages. The lung tissue contained patches of congestion. The mucous membrane of the trachea was pale and covered with a small amount of clear viscid mucus. The thyroid gland normal. The nasal cavity and the sinuses in connection with it, as well as the tympanum, appeared normal. The pericardium contained a few c.c. of yellow tinged clear fluid.

Heart.—Size normal ; substance very pale and flabby. The chambers contained dark fluid blood and clots. The endocardium, the valves, and the intima of the aorta appeared normal.

Abdomen.—The cavity contained about two hundred and fifty c.c. of a light straw-coloured fluid.

Liver.—Of normal size ; its capsule here and there slightly thickened ; the parenchyma pale and friable.

The Gall Bladder.—Filled with thick, fluid, greenish bile.

The Spleen.—Enlarged (20 × 10 × 6 c.m.), the capsule very thick and partially adherent to the parietal peritoneum ; the pulp very dark purple-red and slightly diffluent ; on section, enlarged malpighian bodies could be seen in some parts, whilst in others no structure could be made out in the dark purplish mass.

The Kidneys.—Were of normal size, capsules stripped easily. Externally they retained the deep embryonic furrowings ; the cortex presented an appearance of fatty striation, otherwise they were normal.

The Bladder.—Contained nearly half a litre of cloudy urine. The mucous membrane was pale. The genital organs showed no changes. The suprarenals were greatly congested. Pancreas normal.

Stomach and Intestines.—The mucous membrane of the stomach was pale, that of the small intestine somewhat congested ; the large intestine being normal. The stomach contained a little mucus ; the small intestine was partially filled with yellowish-brown chyme, and here and there in the recesses of its folds a few anchylostomes were found.

Lymphatic Glands.—Mesenteric lymphatic glands were enlarged and showed haemorrhagic infiltration, others were normal. The inguinal glands were greatly enlarged, being six c.m. long and four c.m. broad. On cross section they appeared uniformly yellowish in colour.

Pieces were taken from all the organs and fixed in the usual fixing fluids :— ZENKER's, FLEMMING's, hydrarg. perchlor., and alcohol. The brain and spinal cord were fixed in four per cent. formalin.

MICROSCOPICAL EXAMINATION

The heart showed a fairly extensive small-celled infiltration in the endo-, epi-, and myocardium. The epicardial fat was well defined from the muscle, and in it was an accumulation of lymphocytes, large mononuclear and polymorphonuclear leucocytes. The infiltration extended along the connective tissue between the muscle fibres, and areas of infiltration were seen around some of the larger vessels in this situation, with a few mast cells and giant cells (these latter containing five to eight centrally-placed nuclei, or sometimes only fragments of nuclei). Here and there were large haemorrhages which extended from the perivascular connective tissue into the adjacent muscle, often destroying it. Frequently one could see, lying near a vessel wall, wedge-shaped patches of red blood corpuscles which were certainly the product of diapedesis, although no corpuscles were found in the wall itself. Many of the muscle fibres were smaller than normal, the striation was faint and around the nuclei were collections of reddish-brown pigment. These changes were for the most part equally distributed throughout the whole thickness of the myocardium, but in places were more marked in the left ventricle than in the right.

For the detection of bacteria, sections were stained by LÖFFLER's methylene blue, carbol fuchsin (Pfeiffer), carbol thionin and by GRAM's method. Only a very few bacilli (decolourized by GRAM's fluid) were found. These were considered to represent *post-mortem* contamination.

Such parts of the lungs as appeared normal to the naked eye were found on microscopic examination to be hyperaemic. The congested vessels often contained a good number of white blood cells. The bronchi contained desquamated epithelium and exudation. The lymph tissue around the bronchi showed hyperplasia. The pleura showed various-sized extravasations of blood in its connective tissues, the blood vessels being very large. The pneumonic-looking parts showed typical catarrhal pneumonia, the alveoli were filled with red blood and exudation cells. The process had gone on further in some parts ; there the whole tissue formed a homogenous mass interspersed with red blood corpuscles and exudation cells. In the consolidated parts were a good number of cocci staining by GRAM, and numerous GRAM-negative bacilli and cocci.

The sections of the *liver* showed a thickening of the capsule. Between the chains of liver cells were many partly degenerated blood cells, decreasing in number as the centre of the liver was approached. The connective tissue was increased in amount and contained a few lymphocytes. Many of the liver cells had no nucleus, the protoplasm was vacuoli , and in various stages of fatty degeneration. A few of the cells contained small clumps of yellowish pigment occupying more than half of the cell. The blood vessels which were very much congested, contained a limited number of white blood corpuscles.

The *kidneys* presented the picture of parenchymatous degeneration. The protoplasm of the epithelial cells showed granular degeneration. The blood vessels, especially in the cortical region, contained very many white blood cells, and here and there in close proximity to the vessel wall were numerous red blood corpuscles. In places only scanty remains of normal kidney tissue were visible, the field being occupied by well stained connective tissue, its meshes entirely filled with red blood corpuscles. The glomeruli showed the same congestion, distended capillaries sometimes forming more than two-thirds of the whole glomerulus.

The *spleen* in section showed a thickening of its capsule. The malpighian bodies were few in number and not prominent, and from them irregularly defined processes ran out into the surrounding tissue. There were two zones to be made out in a malpighan body, viz., an external zone consisting only of lymphocytes, and a central one consisting of large cells containing a vesicular nucleus. Amongst the latter were large non-nucleated cells (forty to fifty μ in diameter), the protoplasm of which stained a dull red with eosine, and in addition a few leucocytes with eosinophile granules. The trabeculae were hyperplastic, and the vessels showed endothelial proliferation. The congestion of the spleen was most striking, especially in the periphery. Interspersed in the tissue were red blood corpuscles, sometimes clumped together in dense irregular heaps, in which a few lymphocytes were also included. The red cells showed indistinct contours, and by their staining reaction were evidently degenerated. Here and there were small irregular necrotic areas, in which only a few connective tissue cells were present. The cellular elements of the organ included very numerous large hyaline cells, containing inclusions of red and white cells, a very few nucleated red cells in the larger vessels, and, in the tissue of the pulp, giant cells with numerous irregularly placed and irregularly shaped nuclei and a large protoplasmic body. Throughout the spleen are found mono- and polynuclear leucocytes with eosinophile granulation. Iron-containing pigment is occasionally seen, both intracellular and free. In the vessels and in the tissue itself occasional filaria embryos were met with.

Lymphatic Glands.—The most marked changes were found in the lymphatic glands. The vessels were found to be highly congested in accordance with the naked eye appearance. Side by side with normal glands, in nearly all groups, there were others which contained very numerous red corpuscles, lying free in sinus-like spaces partially filled with large phagocytic cells. In nearly all the lymphatic groups were also transitional forms between normal glands and those showing the above described changes. The changes bore no proportion to the size. In the same lymphatic gland often one part would be quite normal, while another part showed typical sinus formation.

These enlarged glands in the first stage of their formation showed a thickened capsule, with bands of fairly thick connective tissue running in from it towards the centre and containing enlarged vessels showing distinct proliferation of their endothelium. In some places the lymphoid tissue does not reach right up to the capsule, but a lightly stained fine connective tissue meshwork intervenes, which contains, besides a few lymphocytes, a number of red corpuscles, large phagocytes, and iron-containing pigment granules. The nucleus of the phagocytes is peripherally placed, and their inclusions consist of the following :—numerous darkly-stained nuclei, the size of lymphocytes, and red blood cells which either stain yellow with Van Gieson's method or appear merely as unstained vacuolar areas in varying number often filling the whole cell. The intervening spaces in the sinus are filled with coagulated fluid. Sinuses with the same contents as the peripheral one are found in very small numbers in the interior of the gland, recognizable at the side of the connective tissue strands by their light staining. The follicles are not so distinct as normally ; they are larger and not sharply defined from the surrounding lymphoid tissue.

The majority of the smaller glands presented a similar microscopic appearance ; frequently there were a good number of red corpuscles between the lymph cells, and the sinus system was more or less pronounced. Sometimes there occurred only a short peripheral sinus, with one or two central off-shoots ; in other places, the whole gland was interlaced by them. In some the follicles were normal, in others lightly stained, and contained, in addition to larger vacuolated cells and lymphocytes, a fair number of small cells two-thirds the diameter of a red blood corpuscle, which had an eccentric, deeply-stained, small nucleus and protoplasm staining faint pink with eosin. Besides, there were very many small nuclei both free and contained in other cells, staining darkly with haematoxylin. The blood vessels were much dilated, and contained, besides lymphocytes, a good number, as a rule, of large mononuclear and polymorphonuclear leucocytes and a few eosinophile cells.

Some of the larger lymph glands showed the change in a more advanced stage (see Fig. 6). In these, by a marked hyperplasia of the connective tissue, the lobules of lymphoid tissue became contained in a framework of connective tissue, producing thereby an alveolar structure. In the centre of the gland, an accumulation of connective tissue was extended by radiating septa to the capsule ; this was thin, and had large dilated vessels surrounded by numerous lymphocytes running in it. There were no fat cells in the connective tissue of the glands, showing that these were true lymphatic glands, and not new formations in the adipose tissue. The sinus formation was as described in the first stage. Around the congested vessels were nearly always deposits of red corpuscles with a little blood pigment. Follicles were not to be seen.

Fig. 7 shows this transformation in one of the mesenteric glands. A sinus is seen not far from the capsule, filled with lymphocytes, and surrounded by red blood corpuscles, these latter being easily distinguishable from the blood vessels by the absence of endothelial cells.

The cellular elements included divisional forms of lymphocytes; giant cells, resembling those of bone marrow; large hyaline cells with included red corpuscles in all stages of degeneration, sometimes only appearing as vacuoles; mono- and polymorphonuclear leucocytes with eosinophile granulation; phagocytes; and plasma cells.

In some of the glands were seen all stages between phagocytes containing red cells and eosinophile cells. In the first stage were phagocytes with their nucleus placed peripherally, and the protoplasm of the cell filled with red corpuscles, stained a peculiar colour with eosine. The eosine-stained red corpuscles became smaller and smaller in their including cells, whose protoplasm in a later stage seemed to be unevenly stained a brilliant red tinge. Later, the nucleus changes its form and becomes polymorphonuclear, and in other cells one can almost see the eosinophile granules crystalizing out from this red-stained protoplasm. Some of the eosinophiles are destroyed in the lymph glands by phagocytosis, whilst others appear to enter the circulation. New formation of lymphatic tissue was noted; for example, in the adipose tissue around the axillary glands there was an accumulation of lymph cells between the fat cells, and in some places there was distinct follicle-like formation around the vessels.

The *Bone Marrow* of the femur in some places had normal appearance of fat marrow, but in others however the marrow was very cellular, the fat tissue being reduced to a few islets, and replaced by cellular tissue composed of normal marrow cells with very few nucleated red corpuscles, and a large number of eosinophile cells. The vessels were greatly congested and there were frequently haemorrhages around the vessel walls; the blood corpuscles showing degeneration. In different parts there were varying numbers of phagocytes containing red blood cells. Blood pigment was only infrequently met with. Here and there the whole of the tissue was replaced by a homogenous substance containing very few cells, staining yellowish with VAN GIESON and red with eosine, and presenting the appearances of gelatinous degeneration.

Brain and spinal cord were fixed in four per cent. formalin and hardened in alcohol and sections were cut from the different regions. The sections were stained by haematoxylin, eosin and VAN GIESON, WEIGERT's method, WEIGERT-MARCHI, NISSL and UNNA, and for bacteria with LÖFFLER's methylene blue, carbolfuchsin, PFEIFFER, carbol thionin and GRAM.

The pia and arachnoid shewed a fair amount of pigmented cells, similar to those observable in skin, the pigment being dark-brown and granular. The large and small vessels were surrounded in a varying degree by small-celled infiltration; sometimes the larger vessels had a quite normal wall. The small-celled infiltration consisted of lymphocytes, phagocytes, with all kinds of inclusions, also a few larger mononuclear and polymorphonuclear leucocytes, and a large number of red blood corpuscles. The same infiltration was found about the cells of the pia and accompanying it into the cerebral sulci and to a certain extent into the brain cortex itself. In the brain the infiltration occurred chiefly around the vessels of the deeper parts of the brain, those of the cortex showing relatively slight changes.

The vessels in the deeper parts were very large and congested, the perivascular lymph space dilated, sometimes empty, at other times occupied by coagulated exudation or filled with lymphocytes. The proliferated endothelium projected into the lumen. The vessels in the more deeply situated parts of the brain were much more changed, especially in the region of the large grey basal ganglia. Here the vessels were surrounded by a thick layer of lymphocytes, filling up the perivascular space and extending into the brain substance. Amongst the exuded lymphocytes there were a good number of red cells. There were also cells resembling granulation-tissue cells, hyaline with a vesicular nucleus; large cells (thirty to fifty μ in diameter) with protoplasm stained reddish with eosine and having one to three nuclei; a few phagocytes and an occasional plasma cell.

The lumina of the vessels were often narrowed. Close to the vessels were various sized haemorrhages without any lesions of the vessel wall.

Very often, external to the layer of white cells which surrounded a vessel, was a second layer of red blood cells infiltrating the brain substance in the neighbourhood. In some places the brain was altogether destroyed through haemorrhage, but no blood pigment was seen, and red softening was marked. Around the infiltrated vessels was usually a proliferation of glia cells. The endothelium of the vessels was proliferated and the vessels contained many white blood corpuscles, sometimes in so large numbers that they seemed to fill the whole vessel like a thrombus. The infiltration was in general equally pronounced both around artery and vein, but sometimes the vein was more changed than the artery.

Here, and in other sections, where the vessel was seen in tangential section, red corpuscles were present in the media and adventitia. The ependyma of the lateral ventricle was proliferated, forming a dense fibrous layer.

The epithelial cells of the choroidal plexus approached the columnar in type and often had gaps between them.

Similar changes to those in the cerebrum were found in the pons, medulla, and spinal cord.

The pons on section appeared much congested, the vessels were irregularly sheathed with a layer of cells of the same nature as those above described; the intervals between them being occupied by coagulated fluid. Throughout the section of the pons were seen various-sized haemorrhages; the endothelium of the vessels was thickened, and there were a fair number of white blood cells in the lumen. Similar changes but more pronounced were found in the medulla—small-celled infiltration around the vessels, with a dilated perivascular lymph space, filled with transudate sometimes containing lymphocytes. The vessels in the white matter were not so much altered as those in the grey. Haemorrhages were also present in far greater numbers in the grey matter though no pigment was seen.

The pia and arachnoid of the spinal cord was the seat of a well-marked small-celled infiltration, the meshes in the connective tissue of the arachnoid being often altogether obliterated by it. It is worthy of note that in this region the walls of the larger vessels were very often normal, whilst the small ones showed marked changes.

The spinal dura mater presented the same change as the cerebral. The congested vessels ran between the connective tissue, in places surrounded by a few lymphocytes, and here and there even small collections of lymphocytes.

The inflammation continued along the vessels into the fissures and white substance of the cord. Both fissures were often indicated by a dark blue band, this appearance being produced by the accumulation of exudation cells alongside the vessels running into the fissures. The changes in the grey matter of the cord were also much more marked than elsewhere. The periphery of the cord was very oedematous, and showed proliferation of the neuroglia. The grey matter was often intersected by a network of congested capillaries, which were surrounded by a thick sheath of cells (consisting of elements similar to those of the brain vessels). The congestion of the vessels was so great that the vascular supply of the cord was displayed in the sections almost like a diagram. The perivascular changes were irregularly distributed, now one, now another vessel showing them. Relatively, few white cells were found in their lumen, and but slight signs of endarteritis. The epithelium of the central canal was proliferated, as also the neuroglia adjacent to it.

The most marked changes were found in sections of the spinal cord taken from the level of the sixth cervical down to the third dorsal segment. In the seventh cervical region, the artery of the left posterior horn was surrounded by a layer of lymphocytes, four to six deep, with a layer of red blood corpuscles of the same width, external to it again. At the base of the horn a haemorrhage destroyed its substance in half its width. In the grey commissure also an abnormal patch was seen, consisting of two large arteries with veins and a number of capillaries, all sheathed in infiltrated connective tissue.

Fig. 8 represents a section of the cord taken two segments lower down. The artery of the posterior fissure is seen enclosed in small-celled infiltration in the inner third of its course. There is also a haemorrhage on both sides of it extending into the white substance of the cord, and destroying the adjacent medullated fibres, so that there are only a few bundles of fibres left, which appear in isolated groups in the haemorrhagic region. Other smaller haemorrhages are also seen in the posterior horns and in the grey commissure.

All these haemorrhages were of quite recent origin, there being no trace of blood pigment. Below the third dorsal segment there were only some extravasated corpuscles around the infiltrated vessels. The other parts of the spinal cord all showed changes similar to those of the cervical part to a varying extent. Filaria embryos were present here and there in the vessels of brain and spinal cord.

The nerve fibres often showed alterations. The cerebral convolutions presented a marked degeneration of the supra- and intraradiar fibres. Usually there was slight degeneration of the fibres all over the brain, most marked around the larger foci of infiltrated vessels, the degeneration being both of older and more recent date. The fibres were often swollen and disintegrated. The pons and medulla showed degeneration of the medullated fibres irregularly distributed over the whole section, well marked around the infiltrated vessels, but most pronounced in the region of the haemorrhages, where Marchi's method showed an extensive recent degeneration. The spinal cord presented the same condition, but certainly more degeneration in the posterior than in the lateral columns, and less still in the anterior columns.

The large nerve cells of the brain and spinal cord which contained a fair amount of pigment, showed very marked changes, not confined to a certain group, but irregularly distributed in the whole central nervous system. The cells in the basal ganglia and of the anterior cornua of the cord were in an advanced stage of alteration. In the neighbourhood of normal nerve cells were others whose processes seemed to be broken away. They were spherical in shape with a dilated pericellular lymph space. They often showed chromatolysis, the Nissl bodies were nearly disintegrated, and a powdery mass occupied the whole body of the cell instead. Sometimes the chromatolysis was only peripheral, the Nissl bodies in the centre well preserved ; at other times, the change was only central, in the periphery the Nissl bodies being easily distinguishable, and the centre occupied by a homogenous mass. The nucleus was often normal, but at other times had an irregular contour, or was even not distinguishable at all. Here and there were nerve cells with vacuolated protoplasm. Some of the nerve cells were oedematous, others were shrunken, stained dark blue, and in a later stage represented by a number of disintegrated fragments ; they were pyknotic. At various levels in the cord, the number of the large anterior root cells seemed to be unequal on the two sides.

The nerve bundles coming off from the spinal cord also showed great dilatation of their vessels, sometimes forming more than half the bulk. Frequently there was slight degeneration of the fibres and the vessels were surrounded by a thin layer of lymphocytes. The spinal ganglia at the various levels showed changes analogous to those in the cord, viz., small haemorrhages between the ganglion cells, and slight round-celled infiltration of the vessels. Haemorrhages were also present in the surrounding fat.

In the peripheral nerves were sometimes signs of neuritis, small-celled infiltration in the endo- and perineurium, and slight degeneration of the fibres.

With the above-mentioned bacteria-staining methods, microbes were only found in a few sections of the central nervous system, although very many sections were examined. They consisted of a few long bacilli in short chains and groups, and a few large cocci. The specimen stained by GRAM's method showed no micro-organisms.

B.—The Second Case, Tomi ; Died June 17, 1904

Post-mortem three hours after death.

Length one hundred and fifty c.m. ; very emaciated ; slightly built ; skin dry ; desquamating ; no particular pathological changes ; Rigor mortis commencing in upper extremities. Skull dolicho-cephalic. Pupils unequal, the right one smaller. Left eye showed a corneal opacity one mm. in diameter. Right eye, corneo-scleral junction at its right lower quadrant, ill defined, with peri-corneal injection corresponding. Conjuctivae and sclera pale ; slightly jaundiced. Mucous membrane of lips and mouth very pale. Neck short, thin, its hollows well marked. Glands on both sides of the sterno-mastoid muscle visible as slight elevations. Thorax barrel-shaped ; deeply indrawn intercostal spaces. Inguinal glands much enlarged ; skin over them elevated. External genitals normal.

The under surface of scalp pale, here and there dark-blue, dilated veins visible. The circumference of skull fifty cm. ; skull cap thin with very numerous pacchionian depressions, especially along the coronal suture. Dura not tense, adherent to the bone ; inner surface smooth and glossy, no thickening nor haemorrhages ; all its sinuses filled with dark fluid blood. The amount of cerebro-spinal fluid was increased. The capillaries were injected ; the pia mater, especially along the edges and over the occipital lobe was opaque and thickened.

The base of the brain presented the same changes in the leptomeninges. Arteries not atheromatous. The gyri and sulci normal. The brain substance on cross section soft and oedematous. All over the cut surface numerous congested capillaries and a few small haemorrhages were visible.

The ventricles were somewhat dilated ; the ependyma smooth and firm. The spinal dura mater appeared normal. The spinal canal contained much yellow-coloured cerebro-spinal fluid in which were found numerous leucocytes and a few trypanosomes. The anterior and posterior spinal arteries with their corresponding veins could be followed as thick cords along the spinal cord and even traced to their last ramifications.

On the anterior surface of the cord, on the right side, was a spindle-shaped dark red-stained mass (seven mm. in breadth) extending from the sixth cervical to the third dorsal, sharply defined and resembling a blood clot (Fig. 4). The cauda equina was embedded in gelatinous tissue. On cross-section the central canal was dilated ; the structure of the cord was well preserved ; the vessels in the grey substance and those entering the cord were much dilated. The congestion was less marked in the lumbar region. At places a greyish stripe of infiltration was visible at the sides of the vessels.

Tympanic and nasal cavities were normal.

Thyroid normal. Both tonsils were enlarged but not actively. The glands of the neck were enlarged (four cm. long, two cm. broad); on cross section they presented a partial haemorrhagic infiltration, being brownish-red in colour and speckled with grey points the size of a pin's head (Fig. 5). The connective tissue at the hilus was hyperplastic. The submaxillary lymphatic glands were also haemorrhagic. Lungs were free from adhesions and much congested. In the pleura of the right lung numerous haemorrhages were present. The peri-bronchial glands were enlarged, showing the same changes as the glands of the neck.

The pericardium contained six c.c. of yellowish, blood-stained serum. The heart was of normal size, pale, and flabby; the epicardial fat well defined from myocardium. The cavities contained much dark fluid blood. The bicuspid valve was a little thickened, the other valves and aorta were normal. The mucous membrane of oesophagus and trachea was pale.

The abdomen contained a few c.c. of clear fluid. The liver was congested but otherwise appeared normal. The capsule was not thickened. The gall bladder contained much dark greenish bile. The spleen was increased in size (18 × 11 × 4 cm.), of a dark-reddish purple colour, hyperaemic, of solid consistence; capsule thickened.

The malpighian bodies appeared hyperplastic on section, the medullary substance showed small white striae, but was otherwise normal. The bladder contained cloudy urine, its mucous membrane pale. External genitals normal. Stomach and intestine showed a little congestion. Slight enlargement of lymph follicles and Peyer's patches could be made out; no cicatrices nor ulceration. The mesenteric glands were of a somewhat haemorrhagic appearance. The inguinal glands were the most enlarged (5 × 3 cm.), and showed the same changes as the cervical glands. Pancreas and supra-renals normal.

The bone marrow of the femur was reddish, with irregular greyish patches disseminated in it.

Histology

On microscopical examination the organs showed lesions very similar to those of the previous case.

The *Epicardium* showed a varying amount of small-celled infiltration, most marked in the neighbourhood of the larger vessels and continuing along them into the myocardium. The infiltration consisted of leucocytes with a fair number of eosinophile cells and numerous red blood corpuscles. The endocardium also showed small-celled infiltration with similar constituents as in the epicardium. The striation of the muscle fibres was frequently indistinct, and showed accumulations of brown pigment around their nuclei.

The *Lung* presented a remarkable congestion. The vessels of the alveolar septa were cork-screw shaped, projected into the alveoli and contained plenty of large mononuclear leucocytes. In some places were signs of commencing pneumonia. The alveoli were filled with a varying amount of exudation containing eosinophiles, and a large number of red blood corpuscles. There was striking hyperplasia of the lymphoid tissue around the bronchi. In the inflamed parts of the lung were a varying number of diplococci (stained by GRAM's method) and a few bacilli.

The *Liver* showed a little hyperplasia of the connective tissue. The cell rows were attenuated ; of the nuclei some were only faintly stained, others unstained ; the protoplasm being often merely an accumulation of various-sized fat droplets. No pigment was visible. Here and there were accumulations of red corpuscles between the liver cells.

The *Kidney* showed hyperaemia to such an extent that in some small places there was no epithelium to be seen, but only a delicate connective tissue with its meshes filled with red blood corpuscles. The glomeruli were often half-filled by dilated capillaries. Around the vessels were haemorrhages. Here and there parenchymatous degeneration was pronounced, the tissue being transformed into a homogeneous mass, with occasional tubules and a few epithelial cells left, and the whole traversed by numerous congested vessels containing many leucocytes.

The *Spleen* showed hypertrophy and hyperplasia of its follicles. The malpighian bodies were sharply defined and showed a light centre of large, irregularly-shaped cells with vesicular nuclei, other cells with much protoplasm and numerous (six to eight) irregularly situated, segmented nuclei, and a few mono- and polynuclear eosinophiles—all these cells being held in a fine meshwork of connective tissue. Around this centre is a corona of very densely-packed lymphocytes, while the external part is made up of the same interspersed with red blood corpuscles and polymorphonuclears. The congestion is very noteworthy, especially in the peripheral parts, where often nothing is visible beyond very thin sinus walls, surrounded by innumerable red cells. The sinuses contain many leucocytes, with a few phagocytes among them. The difference in staining reaction of the red cells is striking. In the VAN GIESON stained specimen, some of the corpuscles took the picric acid very intensely, others being only faintly or not at all stained. Sometimes they were clumped together and showed small iron-containing pigment granules ; these being found all over the spleen, and both free and intracellular, as for example, in the endothelial cells of the sinuses. The arteries show proliferation of their endothelium, and contain a fair number of leucocytes and a few megaloblasts. The spleen tissue contained phagocytes (with included red blood corpuscles and nuclei of lymphocytes) plasma cells, many eosinophiles, and giant cells of mononuclear type.

The *lymph glands* show generally the same changes as in the first case. The majority of the glands are affected, and all stages can be followed out from normal gland structure to that of haemo-lymph glands.

The following is a description of a typical haemo-lymph gland taken from one of the enlarged glands of the neck :—

There is a marked hyperplasia of the connective tissue, the capsule is thin and has enlarged vessels running in it. Underneath the capsule is the peripheral sinus, which does not extend round the whole gland, since at places the lymphoid tissue reaches the capsule. In the sinus are many red blood corpuscles, a few leucocytes and phagocytes and coagulated fluid ; from this sinus branches run towards the centre. The germ centres are in greater number than normally and are enlarged. They show nothing abnormal in their constituents except an infiltration of blood cells. The vessels often have an accumulation of red cells around them. The arteries inside, and to a less extent outside the glands show endarteritis. In some of the glands, chiefly in the periphery, are ill-defined strands of densely packed lymph cells. Similar patches, but smaller, are found in the central parts of the gland. A good number of phagocytes, a few giant cells, and a varying number of eosinophiles are found in the glands.

The vessels in the adipose tissue about the glands often have small new growths of lymphoid tissue around their walls.

Those lymph glands which appear slightly changed to the naked eye are found microscopically to be highly congested. Thick vessels enter at the hilus and divide into large branches running towards the periphery. Numerous free red blood cells are present among the lymphocytes throughout the glands and also there is a slight quantity of blood pigment giving an iron reaction.

The *long-bone marrow* in some places has the microscopical appearances of red marrow. It is very rich in cells, with but little fat. The vessels are very congested and contain a good number of leucocytes and a few nucleated red cells. The cellular elements present no abnormality, consisting of giant cells, eosinophiles, and a few phagocytes. Blood pigment is present in small quantity.

Eyes show microscopically nothing abnormal except a little infiltration at the corneo-scleral junction and in the cornea. The pial sheath of the optic nerve contains more cellular elements than normal, and the vessels of the nerve show well-marked small-celled infiltration.

Suprarenals are very congested. Enlarged vessels run in the capsule and between the cells separating them.

The *aorta* occasionally shows a little small-celled infiltration around its *vasa vasorum*.

The *central nervous system* presents much the same changes as in the case of 'Kitambo,' but as a rule in a less marked degree.

The leptomeninges are inflamed in varying degrees, the cellular infiltration being chiefly around the vessels, where it consists of a thick layer of lymphocytes; some of the vessels however show no such infiltration around them. This infiltration is found along the vessels running in the sulci, and it is made up of lymphocytes, a few large mononuclears, phagocytes, with peripherally situated nuclei and all sorts of inclusions, a varying number of red blood corpuscles, and cells having the appearance of granulation tissue cells. The infiltration to a certain extent accompanies the vessels into the cortex itself, being usually more marked in its deeper portions, especially in the large grey ganglia. The perivascular space is in places dilated and contains transudate.

In this case also the changes were most marked in the basal ganglia, where a very extensive layer of infiltration was found around nearly all the vessels. The vessels contain a good number of white blood cells, and in the larger arteries sometimes the whole wall contains blood corpuscles interpolated among its own normal constituents.

The perivascular infiltration consists mainly of lymphocytes, a few large mononuclears, granulation tissue cells, and a few plasma cells. External to the layer of cells often occurs a large space filled with transuded fluid. Usually the endothelium of the larger vessels is normal, while that of the smaller ones is proliferated, the intima appearing as little projections into the lumen of the vessel.

The infiltration extends to the brain tissue in the neighbourhood of the vessels, destroying it. The neuroglia is markedly proliferated in places. There are only a very few capillary haemorrhages.

In the *choroid plexus* there are many gaps between the cells and a slight inflammation of the connective tissue. The cells themselves, however, show very little change. The *pons and medulla* show the same perivascular changes as in the cerebrum, with occasional capillary haemorrhages. The meningitis is most pronounced over the cerebellum.

The spinal cord and its membranes show the same changes as the brain. The pia and arachnoid are more or less infiltrated with round cells, the infiltration following the vessels into the substance of the cord. The pia shows a haemorrhage into its substance at the level of the first dorsal. The connective tissue in the pia is loose owing to extravasated red blood corpuscles.

The peripheral part of the cord is oedematous, and its neuroglia proliferated. Around the vessels of the cord the small-celled infiltration is much more marked in those found in the grey substance than in the white; groups of six to ten vessels sheathed in a dense layer of lymphocytes are often observed. The neuroglia is a little proliferated. Various sized small haemorrhages are very often found in the grey matter, especially in the posterior cornua, often involving them to more than one-third their breadth; no blood pigment present. The nerve roots are also the seat of small haemorrhages. The central canal is dilated, and its epithelial cells proliferated. The vessels are generally very much congested, and show a thickening of the intima. The perivascular infiltration often seems to compress the vessels.

The *nerve fibres* show little degeneration, and that mostly around the infiltrated vessels.

The large *nerve cells* of the brain and cord are greatly altered. The changes occur in nearly all groups. Somewhat irregularly distributed side by side with normal cells are others which do not contain any NISSL bodies, and appear disintegrated into a dust-like mass. Sometimes only a peripheral zone of NISSL bodies remains, at other times they are only present in the centre so that all stages of chromatolysis are seen. Often the nucleus is well preserved, at other times it is not distinguishable at all. Irregular, fragmented cells are met with, their processes seeming to have been broken off. Their protoplasm, especially of the cells of the anterior cornua, is often quite filled with small vacuoles.

The *spinal ganglia* sometimes show the same small-celled infiltration around the vessels as in the nervous centre. Small haemorrhages are found here and there.

Many of the *peripheral nerves* were also examined. Some, such as the sciatic and median, appeared normal; others, for instance, some branches of the lumbar plexus, vagus, and others, showed a more or less pronounced small-celled infiltration of the peri- and endoneurium.

Very many sections of all the organs were examined for bacteria with the above-mentioned methods, and, although very carefully searched, yet only a small number of large bacilli and large cocci which did not stain by GRAM's method were seen.

In the examination for trypanosomes in only a few sections of the brain, for example in the vessels of the choroid plexus, were a small number of trypanosomes found.

C.—THE THIRD CASE, BOYO

A black boy, fourteen years of age, died the 25th of May, at six p.m. The examination was not made until the 26th, at five p.m., twenty-three hours after death.

Body was very emaciated with sunken orbits and temples and deeply indrawn intercostal spaces. On the soles of both feet were numerous ulcers caused by chiggers. The limbs were much wasted. Rigor mortis was marked. Over the sacrum was a superficial bed-sore, ten c.m. in diameter. The skull was dolichocephalic, measuring fifty c.m. at circumference. The *dura mater* very adherent to the skull, which was of normal thickness, having deep sulci for the vessels and numerous small depressions for the pacchionian bodies. The dura appeared normal, and its sinuses contained a fair amount of clotted blood. The surface of the brain was of normal configuration, the veins of the pia very congested and filled with dark clotted blood, and showed opaque white bands along the vessels and thickenings in places.

The base of the brain was normal ; the brain substance firm, and the vessels of the grey matter slightly congested ; ventricular system dilated, its ependyma glossy, smooth and firm, showing congested vessels. The cerebellum presented the same congestion of its leptomeninges (Fig. 2), but appeared otherwise normal ; pons and medulla macroscopically normal. The cord showed very congested vessels, the anterior and posterior spinal arteries appearing as thick coiling threads (Fig. 3). On cross section, hardly any change was seen except dilation of the central canal. The tympanic cavity was normal. Diaphragm on both sides reached the fourth rib.

Thyroid was a little enlarged, but appeared normal on section. The mucous membrane of the tracheae was swollen, congested, and of a dark red colour. Nearly the whole of the pharyngeal mucous membrane as far down as two cm. above the glottis was ulcerated, and covered with a stinking greenish-grey coating. The mucous membrane of the nasal cavities showed the same condition, and were filled by a greenish cheesy mass. The ulceration extended along the soft palate to the middle of the roof of the mouth. The uvula was oedematous and swollen. The mucous membranes of the frontal, ethmoidal sinuses and of the antrum were normal.

The *glands of the neck*, especially at the posterior border of sterno-mastoid, were enlarged (some three cm. in diameter), quite free, and on cross section presented a greyish meshwork filled with reddish-coloured tissue. Some of the glands, however, appeared normal.

Both *lungs* were free and not adherent. The visceral pleura was thickened and showed a few haemorrhages. The right lung was generally congested, with here and there patches of consolidation the size of a hazelnut. The mucous membrane of the main bronchus was livid, while the smaller bronchi contained pus. The left lung showed less consolidation than the right, and its main bronchus was only slightly affected.

The *pericardium* contained a few c.c. of yellowish-coloured serum. The heart muscle was pale and flabby. Endocardium, valves, and intima of the aorta normal. The peribronchial glands were slightly enlarged and anthracosed.

The abdominal cavity contained about two hundred c.c. of cloudy fluid. Liver was of normal size, pale and friable, the lobular arrangement indistinct. The gall-bladder full of dark brownish gall.

The *spleen* was enlarged (16 × 11 × 4 cm.), its capsule thickened, its tissue dark red in colour, very soft and easily torn. The malpighian bodies distinct and prominent and of a greyish colour. The urogenital system appeared normal. The mucous membrane of the stomach and intestines was pale ; the latter contained a few examples of *Trichocephalus dispar* of both sexes.

The *mesenteric glands* were slightly enlarged, some being soft and haemorrhagic and others quite normal. Glands of the groin also enlarged (two-and-a-half cm.

long and one-and-a-half broad), reddish in colour on section. Pancreas normal. Suprarenals congested. The bone marrow of the femur was yellowish in colour, and showed several reddish islets.

Histology

The microscopical examination of the *heart* showed an inflammation of the epicardium of some standing. The myocardium showed patches of infiltration around its vessels, which were more numerous in the superficial parts, the muscle fibres being partially destroyed in their neighbourhood. The infiltration consisted of lymphocytes and numerous cells with abundant protoplasm and small round nuclei. The muscle fibres in places were fragmented. Haemorrhages occurred all through the muscle.

The *lungs* presented the appearance of catarrhal pneumonia ; the alveoli were filled with blood cells and exudation, the vessels in the consolidated regions congested, and contained many white cells. The mucous membrane of the right bronchus was desquamated, and in the lumen was a purulent exudate. The lung structure had disappeared in some places, being replaced by exudation containing necrotic particles. The left lung showed similar changes, but to a less extent. Its bronchi contained a fair number of eosinophile cells. The lung tissue and the bronchi were filled with numerous bacteria and cocci, of which many stained by Gram's method.

The sections of the *liver* showed congestion, which was more marked in the periphery than in the centre. The connective tissue around the vessels was increased and infiltrated with lymphocytes. The liver cells were atrophied and filled with fat droplets and their nuclei had disappeared.

The section of the *kidneys* showed cloudy swelling. In its congested vessels are many white corpuscles.

The *spleen* showed considerable alterations of its structure. There was a striking congestion of the whole organ. In the section stained with polychrome methylene blue, stained areas of lighter appearance with a few nuclei in them and darker stained ones consisting of lymphocytes occurred. The light stained areas were the congested parts. The endothelium of the arteries was proliferated. The follicles were hyperplastic, and from them processes extended into the pulp tissue around. The cellular elements were as follows :—Normal spleen cells, numerous phagocytes, giant cells with a polymorphus nuclei and large protoplasmic bodies, and, in addition, a good number of large cells with peripherally placed nucleus and very vacuolic protoplasm. Iron containing pigment, both intracellular and free, was found all through the organ.

The *lymphatic glands* presented the same microscopical appearances as in the other cases, but the changes were not so extensive. Besides congestion, some of the glands showed the same sinus formation as has been described above. These sinuses were filled with red blood corpuscles and large phagocytic cells. Glands with this sinus formation were found in all the groups. Very often the lymphoid tissue was not confined by the capsule, but was also found external to it, and lymphocytes were also interspersed in the adipose tissue. The germ centres in some of the glands were normal, but in others they were broadened out with numerous gaps in their continuity, whilst in others still they were not recognizable at all. The lymphoid tissue was very often interspersed with a large number of red cells, so that in the specimen stained with methylene blue lighter areas of unstained red cells and darker ones of lymphoid tissue were met with. The vessels often had accumulations of red cells around them, and in their lumen many white corpuscles.

Among the various cells found inside the sinus and outside it were very numerous phagocytic cells with red blood corpuscles, which in the specimen stained with modified LAVERAN's method, were deeply stained orange ; other cells were mono- and poly-nuclear leucocytes with eosinophile granules ; cells of the size of large mononuclear leucocytes having small nuclei and basophile granules ; giant cells in limited numbers ; occasional cells such as are found in bone marrow, of an irregular oblong shape, staining a peculiar dark blue colour with haemotoxylin and containing one or more vacuoles, the protoplasm presenting a meshwork with one or two darker-stained spots in it ; and a few plasma cells. Blood pigment, which gives the Prussian blue reaction, was present in nearly all the glands.

The sections of the *bone marrow* of the femur showed the ordinary constituents of marrow ; nucleaed red cells were present in small number. The vessels were congested, and around them were very often accumulations of red blood corpuscles. Some parts presented typical gelatinous degeneration. In one place in the medullary substance of the left suprarenal was an infiltration of lymphocytes. The testes and epididymis were normal.

Brain and spinal cord showed the same changes as in the previous case, but to a far less extent. The pia and arachnoid over the cerebellum and over the convexity, more especially, of the cerebrum, presented a small-celled infiltration. The vessels were highly congested. The small-celled infiltration accompanied the vessels into the cerebral cortex. Many of the vessels of the cortex, however, were free from this perivascular infiltration, and only showed enlargement of the perivascular lymph spaces. The vessels of the grey basal ganglia were the most affected. The perivascular lymph spaces were occupied by a cellular accumulation consisting of lymphocytes, red blood cells, and a few plasma cells. The same changes were observed around the vessels of pons and medulla, while in the cord they were very little marked ; here the vessels have often a much-enlarged perivascular lymph space with a few lymphocytes in it. The cord showed a gliosis of its central canal. The nerve fibres presented very little degeneration, while the nerve cells, however, showed different stages of chromatolysis and pyknosis, more pronounced in the brain, however, than in the cord. The bacteriological staining methods revealed a varying number of large bacilli and large cocci, which did not stain by GRAM's method, in all the organs. They are to be regarded as the result of *post-mortem* contamination.

Trypanosomes were not seen either in the organs or in the central nervous system.

D.—THE FOURTH CASE, DISASI

Well-built, with a fair amount of adipose tissue. Externally, nothing of note. Brain and coverings normal. Right tympanic cavity filled with pus. The whole of right lung consolidated. The lower part of the left upper lobe with the upper part of the lower lobe were congested, and showed small haemorrhages in the pleura.

Liver somewhat enlarged and congested.

Kidneys normal.

Spleen enlarged. Capsule thickened. On cross section the pulp was found soft and showed no particular changes.

All the *lymphatic glands* were enlarged, some being dark-red with pin-head sized grey patches here and there.

The mucous membrane of stomach and intestines pale ; jejunum contained a few ankylostomes.

Microscopical Examinations.—Sections of the *lungs* showed typical fibrinous pneumonia and very numerous diplococci, staining by GRAM.

The *spleen* was very congested.

The *lymph glands* presented the same conditions as in the sleeping sickness cases, only they contained far more free blood corpuscles among the lymphoid tissues. The examination of the *brain* and *cord* did not show any of those changes which were found in the sleeping sickness cases, although a large number of sections of different parts were examined. The perivascular lymph spaces were much dilated. There was neither haemorrhage nor small-celled infiltration in them, but they were often filled with transudation fluid containing one or two free lymphocytes. The large nerve cells only showed such changes as are caused by hyperthermia.

The cerebral vessels contained a large number of diplococci staining by GRAM, and here, as well as in the tissues of the brain itself as in that of the cord, were a great number of large bacilli in small clumps and short chains, not staining by GRAM.

II. EXAMINATION OF ORGANS OF ANIMALS INFECTED WITH *TRYPANOSOMA GAMBIENSE*

We examined the organs of a large number of animals such as monkeys, dogs (including puppies), rabbits, guinea-pigs, rats, and mice, who had succumbed to infection, with various strains of *T. gambiense*.

The brains of some of the monkeys in which the infection had run a longer course showed a marked congestion of the vessels, both in the meninges and in the brain itself. Some brains, especially those in which the infection had run a rapid course, were very anaemic. Those of the latter group showed little or no microscopical changes; those of the former groups, however, presented marked changes affecting the vessels.

The section of one of the chimpanzees' brains showed extreme congestion, especially in the basal ganglia. Fig. 9 is a section from the optic thalamus of this brain. It shows a vessel with a large perivascular space distended with red blood corpuscles and among them a fair number of leucocytes. The endothelium is a little proliferated. The same changes were also observable in many of the neighbouring vessels. The meninges did not show any changes. The pons, medulla, and spinal cord were normal. A *Rhesus* monkey presented, in the region of the left central gyrus, a haemorrhagic cicatrix. Its surface was depressed below the level of the surrounding brain, and was of a yellowish colour. Microscopically it showed destruction of the brain tissue, with much pigmentation at the bottom of the softening.

Two of the infected baboons microscopically examined showed congestion of the vessels of the brain and spinal cord. Microscopically there were haemorrhages around the vessels of the grey matter of the brain, a good number of lymphocytes being present among the red cells. The grey matter of the spinal cord showed many localized haemorrhages. A few of the *Rhesus* monkeys, dying after infection of long duration, showed perivascular changes of varying extent in the brain and spinal cord. Those cases which showed perivascular changes also showed changes in their nerve cells similar to those in the human cases. The processes of the cells were often broken away. Sometimes no nucleus was to be found, and the protoplasm appeared vacuolic.

In the more chronic cases of trypanosomiasis in dogs, rabbits, and guinea-pigs, haemorrhages were present in the grey matter of brain and cord in a limited number. The vessels also often contained a large number of white blood corpuscles, and leucocytes were also found in the haemorrhages. The meninges showed nothing abnormal except a few small haemorrhages. Animals dying more rapidly from the infection did not show these changes in the central nervous system. The other organs showed lesions which varied with the intensity and duration of the infection. The heart often showed all the signs of a haematogenous myo- and epi-carditis. The lungs were often highly congested ; the parietal and visceral pleura had often small haemorrhages. In every case there was great congestion of the liver vessels. They contained a large number of leucocytes. There was proliferation of their endothelium, and they were often surrounded by small-celled infiltration. The liver cells showed fatty infiltration, and, at a later stage, fatty degeneration. Far advanced parenchymatous degeneration was frequently found. The kidneys did not show anything of note, except great congestion of the vessels and smaller and larger haemorrhages between the tubules.

The *spleen*, however, showed great changes. In almost all animals it was more or less enlarged, sometimes up to thrice its normal size. It was generally of a dark purple-red colour, and had a tense capsule. In cases dying after an acute course ot infection its pulp was very soft, and the follicles large and very prominent. Microscopically, the hyperaemia was striking, being more pronounced at the periphery than towards the centre. In some cases small necrotic areas were present.

The spleen cells generally took the stain deeply. The follicles were hyperplastic and irregularly defined, with processes running out from them. They may be described as follows :—a centre of lightly-stained cells having the appearance of granulation cells, around it a dense layer of lymphocytes with numerous red blood corpuscles interspersed. The vessels running in the trabeculae showed proliferation of their endothelium. There were a large number of phagocytes with included red cells and here and there were leucocytes with eosinophile granules. The red blood corpuscles accumulated in the spleen often showed all the signs of degeneration. Blood pigment, giving the iron reaction, was also present, both intracellular and free.

The spleen of those animals which had died after a more chronic infection was in the majority of cases much enlarged, dark, and of firm consistence. The malpighian bodies, however, were not so prominent, but rather seemed to be lessened in number and in size. On microscopic examination, the trabecular system showed much hyperplasia. The whole organ was very hyperaemic, many of the blood cells showing degeneration. The phagocytes and leucocytes with eosinophile granules were increased in number. Some cases had a large amount of blood pigment.

The *lymphatic glands* were usually enlarged, and their stroma hyperplastic. In nearly all the groups besides glands of normal aspect there were others reddish-brown or dark-brown in colour, which presented intersections of greyish bands corresponding to the hyperplastic connective tissue. On microscopical examination they showed sinus formation throughout the gland. The sinus contained many red and white blood corpuscles, phagocytes, which had included pigment, and the granular remains of red blood corpuscles. The lymphoid tissue often had many free blood corpuscles interspersed through it, along with a varying number of eosinophile cells, pigment, and giant cells. In some glands the lymphoid tissue was reduced to smaller or broader bands, between which were lightly stained strips of finely reticulated connective tissue having in its meshes a varying number of blood cells and large hyaline cells packed with pigment and very numerous free pigment granules.

The long-bone marrow sometimes presented the appearance of red marrow. Microscopically it occasionally showed slight gelatinous degeneration.

In animals having large numbers of trypanosomes present in their peripheral blood at the time of death trypanosomes were easily detected in the sections of the organs (Fig. 10).

They were found both singly and in groups in the lumen of the vessels along with numerous leucocytes. Only in the spleen, however, were they found outside the vessels among the tissue cells. For staining the trypanosomes we used a modification of LAVERAN's method, which we found to give the best results for tissue imbedded either in paraffin or celloidin.

The section is stained in a mixture of

1 c.c. Borrel blue
4 c.c. Eosin (1 in 1,000 solution)
6 c.c. Distilled water.

Stain for half-an-hour or a little longer. The section will now be of a dark-blue colour. Wash for a short time in distilled water, and differentiate with orange tannin (Unna), wash again well in water till it appears purple-red in colour, then pass rapidly through absolute alcohol into xylol and mount in *neutral* Canada balsam. A very easy method of dehydrating is to use aniline oil. The sections after differentiation with orange tannin and washing with water are fixed upon the slide. The excess of water is removed by blotting paper, and pure clear aniline oil is added two or three times for a very short time. After removing the oil, the sections are passed through xylol and mounted in the balsam. Both methods by careful management give the same good results. The protoplasm of the trypanosome is stained orange, and the chromatin of a red-violet colour.

The flagellum is unstained. Thin sections are needed to get good results. Thick sections stain blue throughout.

GAMBIAN HORSE TRYPANOSOMIASIS

For studying the lesions caused by *T. dimorphon* in the organs of experimental animals, microscopical examinations were made of monkeys, dogs, rabbits, guinea-pigs, and rats.

Macroscopically, the leptomeninges of brain and spinal cord were very highly congested in all the more chronic cases, showing dilated capillaries in a meshwork of large dark veins. Cross sections showed the same congestion, especially in the grey matter, in which were also a varying number of haemorrhages. The cerebro-spinal fluid was generally increased in amount. The lungs were normal, the heart flabby. There was generally effusion in the pericardium and pleural cavities. The liver was usually much congested, its vessels enlarged and filled with both dark fluid and clotted blood. The capsule was very often thickened.

The *spleen* in all the animals was very much enlarged, being sometimes four or five times its normal size. On section it often showed haemorrhages, the pulp being dark-red in colour. The follicles were usually hyperplastic and prominent.

The *kidneys* appeared normal.

The *lymph* glands were enlarged as a rule, and whilst few appeared normal, most of them were light or dark-brown in colour with greyish intersecting bands of hyperplastic connective tissue.

The *bone marrow* in most cases was dark-red in colour with a few grey islets in it.

Microscopical Examination

In some of the vessels of the grey matter of the brain and spinal cord, the perivascular spaces were filled with red blood corpuscles, pigment granules, and a few leucocytes. The tissue around the vessels was often destroyed.

Spleen. The most striking feature was the extreme congestion which, in the majority of the cases, was most marked in the periphery, where sometimes nothing could be seen but red blood corpuscles with a few spleen cells here and there amongst them. The follicles were enlarged, and consisted mostly of leucocytes. In sections from the periphery, the cells often seemed to be arranged in cords along fine bands of connective tissue. The space between the cords was packed with red blood cells and phagocytes. Nearly all sections showed large numbers of hyaline cells containing red corpuscles and pigment. The more chronic the case the more blood pigment was found in the spleen, so that in all old cases the whole of the organ was filled with large granules, of which a fair number were intracellular. In some sections eosinophile cells were present in large numbers. There were also more or less extensive haemorrhages, the large ones destroying the tissue right up to the capsule, thus accounting for the ruptured spleen sometimes found. The vessels showed great proliferation of their endothelium, so that in places they seemed to be obstructed.

The *lymphatic glands* presented marked changes. Very often the lymphoid tissue was reduced to small cords traversing the gland. Beneath the capsule was a small layer of lymphocytes. The spaces between the bands of lymphoid tissue network contained a few lymphocytes, hyaline cells with two or more nuclei, cells with a large quantity of included pigment, giving the iron reaction, and very many large free pigment granules (see Fig. 11).

It is remarkable that in some cases in which the spleen contained only traces of pigment the lymph glands were practically filled with it. The amount of pigmentation in the glands and spleen increases with the duration of infection.

The *kidneys* were normal in most cases, sometimes they showed parenchymatous degeneration.

The *liver* cells were often wasted, sometimes showing fatty degeneration, and had no nucleus or only a faintly stained one. Blood pigment was often to be found in the liver.

The other organs showed nothing abnormal, except congestion of vessels.

Surra, Nagana, Etc.

We examined microscopically the organs of rabbits, guinea-pigs, and rats infected with *T. brucei* and *T. evansi*, and the organs of young dogs infected with *T. equiperdum*.

In the organs of animals infected with *T. brucei* we found in the brain and spinal cord congestion and a few haemorrhages around the vessels, as for the other organs, we can only confirm Baldwin's findings. We could not find a periodical variation of the pigment of the spleen, but the amount of pigment increased with the duration of the infection. In acute cases there were very often haemorrhages in the spleen destroying its tissue, and often extending up to the capsule. The liver showed small necrotic areas in places.[1] The lesions in Surra and Mal de Caderas were of the same nature, but showed slight variations. The amount of pigment in the spleen in these two latter diseases was always very small. Trypanosomes in groups were found in nearly all vessels.

The organs of one pup infected with Dourine were normal, as were the brain and spinal cord. The spleen was not much enlarged, and was of normal microscopical appearance. The lymph glands were greatly enlarged, however, the enlargement being due entirely to the new formation of lymphoid tissue.

Summary

The pathological histological changes of the brain and spinal cord in cases of sleeping sickness were first described by Mott, Warrington, and the Portuguese Commission. Low and Mott describe the case of a European. Mott has recently, in a lecture on the cerebro-spinal fluid, recorded the changes found in some more recent cases.

The changes described by all the authors are the small-celled infiltrations around the vessels of brain and spinal cord, especially remarkable through the presence of plasma cells. Some of the authors, especially Mott, have described diplococci as being present in the vessels of the central nervous system. In our three cases of sleeping sickness a few cocci and bacilli, negative to Gram, were seen in the brain, cord, and organs, but they were so few in number that they could be considered as due

1. This observation is confirmed by Neporogny and Yakimoff. Modifications du foie dans les Trypanosomiases experimentales (Recueil des Travaux dédiés a M. Lukianoff a l'occasion de son jubilé scientifique. St. Petersbourg, 1904).

to *post-mortem* contamination. The cases died during the summer months; the earliest autopsies were performed four hours after death.

We may draw attention to the fact that large quantities of pure blood or cerebro-spinal fluid taken during life from these cases were inoculated intraperitoneally into monkeys, guinea-pigs, rats, and mice, and intravenously into rabbits without causing any septic infection. As much as twenty c.c. of pure blood has been inoculated, and cerebro-spinal fluid in the amount of ten c.c. Cultures were also made from the blood and cerebro-spinal fluid of two of the cases of sleeping sickness, and were negative, with the exception of one or two tube and flask cultures, which showed a growth of *Staphylococcus albus*.

Undoubtedly a large number of sleeping sickness cases do not die from the original infection, but rather from some secondary infection, such as pneumonia, septic meningitis, etc., caused either through septic processes starting in the oral or nasal cavities or due to the generally debilitated condition, a result of the trypanosome infection. Among the experimental animals a heavy mortality occurs when any epidemic occurs among them. Haemorrhagic lymph glands have been described by DUTTON, TODD, and CHRISTY in their series of sleeping sickness cases. The two first observers have also described such glands in their experimental animals infected with *T. gambiense* and *T. dimorphon* (Senegambia report).

In all the three cases of sleeping sickness, and in the case of trypanosomiasis, and in many of the experimental animals infected with *T. gambiense* and *T. dimorphon*, haemorrhagic lymph glands have been found. These glands have all the characters of the haemo-lymph glands, as described by ROBERTSON, CLARKSON, VINCENT and HARRISON, WARTHIN, DALTON, KELLY, and other observers. These authors describe them as normally present, but in small numbers, in human beings and animals, and always in the neighbourhood of large blood vessels. We find that these glands are present in large numbers, and all stages between normal and haemo-lymph glands are to be seen, especially in the human cases. Necrotic areas were present in the spleens of our human cases and some of the animals. The spleens of all were intensely congested. Blood pigment giving the iron reaction has been found in the spleen and glands of these cases. It would seem from all these facts that an extensive destruction of the blood corpuscles occur and, as the bone-marrow is always degenerated, that there is not a sufficient formation of new cells.

Animals infected with various strains of trypanosomes derived from sleeping sickness and trypanosome fever cases show similar changes in their nervous system and organs as those described in sleeping sickness cases; and these changes depend largely on the duration of the disease; and, moreover, similar changes are described above in animals infected with *T. dimorphon* (but only after the disease has continued for a long time). Further, SIVORI and LECLER describe in their paper, *La Surra Americane* (Mal de Caderas), haemorrhagic areas in the grey substance of the posterior cornua and small-celled infiltration around a blood vessel in the lumbar region of a horse naturally infected with the malady (it had shown paraplegic symptoms). Neuritis has been described in animals infected with *T. equiperdum*.

From these facts one must conclude that the lesions in the brain, cord, and organs can be produced by the trypanosomes. We have only found these changes occurring in animals infected with the parasite for some time, and in whom there were evidences of the duration of the disease, such as anaemia, loss of weight, etc. It would, therefore, appear that only in the chronic infected animals do the lesions occur.

In the 'trypanosome fever' case we have not found the same appearances in the brain and spinal cord as in our sleeping sickness cases, probably because the disease was not long enough established to produce the changes around the vessels of the nervous centres.

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ADDENDUM (see p. 13)

Note on the effect produced on rats by the trypanosomata of Gambia fever and sleeping sickness, by H. G. Plimmer, F.L.S., communicated by Dr. C. J. Martin, F.R.S. Received December 1, 1904. Read January 19, 1905.—*Proceedings of the Royal Society*, T. LXXIV, No. 504, February 24, 1905, pp. 388-390.

Synopsis of the Paper :—

Gambian Fever. Fourteen rats

Parasites appeared about four weeks after inoculation. Duration of disease, two months twelve days. Parasites present in large numbers towards end. Paralysis. Nervous symptoms, none ; before death, animal heavy and apathetic.

Sleeping Sickness. Three rats

Parasites never found in the blood. Duration, six to nine months. Paralysis—

Both hind legs		May 12,	death	May 23
,,	,,	Aug. 2,	,,	Aug. 30
,,	,,	Aug. 28,	,,	Sept. 8.

Post-Mortem

Spleens not enlarged. No microscopic lesions. The blood was citrated and centrifugalized, and the organs were mashed and washed with normal salt solution and centrifugalized, but in no case were any trypanosomata found. Portions of the extracts of liver and spleen and spinal cord were injected into other rats, but up to the present these show no sign of illness. *In an addendum, December* 14, 1904. Two of the three rats inoculated developed paraplegia. The blood examination of these animals fails to discover any trypanosomata. Apart from the paralysis the animals show no sign of ill-health. In the mashed spinal cord of each of the rats the characteristic trypanosomata were found in small numbers, but none were found in the brains which were examined in the same way.

Mr. Plimmer concludes

1. 'These experiments go to show that the two diseases—Gambia Fever and Sleeping Sickness—from which the organisms were obtained, are distinct ; the duration of the disease, the symptoms and the *post-mortem* appearances being quite different. It is evident that these two organisms are quite separate and distinct, as their different effects on similar animals indicate. The fact of the clinical observation that Gambia fever not infrequently appears to terminate with all the symptoms of sleeping sickness may quite possibly be explained by a double infection. For, in both rats and monkeys, the one trypanosoma does not interfere with the other, but the more active organisms—that of Gambia fever in the case of rats and monkeys—kills in about the same time, whether inoculated before, with or after that of sleeping sickness.'

2. 'There can be no question, from the above experiments, of the susceptibility of the rat to the trypanosoma of sleeping sickness.'

3. 'These experiments show that the inoculation of the trypanosoma of sleeping sickness into rats gives rise to no obvious symptoms for many months, nor are trypanosomata discoverable in the blood by microscopic examination. But after a period of from six to nine months paraplegia occurs, leading to the death of the animal ; and *post-mortem* the organisms are found only in the spinal cord. The organisms are thus in rats, as sometimes in man, entirely confined to the nervous system ; where, as in monkeys, they are, in my experience, always generalized at some period of the disease.'

In this laboratory more than seventeen rats have been used in the research. The following tables show the behaviour of the parasite in a *few* of the rats infected with the various strains. The third column gives the record of the parasite as proved by microscopical examination.

Explanation of Signs

+ + + Very numerous, fifty or more to a field.
+ + One or more to a field.
+ Fairly numerous.
– Scanty.
o Absent.
p. Periodicity, the parasites disappearing or diminishing to reappear or increase.

Example—+, p, –, o, read :—
'+,' the parasites were fairly numerous at first.
'p,' periodicity then occurred, the numbers diminishing or disappearing to reappear.
'–' the parasites became less numerous, and
'o' at death the blood was negative.
Unless 'o' is recorded, understand parasites seen at death.

From these figures it is evident that the results of the inoculations of our many different strains are absolutely opposed to those of Plimmer. As noted before, the strains used by Plimmer are two of those used by us and Professor Laveran. The record of the direct inoculations and sub-inoculations of blood from 'Kitambo,' and of blood and cerebro-spinal fluid from 'Tomi,' *show that no such a feature* as no trypanosomes appearing in the blood but in the spinal cord, and later on, paralysis occurring was observed.

Mr. Plimmer claims that in man the organisms are sometimes entirely confined to the nervous system. Careful examination of the blood in such cases would reveal the parasites. As pointed out under Periodicity of the Parasite in the Natives (see p. 10), the daily examination of the blood for many days is necessary before such a decision can be arrived at.

Until Mr. Plimmer can show that he has been able to obtain his original results on a large series of rats inoculated with the Uganda and other strains of Sleeping Sickness, the question may well be raised : 'Must such a dogmatic conclusion, as this result of only seventeen experiments, be accepted as to the differentiation of the parasite of "Uganda" Sleeping Sickness from that of "Gambian Fever"?' The figures of this laboratory are entirely opposed to such a conclusion.

Uganda Sleeping Sickness

Incubation—days	Duration—days	Record of parasites in the blood
20	210	–, o
14	140	–, p
14	127	–, p
9	129	–, p
5	11	+
13	61	+, –, p
5	29	+
4	33	+ +, –, p, +
5	76	+ +, –, p
4	42	+, p

Congo Sleeping Sickness—Direct Inoculations

Incubation—days	Duration—days	Record of parasites in the blood		
18	17	+, –, p	Kitambo	Blood
18	86	+ +, p, +		
13	35	–, p	Tomi	
13	92	–, p, +		
11	54	–, p, o		
19	63	–, p, o		
10	51	–, p	Tomi	Cerebro-spinal fluid
9	47	+, p		
12	68	+, p, –, o		
12	42	–, p, +		

Congo Sleeping Sickness
Subinoculation of Strains from Congo Free State Expedition

Incubation—days	Duration—days	Record of parasites in the blood
10	72	–, p
21	44	–, p
5	70	+, p, o
19	84	–, p
4	187	+, –, p, o

'Congo Fever.'—Direct Inoculations

Incubation—days	Duration—days	Record of parasites in the blood	
9	112	–, p, o	Mpangila
9	191	–, p, +, o	
11	24	+, o	
8	58	–, p, o	
10	168	–, p, o	
7	35	+	Disasi
5	18	–, +	
11	36	–, p, o	
4	19	–	
14	51	–, p, +	
9	57	–, p	Banja
9	39	+, p	
12	50	+ +, p, o	
14	90	+, p, –, o	
14	101	+, p, –, o	

'Congo Fever.'—Subinoculations

Incubation—days	Duration—days	Record of parasites in the blood
14	26	–, p
7	24	–, p, o
10	38	–, p, o
8	102	–, +, p, –
$6\frac{1}{2}$	82	+, p, o
2	76	+ + +, p, +
2	53	+ +, p, –, o
9	49	–, p
9	33	–, +
12	69	–, p, +
15	94	–, p, + +

'Gambia Fever.'—Subinoculations

Incubation—days	Duration—days	Record of parasites in the blood
Gunjur strain		
7	106	–, p, +
3	22	+, p, + +
7	134	+, p, –, o
6	70	+, p, + + +
1	72	+ +, p, –, +
1	35	+, p, –
10	33	–, +
6	72	+, p, + + +
'Q' strain		
8	365	–, p, o
'Lammin' strain		
18	366	–, p, o, +

GLAND PUNCTURE IN TRYPANOSOMIASIS

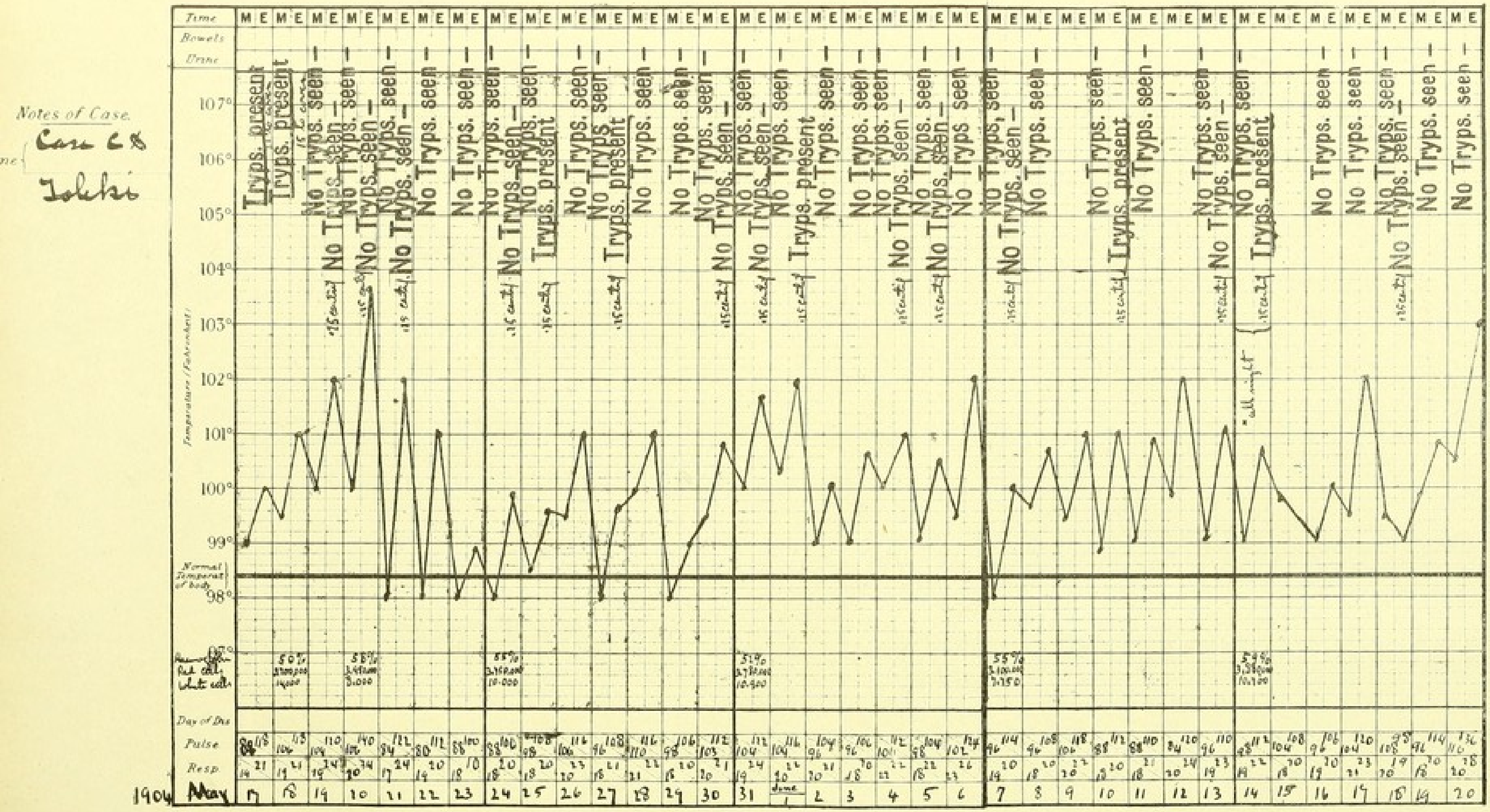

FIG. 1. Commencing at 9 a.m. on June 14 the blood was centrifuged at three hour intervals for a space of twenty-four hours. Parasites were found only at 9 and 12 a.m. Unless it is otherwise indicated the examinations noted were always made with fresh coverslip preparations of finger blood

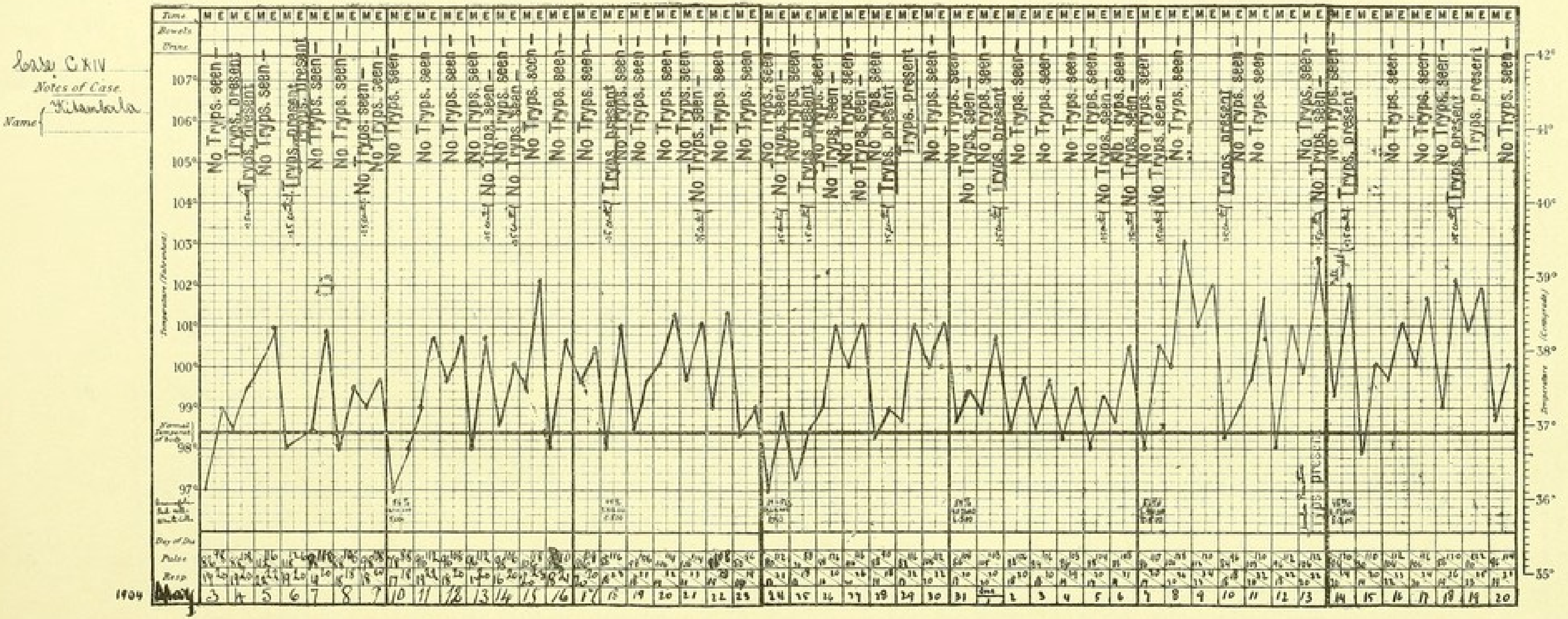

FIG. 2. Commencing at 9 a.m. on June 14 the blood was centrifuged at three hour intervals for a space of twenty-four hours. Parasites were found only at 9, 12, and 6 a.m. Unless it is otherwise indicated the examinations noted were always made with fresh coverslip preparations of finger blood

GLAND PUNCTURE IN TRYPANOSOMIASIS*

COMPARED WITH OTHER METHODS OF DEMONSTRATING THE PRESENCE OF THE PARASITE

FOURTH INTERIM REPORT

From the Expedition of the Liverpool School of Tropical Medicine to the Congo, 1903

BY THE LATE

J. EVERETT DUTTON, M.B. Vict.

WALTER MYERS FELLOW, LIVERPOOL UNIVERSITY

AND

JOHN L. TODD, B.A., M.D. McGill

THE great need of a good routine method of searching for the parasite in persons supposed to be infected with trypanosomes has long been apparent to us.

When the investigation of human trypanosomiasis was commenced it was thought, from the analogy of similar diseases in animals, that the microscopical examination of body fluids, particularly blood, and their experimental inoculation into laboratory animals would be the two methods which might be employed in the examination of suspected individuals.[1] Animal inoculations were soon found to be impracticable because of the uncertain and variable pathogenicity of *T. gambiense* to all ordinary laboratory animals,[1,2] and the examination of the blood alone was relied upon for diagnosis. Unfortunately, the parasites appeared only periodically in the peripheral circulation of even known cases, and often a prolonged search of many preparations was without result or only revealed a single parasite. Therefore repeated and tedious examinations of many preparations were necessary before a suspected case could, even tentatively, be said to be uninfected.

It was found that if infected blood were mixed with some diluent which prevented coagulation and centrifugalized, the parasites were deposited, along with the white corpuscles, between the red cells and serum.[3] Various methods of centrifugalizing large (5 c.cm.) or small (·5 c.cm.) quantities of blood were devised. During the past two years we have employed a simple method of centrifugalizing small quantities of blood which has given very satisfactory results. An inspection of the accompanying charts (Figs. 1 and 2) will suggest how frequently blood negative to coverslip examination has been positive when examined by this method.

* Dr. Todd informs me that this paper was written at Nouvelle Anvers, in August, 1904. A copy arrived in Liverpool two months later, but was unfortunately mislaid, so that the publication of the article has been unfortunately delayed until now. (Signed) Ronald Ross, Professor of Tropical Medicine, University of Liverpool.

The apparatus necessary are an ordinary alcohol lamp, a high speed centrifuge, a few capillary pipettes, a diluting fluid—we used a 1·5 per cent. solution of sodium citrate in normal saline—and a special bulb-shaped tube capable of containing ·25 to ·5 c.cm. (Fig. 3). These tubes are easily drawn out in the flame of a bunsen from easily-fusible glass tubing having an internal diameter of a little more than five millimetres. They are afterwards cut with a file to a length which fits the haematocrit arm of the centrifuge.

It is very necessary for the successful use of these tubes that each step should be done quickly. The patient's finger must be well pricked so that the blood flows freely and in fair quantity. The longer arm of a perfectly clean tube—if it is greasy blood will not enter—is gently touched to the drop of blood and the tube allowed to half fill by capillarity—breathing through the tube just before using it will cause the blood to enter more easily. The tube is then quickly transferred to the diluting fluid and allowed to almost, never totally, fill itself. The filled tube is gently rotated so as to thoroughly mix its contents, and then, held so that there is an empty space at either end, the extreme tip of the longer arm is placed in the flame of an alcohol lamp and allowed to seal. If the mixture of blood and diluent becomes coagulated by heat, or if an air bubble forms in the tube before it is sealed, it will be found better to commence again than to attempt to remedy either defect. The best results are

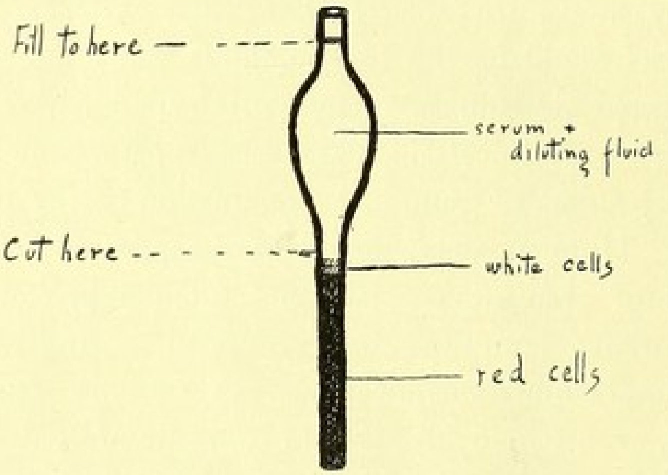

Fig. 3

obtained from tubes so prepared if they are first centrifugalized rather slowly and later at a much higher speed, for instance, for five minutes at eight to nine revolutions per minute of the handle of Deland's centrifuge, and then for two minutes at sixty to seventy (about eight thousand revolutions per minute). At the end of this time a well-marked white ring will have formed above the red cells. The undesired, overlying, clear fluid can be quickly removed by gently scratching the tube at about three millimetres above the white ring with a file and then breaking off the bulb by a smart tap from the same tool. Any superfluous diluting fluid is first removed, and the white cells carefully drawn up together with a small quantity of serum by means of a capillary pipette. If the operation is well done only sufficient material for one coverslip preparation is obtained.

Although such methods are exceedingly efficient, periods do occur during which the most careful examination fails to find trypanosomes in the blood of even advanced cases of sleeping sickness in whom parasites have previously been very numerous. (Fig. 1). Much less, then, can once or twice repeated negative examinations of blood from a merely-suspected person be accepted as proving non-infection.

The introduction of lumbar puncture in cases of sleeping sickness by Castellani supplied a new and valuable diagnostic method, and not infrequently the deposit derived by centrifugalizing from fifteen to twenty c.cm. of spinal fluid showed parasites in individuals from whose blood they had been persistently absent.[4] In early cases of sleeping sickness, however, the conditions were frequently reversed, and trypanosomes were found in the blood, while examinations of the cerebro-spinal fluid remained negative.[5] Neither method, then, can be entirely relied upon. In addition, both spinal puncture and the centrifugalizing of blood require too much time and technique for either to ever become a commonly employed diagnostic method.

The examination of spleen pulp and serous fluids (hydrocele) gave, sometimes startling,[4] but no constantly positive, results.

Although it is scarcely worthy of being considered a diagnostic method, we mention a phenomenon[3] frequently observed in ordinary vaseline-sealed coverslip preparations of fresh blood from cases of trypanosomiasis. The red cells, instead of forming rouleaux as normally, run together into formless clumps and huge agglomerate masses. The condition is easily recognized macroscopically, and the sandy, granular appearance of the preparation is very characteristic. Although this condition is not always seen in infected bloods, and is sometimes observed in preparations from cases who have never been infected, still it has so constantly been associated with the presence of trypanosomes that bloods which 'agglutinate' in this manner are looked upon with the greatest suspicion. More than once has the 'agglutination' encouraged the continuance of an ultimately successful search for parasites. Only once[4] have we had the opportunity of observing a patient (European) from whose blood trypanosomes, once present, have finally disappeared. In this instance autoagglutination of the red cells disappeared with the parasites.

One of the great interests of the note[5] from Capt. Greig and Lieut. Gray, recently communicated by Bruce, was that it suggested a new* and possibly more perfect method of demonstrating the parasite in early cases of trypanosomiasis.

By a comparison of the results obtained from the simultaneous examination of blood, gland juice, and cerebro-spinal fluid from a series of fourteen suspected, though very early, cases of 'sleeping sickness,' we satisfied ourselves that, as a rule, trypanosomes

* Kanthack, Durham, and Blandford[2] had already noted that parasites might occasionally be present in the glands, though absent from the blood, of animals infected with *T. brucei*.

were present in the few drops of fluid drawn by a hypodermic syringe from the enlarged glands of infected persons ; that parasites could be frequently demonstrated by this method where careful centrifugalizing of peripheral blood had failed ; and that the parasites were often seen in as great numbers in the preparations of gland fluid as in the preparations of the sediment obtained by centrifugalizing many (twenty) cubic centimetres of cerebro-spinal fluid.

These results were most encouraging, and it was resolved to test the method further by using it in the examination of apparently healthy persons. Twenty-two natives, coming from districts where the disease occurred, but all absolutely unsuspected of being cases of 'sleeping sickness,' were chosen because of their more or less enlarged glands. These were punctured and trypanosomes were found in the fluid aspirated in eight instances. A simultaneous examination of fresh coverslip preparations only detected two of these cases, and by centrifugalizing the blood only one additional case was revealed. Lumbar puncture was done on two of the cases found to be infected by gland puncture and the spinal fluid shown to be in every way normal. Although the largest cervical glands have usually, for convenience sake, been those punctured, parasites have been found, with equal facility, in glands no larger than peas and in glands from other groups.

Only twice during the examination of a series of thirty cases of trypanosomiasis did a single examination of gland fluid fail to demonstrate the parasite which other methods of examination showed to be present.

On seven occasions (in twenty-six cases) it was successful when centrifugalizing the blood had failed, and it was thrice positive (sixteen cases) where examinations of the cerbro-spinal fluid had given negative results.

Although a general glandular enlargement is very common among African negroes, it seems possible that, at all events in infective areas, persons with much enlarged lymphatic glands must, other causes being absent, be regarded as possible cases of trypanosomiasis. For example, fresh coverslip preparations of blood from a squad of twenty-six healthy soldiers were examined. Two men were infected. Both had been previously chosen, with three others, for gland puncture because of their enlarged cervical glands. Unfortunately, further examination of these cases was not permitted.

A small herd of cattle was established near Coquilhatville in 1902 by the Congo Government. The cattle suffered a good deal from an unrecognized chronic wasting disease, ending in death. The veterinary surgeon (M. Bertolotti) in charge had made an excellent report to the Governor upon the clinical aspects of the disease, and there seemed to be some analogy between the symptoms which he described and those observed in Gambian horses and cattle infected naturally, or by inoculation, with *T. dimorphon*.[1]

When we arrived in Coquilhatville only one cow out of a herd of forty odd head showed obvious signs of disease. The first examination of its blood was negative. Ten days later the blood was again centrifugalized, and trypanosomes were found. The fluid from a superficial neck gland was examined at the same time, and parasites, in fair numbers, were seen to be present. Three days later the animal was killed and an autopsy performed. Parasites, though once more absent to ordinary coverslip preparations of blood, were again found by centrifugalizing. They were also seen in the juice of a hyperaemic mesenteric gland, which was examined almost immediately after the animals death, in about the same numbers as at the previous examination of cervical gland fluid. After this positive result it was extraordinary that many preparations, made one or two hours after death from glands taken from various parts of the body, should have all been negative, while preparations from blood, pleural, pericardial, and peritoneal fluids all showed active parasites.

This observation has a most interesting parallel in the results of our autopsies on cases of sleeping sickness.[4] Only once,[4] and that in an autopsy done within an hour after death, have trypanosomes been found in gland fluid taken *post-mortem* from cases of human trypanosomiasis, but living parasites have very frequently been seen in the various serous fluids.

The bloods and gland fluids of several other animals from this herd were examined with negative result.*

We conclude that :—

(1) The examination of glandular fluid, though not infallible, is a very efficient means of detecting the presence of trypanosomes,

(2) Because of its simplicity gland puncture will be found a very useful routine diagnostic method.

* The neck glands of two cows, infected with trypanosomiasis, since examined at Nouvelle Anvers, were found to contain parasites.

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Fig. 1

Brain of a case of sleeping sickness (Kitambo). (See p. 66)

Fig. 2

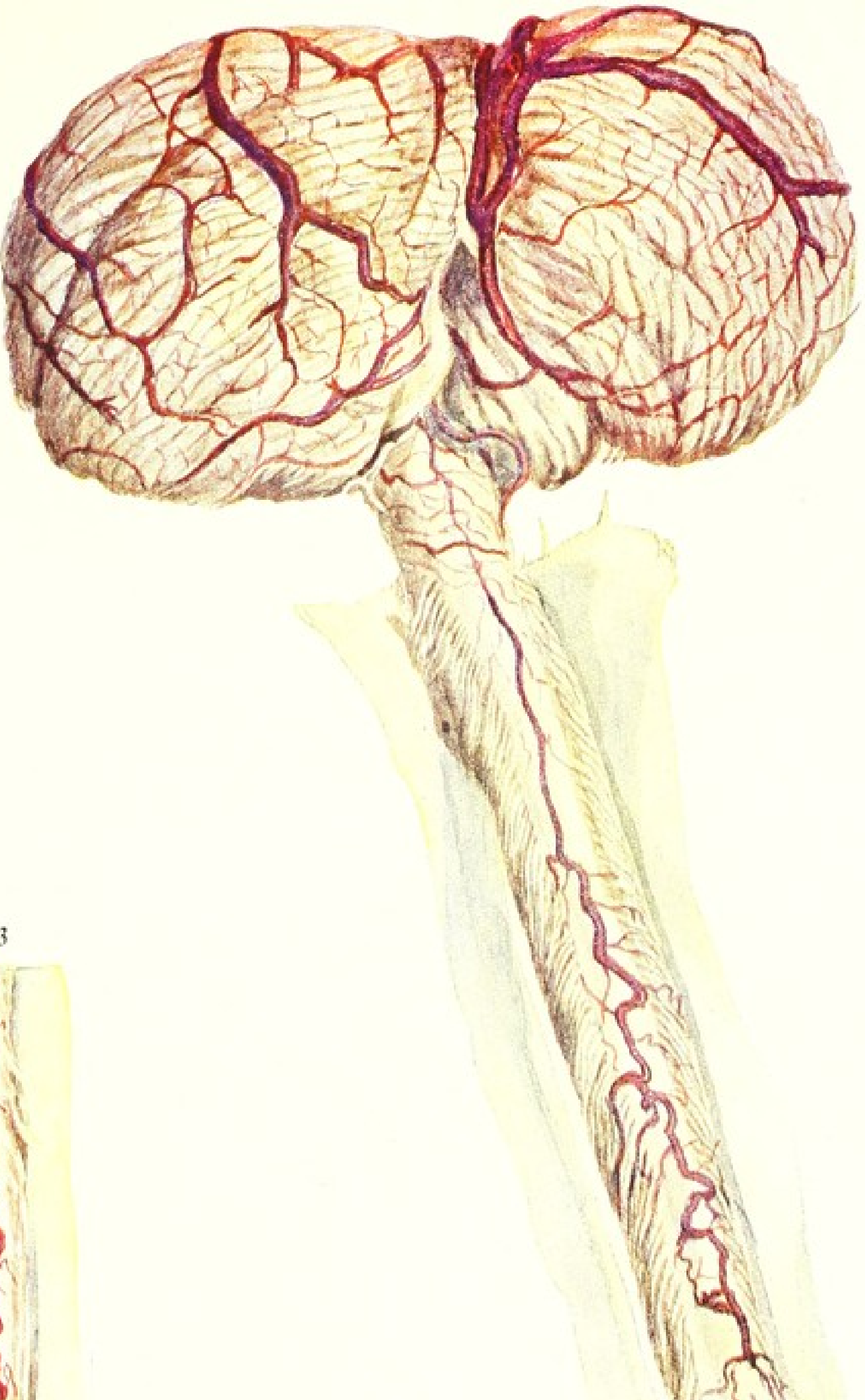
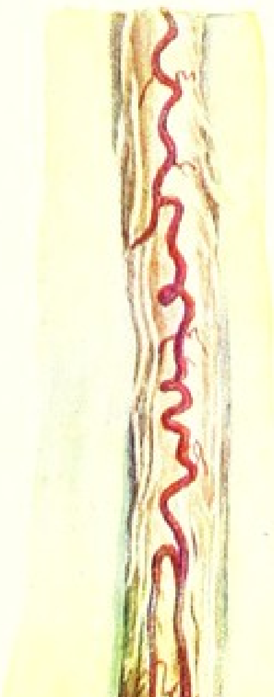
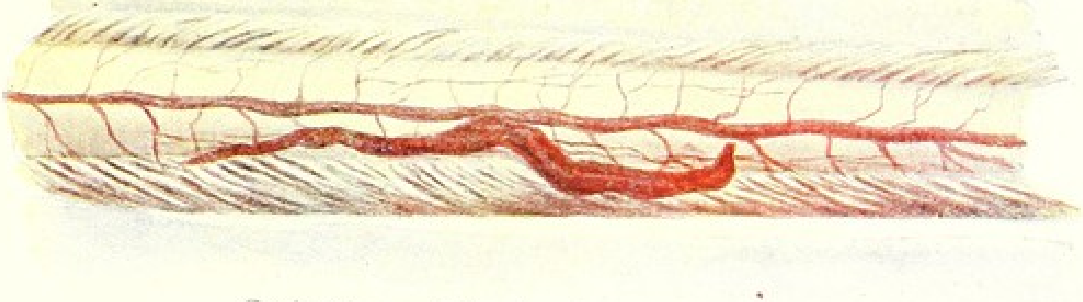


Fig. 3



Cerebellum and cord of a case of sleeping sickness (Boyo). (See p. 81).

Fig. 4

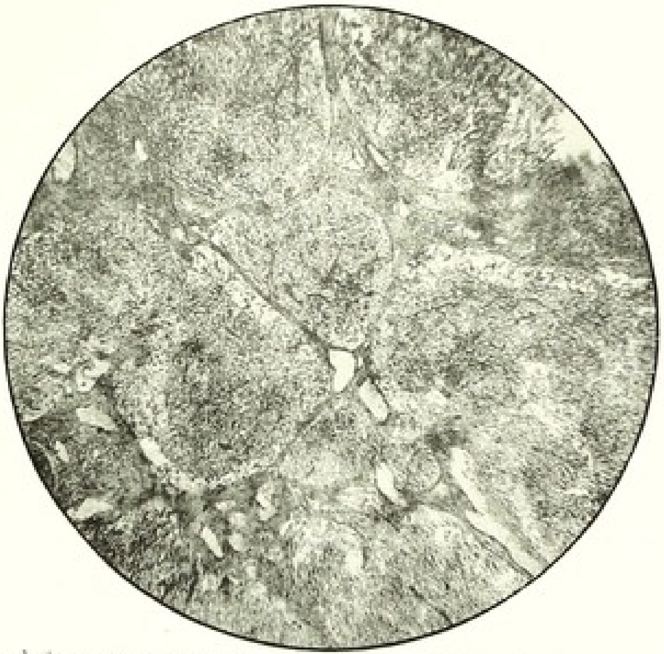


Cord of a case of sleeping sickness (Tomi). (See p. 75).

Fig. 5

Lymphatic glands from a case of sleeping sickness (Tomi). (See p. 76).
To show hyperplasia of the connective tissue.
(A) and (B) Cervical ; (C) Retroperitoneal

Fig. 6



Section of cervical gland from a case of sleeping sickness (Kitambo), x 60. (See p. 70)
To show hyperplasia of connective tissue

Fig. 9

Section of brain (*Thalmus opticus*) of chimpanzee infected with *T. gambiense*, x 300. (See p. 85)
To show small-celled infiltration and haemorrhage around a vessel

Fig. 7

Section of mesenteric gland from a case of sleeping sickness (Kitambo), x 90. (See p. 70).
To show sinus formation. The sinus contains phagocytic cells and red blood corpuscles
(a) blood vessel ; (b) sinus

THE NATURE OF HUMAN TICK-FEVER IN THE EASTERN PART OF THE CONGO FREE STATE

LIVERPOOL SCHOOL OF TROPICAL MEDICINE—MEMOIR XVII

THE NATURE OF HUMAN TICK-FEVER IN THE EASTERN PART OF THE CONGO FREE STATE

WITH

NOTES ON THE DISTRIBUTION AND BIONOMICS OF THE TICK

BY THE LATE

J. EVERETT DUTTON, M.B.

(WALTER MYERS FELLOW OF THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE)

AND

JOHN L. TODD, B.A., M.D. McGill

AND AN APPENDIX ON THE EXTERNAL ANATOMY OF ORNITHODOROS MOUBATA

BY

ROBERT NEWSTEAD, A.L.S., F.E.S.

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PREFACE

Four months ago we were in possession of the main facts stated in this paper. Illness and death retarded the gathering of information and the recording of our observations. It is only now possible to publish a part of our work. At the end of November we both fell ill with recurrent fever. Dr. Dutton's illness was severe, and it was not until the middle of January that his convalescence obviously began. Unfortunately, he over-rated his strength, and even before his fever subsided commenced once more to work, harder and for longer hours than ever. On the twenty-first of February his fatal illness commenced, the twenty-seventh of February he died, after four days' unconsciousness.

For almost a year and a half Dr. Dutton and I have worked together in the Congo. This communication represents only a small part of the results of our observations. Other reports, based on our common work, must soon be written by me alone.

May any weakness in all be recognised as mine, and in nowise due to my absent comrade.

J. L. T.

KASONGO, March 28, 1905.*

* On March 24, 1905, we received the "British Medical Journal" for November 26, 1904, containing the note of Ross and Milne on tick-fever. They are to be congratulated on their discovery. The present paper will help to complete their observations.

THE NATURE OF HUMAN TICK-FEVER IN THE EASTERN PART OF THE CONGO FREE STATE

BY THE LATE

J. EVERETT DUTTON, M.B., Vict.

(WALTER MYERS FELLOW OF THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE)

AND

JOHN L. TODD, B.A., M.D McGill.

On the twenty-sixth of November, 1904, we sent a message to the Committee of our School saying that a spirochaete was the pathogenic agent of the human tick-fever which occurs in the Oriental province of the Congo Free State, and that we had been able to infect monkeys with spirochaetes through the bites of ticks.

In the countries of Africa where it occurs the human tick is generally found to have an evil reputation among the natives. To its bite is attributed a sickness of longer or shorter duration, which may end in death. Accounts of the sickness are mainly derived from the writings of travellers.

Livingstone was the first (4, 5) to describe a "human tick disease" in Portuguese South Africa. In the beginning of 1903 Manson, in his work on Tropical Diseases, (1) was able to sum up in two short pages the known facts of the African disease.

Since our arrival in the Congo our attention has often been called to the human tick and to its evil properties. We found that natives who knew the arachnid had, as usual, a decided dread of it; but it was not until we had left Stanleyville, on our way up the Congo to Kasongo, that we constantly encountered the tick, and saw, for the first time, cases of the disease. We were at Nyangwé, an infective centre, from November 13 to 22, 1904. Here we collected a large number of ticks for experimental purposes, and were fortunate enough to obtain an autopsy on the only fatal case of "tick-fever" that we have seen. We reached Kasongo on November 23, and have here seen further cases, and have been ourselves attacked by the disease.

From this clinical material, from transmission experiments with ticks, and from information and reports received from residents in the Congo, we have been able to show that "tick-fever" in the Oriental province is a relapsing fever, produced by a spirochaete, probably identical with *Spirochaete Obermeieri*, and that this organism can be transmitted by the bite of the tick.*

In addition, we have in one experiment been successful in transmitting the spirillum by the bites of young ticks newly hatched in the laboratory from eggs laid by infected parents.

* We are not in a position to identify the species of ticks which we found in the Congo. All that we have seem to be the same as those we found in the Lower Congo, and judged to be *Ornithodoros moubata*. Some of our specimens have been taken home by Dr. Christy, and have been identified by Mr. R. I. Pocock, of the British Museum as *Ornithodoros moubata*.

The History of Human Tick-fever in the Oriental Province of the Congo Free State.

Livingstone mentions being annoyed by human ticks while at Nyangwé, in 1871; but he does not speak of them as producing disease (2, 3), although he was well acquainted with their pathogenic properties (4, 5). Dr. Hinde, who accompanied the expedition which drove the Arabs from this part of the Free State in 1892-94, saw, at Kasongo, ticks and sick persons who attributed their illness to the bites of these acarids (6). Although he lost some of his own men from the same cause, he believed that the tick was harmless, and the natives had died through the force of an ignorant superstition. His opinion has been shared by practically all the Europeans knowing this district whom we have met. Each told us of the "*Kimputu*"—the local name for the tick—and of the imagined deadliness of its bite. Almost no one believed that there might be some truth in the natives' belief. As a result, all who reported ill through "*Kimputu*" bites were at once suspected of malingering.

It is not altogether difficult to see how such a mistake could perpetuate itself. To a casual observer the human tick resembles the ordinary "harmless" cattle tick.

As Dr. Hinde justly observed (6), ills which have no connection with the tick are attributed by the natives to its bites. The real nature of tick-fever has probably escaped recognition by physicians—microscopes have not been used—through this fact, and because, as seems probable, atypical cases—such as those described below, "No. 7" and J. L. T."—may not infrequently occur. Among all the natives whom we have questioned, only one has certainly recognised the recurrent nature of tick-fever.

In the more typical cases the symptoms of a disease which prostrates the patient on one day and leaves him free from fever on the next must have puzzled many, who could not suspect their specific nature, were it not that to most persons in this part of Africa every fever is malarial, and quinine is at once given. The naturally falling temperature of relapsing fever might thus be easily made to furnish the "therapeutic proof" of its malarial nature. Our own experience illustrates how easily mistakes might occur in diagnoses uncontrolled by the microscope, and based on only a single observation made, perhaps, between the attacks. Since we have been in the Oriental province twenty-four reputed cases of tick-fever have come, or have been sent, to us. The symptoms of seven of these patients were explainable on other grounds. Six were infected with trypanosomata, one with malarial parasites. Seven of the remaining cases gave histories similar to that recorded below in Case 3, and no cause for their illness was discoverable during the one or two days that they were under our notice. In only ten did we find spirochaetes. We have in addition seen spirochaetes in two soldiers, new-comers, who had never heard of the "Kimputu." In all we have had under observation twelve natives infected with spirochaetes.

Immunity, Susceptibility, and Mortality.

Sir John Kirk said (1), while speaking of the tick-fever on the Zambiese, that after recovery from tick-fever the patient had complete immunity from further attacks. We have been told by natives that a man can only once be made ill by the "*Kimputu*." It seems very probable that those living in infected localities may have relapsing fever while young, and grow up immune to the affection. Several Zanzibar traders have lately told us that the human tick "*Papasi*" (7) of Udjiji and Zanzibar (they assert they are the same as the ticks of this region) are harmless, and that their bite gives no disease. As already noticed, Livingstone, in 1871, did not mention that the ticks—"*Tapasi*"—of the Arab town at Nyangwé produced any disease (3). Nyangwé has at present a particularly bad reputation. The natives living inland who are forced to come to that post always endeavour to avoid sleeping there. A small caravan comes monthly to Nyangwé to bring in produce from villages some two days' walk inland. The porters formerly slept at Nyangwé before returning home. As a result there was always some one sick with "*Kimputu*" in their villages. It is generally accepted that strangers are particularly susceptible, and it seems certain that the majority of cases in this district occur among newcomers. All of our cases, save Nos. 2, 4, 7, had recently been exposed, for, probably, the first time to tick bites.

The mortality from tick-fever does not seem to be very great amongst those who are cared for and not exposed to fatigue and hunger. Under adverse conditions the death rate may be high; for example, of twenty carriers who contracted the disease in one caravan sent from Kasongo to Kabambarré ten died

Incubation Period.

The period intervening between the bite of the tick and the declaration of the disease is, from our experience, about one week. The natives usually put it at five days. Occasionally symptoms are said to follow within a few hours of the bite. In no case have we been able to personally verify the dates of both the bite and the commencement of the fever.

Symptomatology.

In the two European cases slight prodromata, mental heaviness, and lack of acuity were noted. In all the cases the onset of the fever has always been sudden, and in no instance preceded by a distinct rigor. The patient is prostrated, and complains chiefly of severe headache, usually frontal occasionally general. Boneache—in the limbs, and backache are distressing: the patient feels as if well beaten. There is a marked distaste for food. Vomiting generally occurs once or twice, but has never been continued. Slight diarrhoea is fairly constant, constipation may occur. The evening temperature during the attacks frequently reaches 104.5° F.; the highest temperature recorded is 105.3deg. F. There are usually three or four attacks which often end in more or less profuse perspiration. As a rule each attack lasts for three or four days, and the intervening periods vary from five to nineteen days.

The spleen is sometimes, not always, enlarged. Herpes, epistaxis, and hiccough, were complications observed. The most characteristic features of the disease have been the prostration of the patients during the attack of fever, and the quick return to comparative health with the fall of the temperature.

The following case reports, charts, and *post-mortem* finding certainly demonstrate the clinical identity of the tick-fever observed by us with the relapsing fever of the text-books (8, 9).

Reports of Native Cases.

CASE 1.—Female, age 27, seen at Lokandu, October 30, 1904, under observation for two days.

History :— Patient and her husband, a soldier, were on their way from Lake Tanganyika to the Lower Congo. On the night of October 12 she was bitten by ticks on the thigh, neck, and arm. Three ticks were caught in the morning, no obvious marks of the bites were left. The following day Kasongo was reached; here the patient remained for a week. On October 21, the day after leaving Kasongo, she fell sick. The incubation period that is, the interval between the bites of the ticks and the appearance of symptoms, is, therefore, in this case about eight or nine days. On getting up in the morning she complained of terrible headache, accompanied by throbbing of the ears. Her husband says that there was fever but no shivering. The headache, though apparently chiefly frontal, extended around the head to the occiput. There was no accompanying nausea or vomiting.

Present Condition :—Temperature sub-normal; pulse 70; respiration 20. The patient is a fairly developed woman; no wasting. She has a pained expression, and keeps the head fixed. Because of severe headache has a piece of "tie-tie"—native cord—tied tightly around the head across the forehead. It is apparently disagreeable for her to be placed in a bright light. She has lost her appetite, and complains of a bad taste in the mouth. She walks gingerly with the help of a friend; extremities are cold; respirations somewhat laboured. Liver is not enlarged or tender. Spleen is distinctly enlarged, extends 5.5cm. below costal margin, not tender. Tongue is flabby and furred. Patient otherwise normal.

October 31st.—Temperature a.m., 97.8; p.m., 101.2; respiration and pulse as before. Headache is still very severe. A slight fulness around eyes is noticed.

Blood examination :—No malarial parasites or trypanosomes were seen in either fresh or stained preparations. In two stained films taken on October 30th two spirochaetes were seen.

CASE 2.—Female, age 26, seen at Ukungwa, October 31, 1904; under observation for one day.

History :—Patient was bitten a month ago by a tick. A week later high fever with chills commenced. At present has no fever, but is weak, quite thin, and still complains of severe headache and of pain in the eyes. Physical examination revealed nothing abnormal; the spleen was not enlarged. No malarial parasites or trypanosomes were seen in either fresh or stained preparations of blood. In four stained films as many spirochaetes were seen. Many ticks were found in the house—a rest-house for native travellers—in which this patient lived. She was the wife of the caretaker, and was not a native of the district.

CASE 3.—Male, age 20, seen November 6, 1904, at Sendwé; under observation for two days.

History :—Patient, a native of this neighbourhood had been employed as a labourer at Stanleyville. He was on his way home, and while at Ukungwa, where he slept in the house inhabited by Case 2, he was bitten by a tick. Patient says that symptoms

DISEASE.

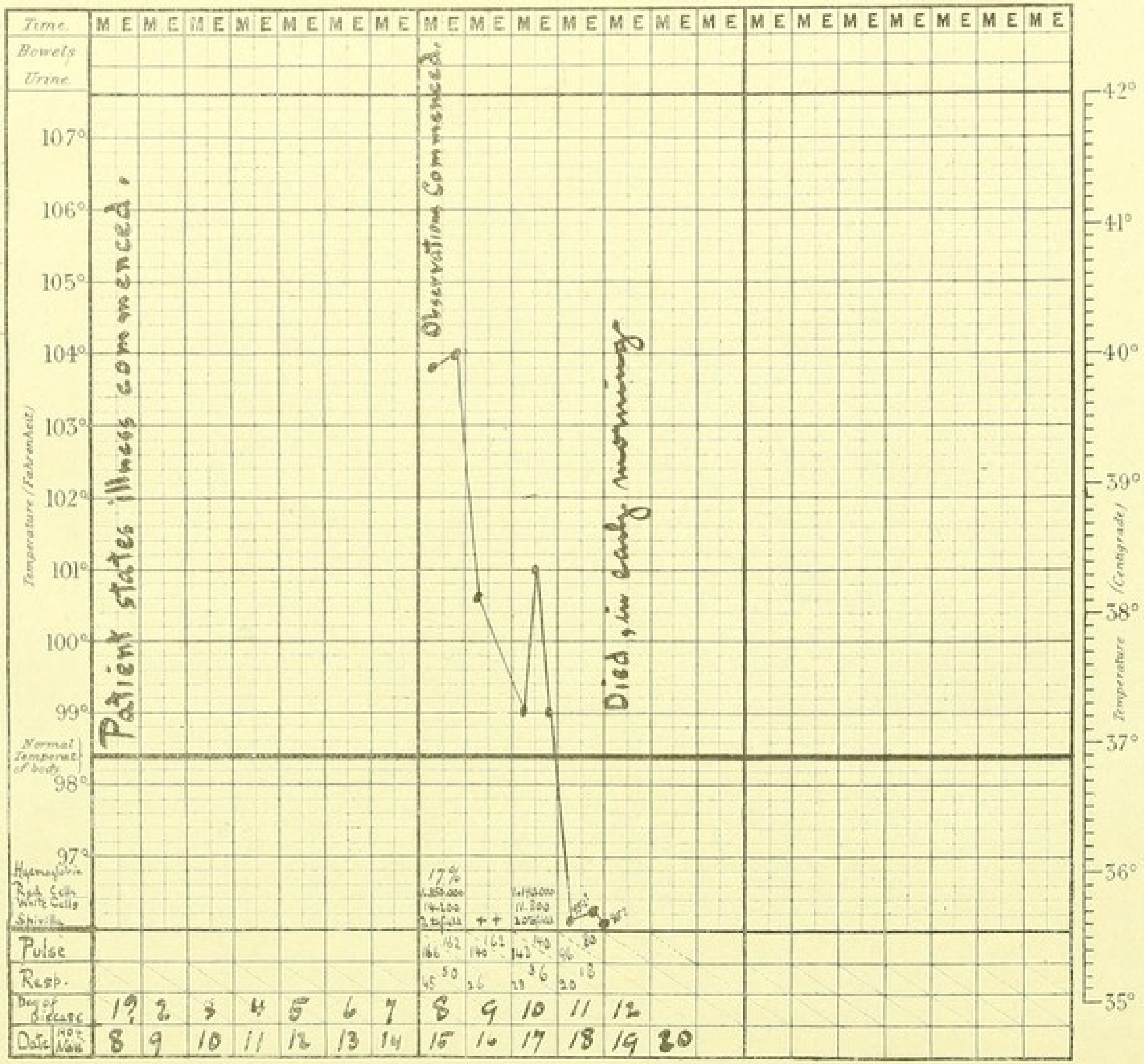
Spirillar Fever

Notes of Case.

Name Case, 4.

Age ♀, 14 : African

Chart I



to face p. 5

commenced on October 15th, four days after the bite. On his arrival at Sendwé, October 24th, where he was employed as a labourer, patient seemed strong and well, and it was not until about a week later (October 31) that he was noticed to be ill. It is very doubtful whether there was any rigor, and the history of fever during the first four or five days of the disease is uncertain. The patient says that his illness commenced with a "bad mouth," and a distaste for food. Pain in the eyes with frontal headache, pain in the nape of the neck and in the loins successively appeared. Patient asserts that these symptoms persisted, though lessening in intensity, up to the present (Nov. 6). There has been no vomiting or diarrhœa—took native enemata. The resident European says that patient is certainly thinner and less robust than on his arrival here.

Present Condition:—Pulse, respiration, and temperature normal. Patient is a thin man, has apparently lost flesh; is obviously weak; has pained expression; eyes watery. Physical examination showed nothing abnormal; spleen not enlarged or tender. The lymphatic glands of the inguinal region were alone enlarged. Blood examination:—Many fresh, centrifuged and stained preparations of the blood were taken. No malarial parasites, trypanosomata or spirochaetes were seen. A few filaria, sheathed and unsheathed, were present. Fresh and stained specimens of spleen juice showed no parasites. Gland juice was examined with negative result.

The history and record of examination of this patient are typical of six other cases who have been brought to us, some weeks after the commencement of their illness, but while they were still weak.

CASE 4 (*Chart No. 1*).—Female, age 14, seen at Nyangwé, November 15, 1904; under observation for four days preceding death.

History:—Patient was born and has always lived in this neighbourhood. On November 7, at about midnight, she was bitten on the foot by a tick. Before daybreak fever, headache, vomiting, and purging came on. The diarrhoea persisted for four days. The vomiting quickly stopped, and recurred only once on the third day of the disease. Though patient has always eaten well, she does not seem to have relished her food. On the second day of her illness she was brought to Nyangwé. She then had generalised headache and pain in her legs; she was in a fever, trembled continually and felt very weak. In spite of these symptoms she has continued work in the gardens.

Present Condition.—Temperature 103.8, pulse 166, respiration 45. Patient is a well-matured, but slight and thin child; is too weak to walk alone, and prefers to lie, not sit on the floor.

Although patient and her master deny that there has been any abeyance in the symptoms, it seems that she is more ill to-day (November 15) than yesterday. This morning she claims to have got up well and to have gone to work as usual, but as the sun became hot she became "tired."

Physical examination revealed no abnormalities save slight puffiness and yellowishness of face about the eyes, and a greatly enlarged spleen, which reached, patient lying on back, to below the umbilicus. Its superficial markings, in the recumbent position, are indicated in the accompanying photographs (Pl. 3, fig. 1).

Blood examination:—Coverslip preparations showed large numbers of spirilla. No malarial parasites or trypansomata were ever seen in this case. On splenic puncture the fluid aspirated contained spirilla in apparently the same numbers as finger blood.

The patient became steadily weaker, spirochaetes were constantly present in her blood, and she died early in the morning of November 19.

Autopsy:—The examination commenced at 9 a.m., six hours after death. The body was that of a thin, but not emaciated girl. Post mortem rigidity present throughout. Skin fairly clean, no eruption. Oedema of dorsa of both feet and of upper and lower eyelids. Pupils equally and widely dilated; mouth clean; no icterus. The usual incision was made; subcutaneous fat fair in amount; much light-coloured blood escapes from cut vessels—looks like blood-stained water; no oedema present over abdomen.

Abdomen: Contains about 5ccm. slightly blood-stained fluid; omentum retracted.

Thorax: Pericardium and pleura normal; about 50ccm. clear fluid in pericardial sac. Heart, weight 114 grammes, on whole fairly normal; muscle pale, firm, slight fatty change at apex of papillary muscle. The extended valves measure—pulmonary 5cm., tricuspid 9.26cm., mitral 8cm., aortic 4.75cm.

Lungs together weighed 342 grammes, are very pale, otherwise normal.

Liver: Weight 1,132 grammes, measures 23 by 14 by 8cm.; cuts firmly, on section very yellow and shiny; no amyloid reaction. Gall bladder pale, moderately filled with viscid bile.

Spleen: Weight 342 grammes, measures 15 by 8.75 by 5.5cm., cuts firm and hard, not easily friable.

Kidneys: Weight together 114 grammes, right measures 7.8 by 4.6 by 2.5cm., cortex 0.6cm, both are almost bloodless and cut firmly, capsule peels with ease; colour, particularly in pyramids, is dirty, brownish-yellow, suggesting fatty degeneration.

Bladder: Normal, filled with highly coloured urine.

Pancreas normal. Stomach and intestines contained no food, many round worms, and very many anchylostomes.

Lymphatic glands normal. Bone marrow at middle of femur was saffron-coloured and firm.

Films taken at the autopsy showed the continued presence of spirochaetes.

CASE 5.—Female, age 28; under partial observation during course of illness.

History:—The patient, coming from Stanleyville arrived at Nyangwé on November 13. The illness commenced there on November 22 with fever, headache, and pain in the limbs. There was no history of a tick bite. On November 23, fever and pain persist; severe vomiting. November 25, temperature 99.6, feels almost well, complains bitterly of aching thighs and calves. Patient remained well until December 4, when the symptoms recurred and spirilla were found in the blood (first examination). This, the second attack, lasted until December 8. There was then a complete absence of symptoms until December 17, when the third and last attack came on with severe vomiting, boneache, and fever.

CASE 6.—Female, age 18; under partial observation during course of illness.

History:—Patient, coming from Stanleyville, arrived at Nyangwé on November 13. The illness commenced there on November 21 with fever, very severe headache, vomiting (once), diarrhoea, and pain in the back. There is no history of a tick bite. On November 22 and 23 the temperature varied between 104.5 at night and 101 in the morning. On November 24 temperature normal, and patient, save weakness, well. Second attack commenced on November 29, with the same symptoms, evening temperature 104. On the afternoon of November 30 profuse perspiration came on, and the temperature fell to normal. Patient then remained without fever until December 14 and 15, when the usual symptoms returned, evening temperature 103. December 16, temperature returned to normal, and patient remained well.

Rather profuse expistaxis occurred in this case on November 22 and 29. The spleen, slightly enlarged after the first attack, was, after the third, 5cm. below the costal margin. The blood was examined on November 29, and numerous spirochaetes seen.

CASE 7.—Male, age 26; seen January 6, at Kasongo; under observation for five weeks.

History:—Patient has lived in Kasongo for the past two years. He states that about a week or ten days ago he was bitten during the night by two ticks. He caught them, burned them, cut his skin at the site of the bites, and rubbed in the ashes as a preventive against tick fever.*

Two days ago his illness commenced, he complained of feeling cold, having fever, trembling and weakness. He has been unable to take food for two days.

* This is the treatment usually employed by natives of this district for tick bites. Its prophylactic powers are widely believed in. Livingstone mentions (5) an analogous practice.

DISEASE.

Spirillar Fever

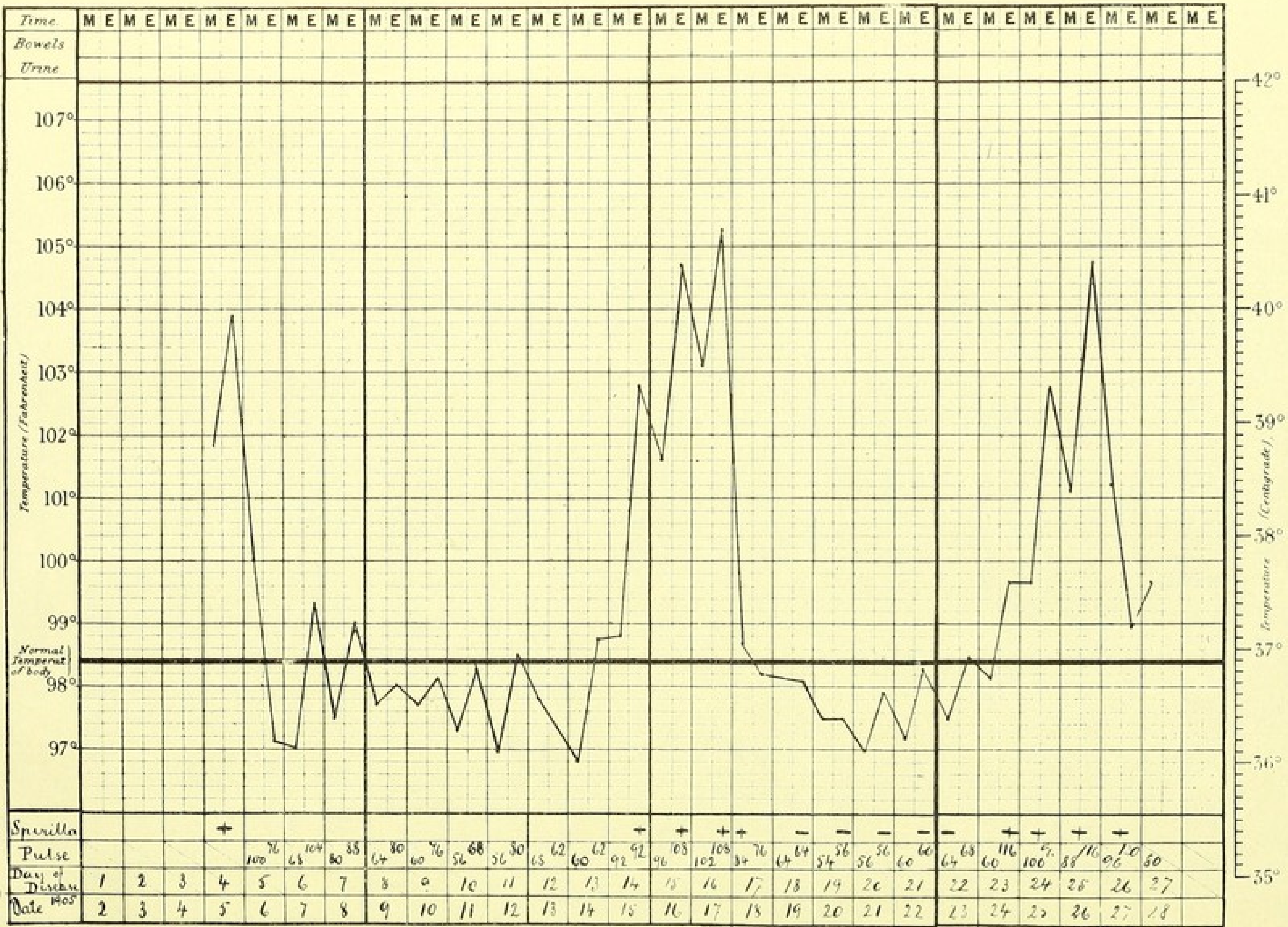
Notes of Case

Name { Case 8

Age ♂, 19

African

Chart II



to face p. 7

DISEASE.

Spirillar Fever

Notes of Case.

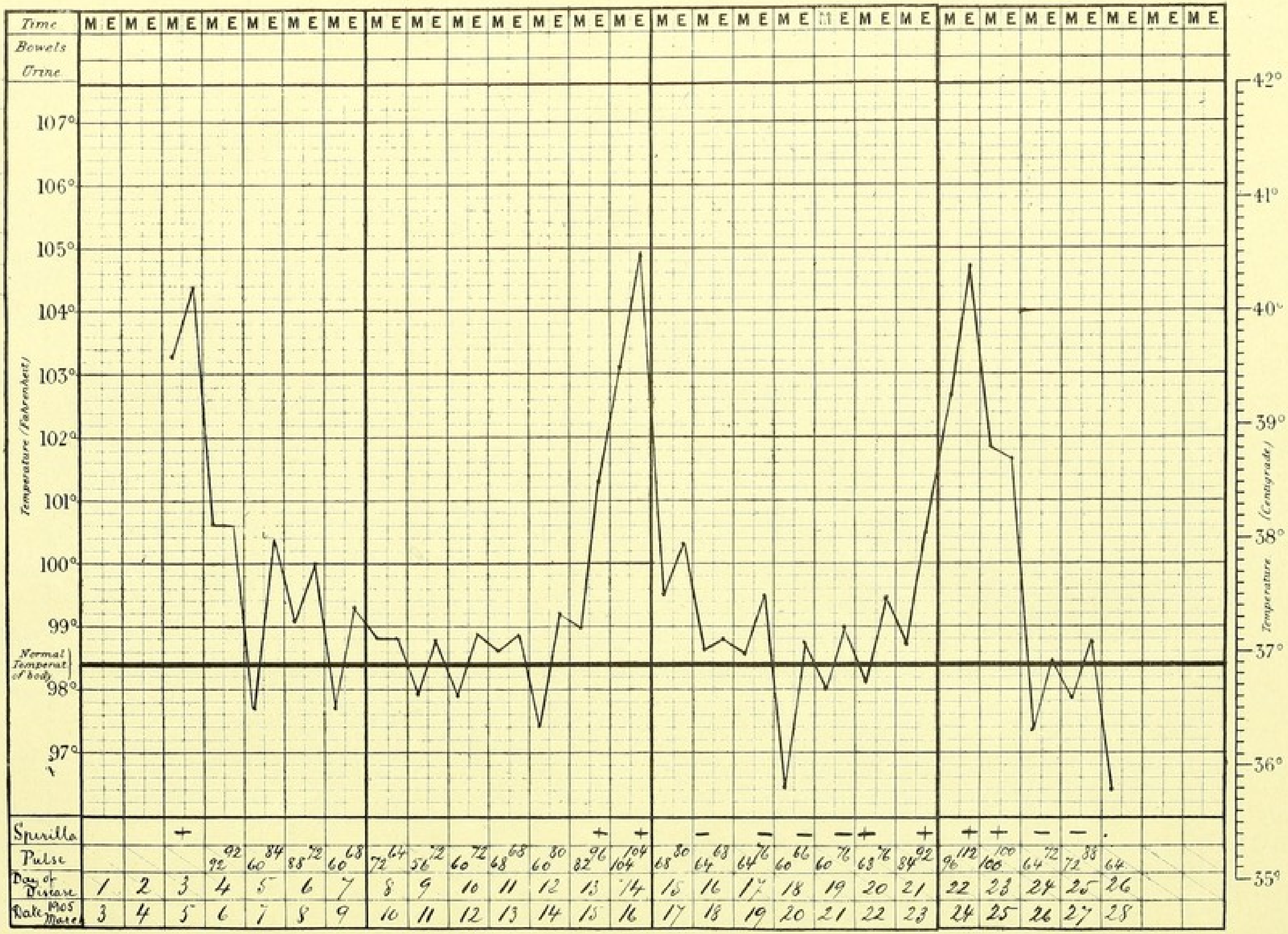
Name { Case 9

Age 20 ♂

African

Case Book No

Chart III



1.7

DISEASE.

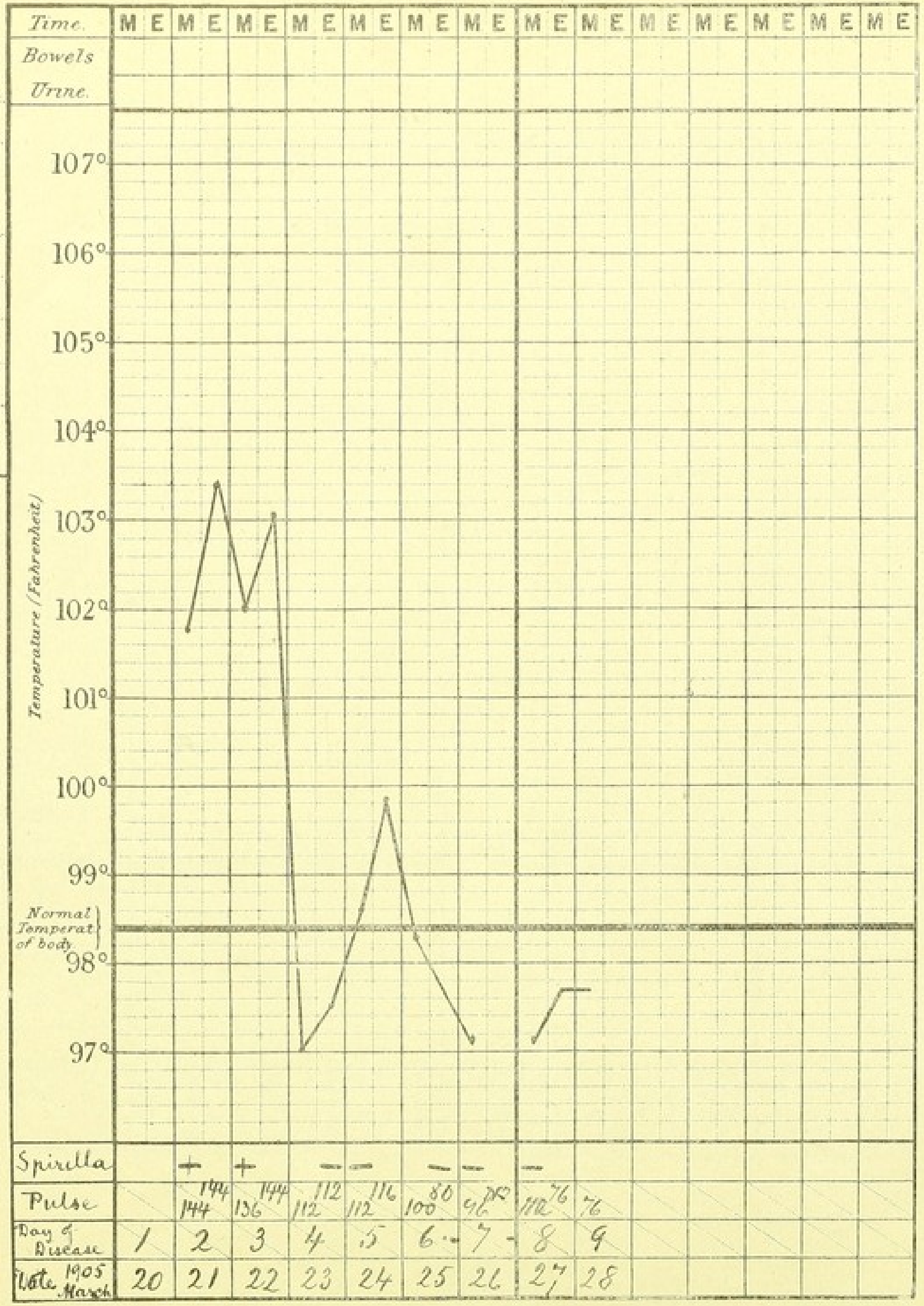
Spirillar Fever

Notes of Case.

Name { Case 10.
5, ♂
African

No

Chart IV



x absent

to face p. 7

DISEASE.

Spirillar Fever

Notes of Case.

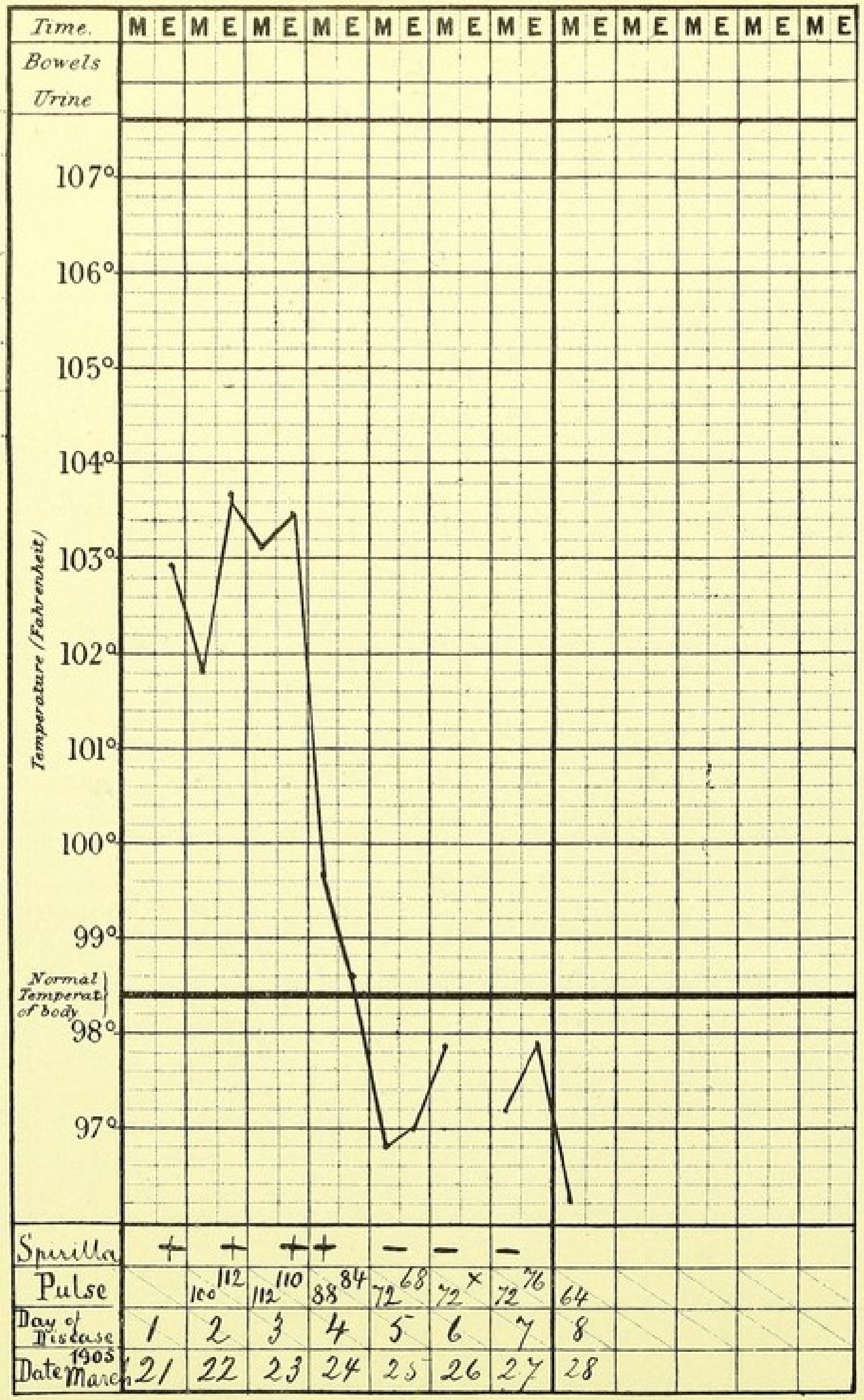
Name { Case 11

Age 28 ♀

African

Mother of case 10.

Chart V



× absent

Physical examination: Temperature 101.4, revealed nothing abnormal, spleen not palpable. Spirochaetes, not numerous, were seen in fresh and stained specimens of the blood by Dr. Heiberg. In spite of repeated examinations, spirilla were never again seen in the blood of this patient, although on January 11 and 13 there was a well-marked rise of temperature (highest 102), and again between January 20 and 31 there was constantly a slight (99 to 100) evening temperature to be recorded.

CASE 8 (*Chart No. 2*).—Male, age 19, first seen March 5, still under observation.

History:—Patient is a soldier, one of a detachment on their way from the Lower Congo to Lake Kivu. He slept on the night between the 23rd and 24th of February at Nyangwé. He fell sick on March 2, at Kasongo, with frontal headache, pain in the back and limbs, anorexia, vomiting, continued constipation, and fever. The liver was normal; the spleen slightly enlarged and tender. The course of the disease was uneventful. The results of blood examinations are entered on the chart.

CASE 9 (*Chart No. 3*).—Male, age 20; first seen March 5, still under observation.

History:—Patient belongs to the same detachment of soldiers as Case 8. The history and symptoms were the same in both, save that the illness commenced in this case on March 3, and there was no vomiting.

The temperature curves of these two cases are remarkably similar.

CASE 10 (*Chart No. 4*).—Female, age 5; first seen on March 21, 1905, still under observation.

The patient is the daughter of a soldier on his way from the north of the Lake Tanganyika to the Lower Congo. She was bitten near Kabambarré on the night between the 13th and 14th of March. The illness commenced on March 20 with headache, pain in all the body, restlessness, anorexia, no vomiting, constipation, and fever. Liver was not enlarged. At the first examination the spleen was found to extend to 8cm. below the costal margin. On March 25 and 26 the pulse was irregular. No malarial parasites have ever been seen in this case.

CASE 11 (*Chart No. 5*).—Female, age 28; first seen on March 21, 1905; still under observation.

Patient is the mother of the preceding case, and was bitten at the same time. Her illness commenced on March 21 with the usual symptoms, the headache being distinctly temporal. There was no vomiting, and the spleen was never enlarged.

CASE 12.—Female, age 27; seen first on March 21; still under observation.

Patient is the wife of a soldier on his way from the Lower Congo to Lake Tanganyika. There is no history of tick bite. Illness commenced March 19 with general malaise, pain in forehead and nape of neck, anorexia — but no vomiting, constipation. Liver normal. Spleen enlarged and tender. Blood was examined on March 21, and spirilla found. The temperature on March 21 was 100.4; it has since been normal, and parasites have not been again seen.

Reports of European Cases.

J. E. D. (*Chart No. 6*). (*Patient's Own Notes.*)

Nov. 25.—This evening felt tired and unable to work as usual; have been partially constipated for past four days.

Nov. 26.—This morning was unable to take breakfast—loathing for food—nevertheless, swallowed a little bread and tea, and started at eight o'clock, after the sun had well risen, on a seven mile walk to Vieux Kasongo. During the first hour felt fairly "fit," and refused to ride on mule. As the sun became warmer, commenced to feel uncomfortable, arms ached so that it was almost impossible to hold sun-umbrella, and reached

White Fathers' Mission at the sixth mile in almost a collapsed state. Was carried in hammock to destination. Blood was examined at 4 p.m., and nothing seen. Six grains of calomel taken, and two small motions obtained. During the night was much distressed by fulness of the abdomen, and vomited four times. A few drops *Tr. Opii.* gave much relief.

Nov. 27.—Felt very slightly better in early morning. Head felt as if "muffled up," and severe throbbing, frontal aching soon developed. Had slight pains in small of back. Fulness and distention of abdomen as distressing as ever. Four cathartic pills taken in the morning had no effect, so calomel grs. 6 was taken, and several small liquid stools were passed during the night. Blood was examined at nine this morning and spirochaetes found.

Nov. 28.—Passed a bad night (7½ grains of antipyrine taken at 1 a.m.), because of severe throbbing headache and distressing fulness of abdomen; vomited twice during the night. Tried to get up in early morning, but soon returned to bed because of fever, weakness, and exhaustion; headache not so bad. Blood examined, spirochaetes present. Antipyrine grs. 10 taken at noon and saline laxative in the afternoon.

Nov. 29.—Was awake, up and down, all night, but not so distressed as during two preceding nights. Started in early morning, carried in hammock, for Kasongo, where arrived at 8 a.m. Throughout this access of fever a constant soapy taste was noted in the saliva.

Nov. 30.—Much better, went for walk; noted bodily weakness.

Dec. 1.—Passed fair night. Woke up after after-dinner nap with distinct oedema around eyes. Herpes has formed on upper lip and just within right nostril; there are two small ulcers on gums.

Dec. 2 to 6.—Save for slight looseness of bowels absolutely well.

Dec. 7.—Slight weariness in arms and legs; on coming in from morning bicycle ride felt shivery.

Dec. 8.—In bed, same symptoms as in previous attack—headache, boneache, lassitude, distaste for food—but no vomiting. Had no great thirst.

Dec. 9.—Same condition, constipated.

Dec. 10.—During early morning temperature fell to 97—a slight perspiration preceding—headache disappeared and appetite returned.

Dec. 11-15.—Fairly well and able to work.

Dec. 16.—Fever recurs in usual manner.

Dec. 17.—Headache bad; 7½ grains of antipyrine at noon. Temperature fell to normal after tepid bath at 10 p.m.

Dec. 18.—Weak, bowels loose, otherwise well.

For the following week (Dec. 19-25) felt very well, appetite was good. From Dec. 26 had a constant slight evening temperature, was rather bilious and constipated (calomel grs. 5, Dec. 31), and had a slight localised boneache, especially in the fore-arms.

Jan. 7.—Felt chilly and good for nothing this evening.

Jan. 8, 9, and 10.—Recurrence of fever with same symptoms as before. The temperature suddenly fell on the night of the 9th during a second heavy sweat. There was no further recurrence of fever. After each attack there was slight looseness of bowels and increase in amount and frequency of urine. The slight ulcer in the nostril lasted for some time after the labial herpes had disappeared. The spleen was tender, but was never easily palpable. For a fortnight succeeding the last attack occasional small evening rises of temperature with slight malaise were recorded. The appetite and general sense of well-being quickly improved under arsenic. Good health continued until about February 15.*.

The temperature chart and diary of this case record graphically the classical description of relapsing fever (8, 9). Spirilla were seen in the blood during each access of fever. Malarial parasites were always absent, and the patient has never at any time had malarial fever.

* No spirochaetes were seen during J. E. D.'s fatal illness.

DISEASE

Spirillar Fever

Notes of Case

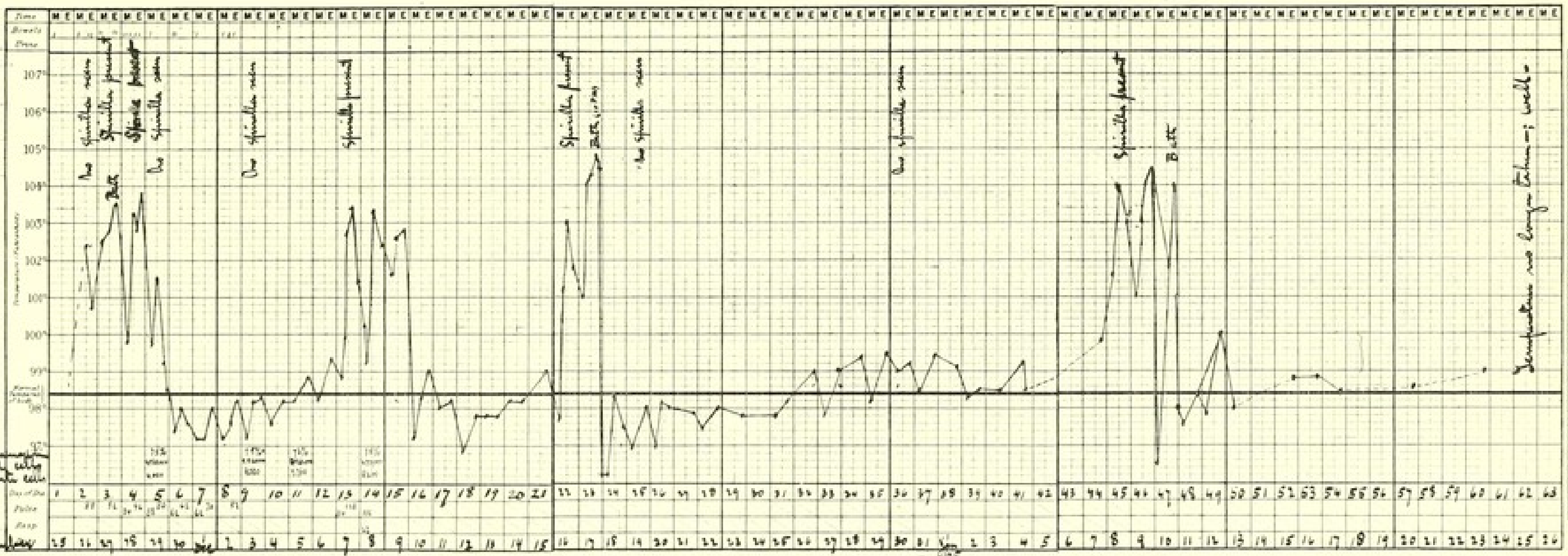
Name J. E. D.

Age 29 ♂

European

Case Book No.

Chart VI



Date of admission

Result 1904/ November

to face p. 8

DISEASE.

Spirillum Fever

Notes of Case

Name J. L. J. ♂

Age 28

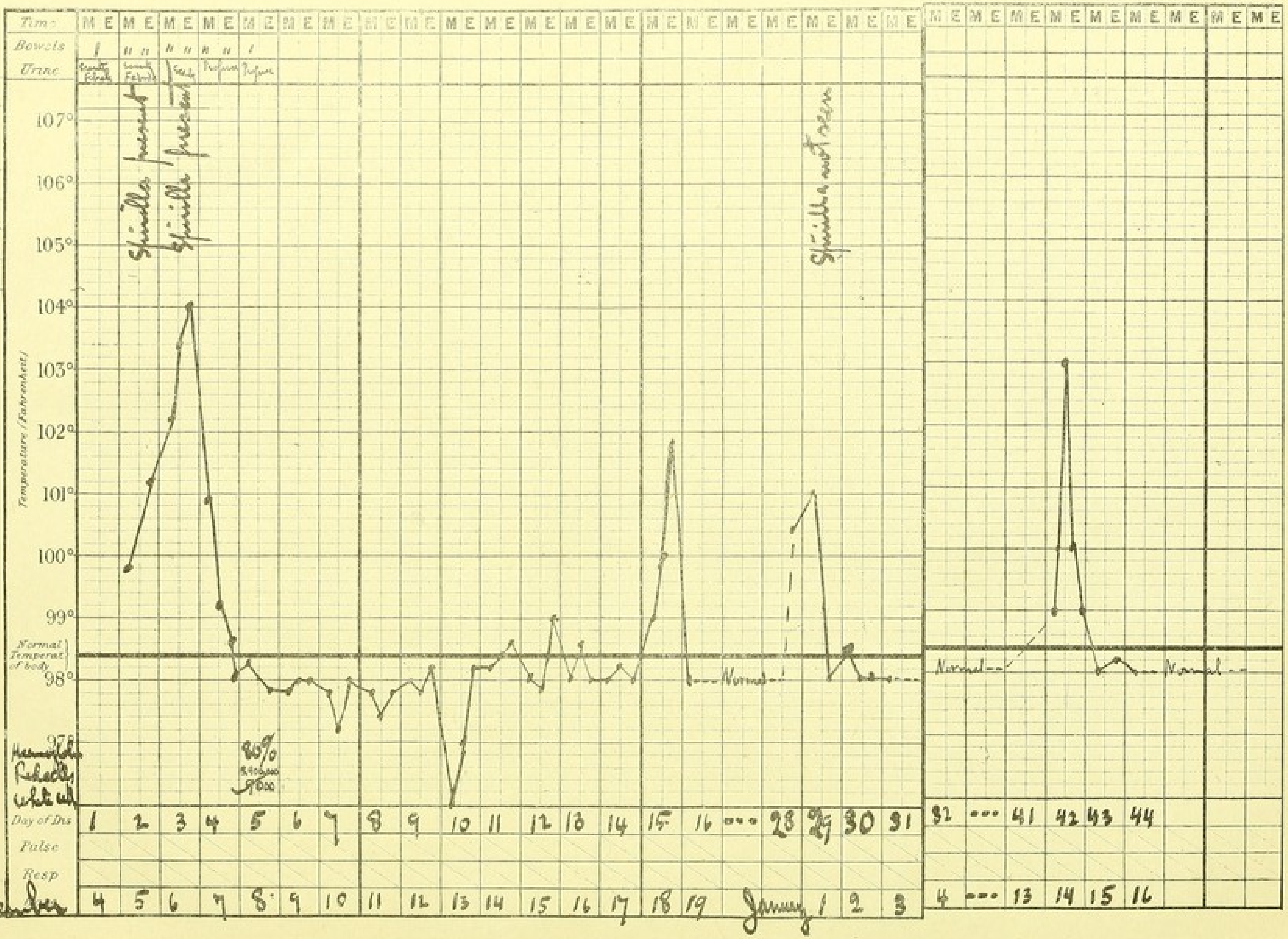
European

Case Book No.

Chart VII

Date of admission

Result



The disease was most probably contracted at the autopsy done on Case 4, at Nyangwé, on November 19; after the autopsy was finished a slight abrasion was noted at the side of one of the finger nails. If such is the case the incubation period was, as usual (8), seven days. Though there is no knowledge of a tick-bite, the possibility of infection by that means cannot be definitely excluded, since on arriving at Kasongo ticks—two—were found in an unopened valise and in a bed-covering in daily use; and this although no ticks were seen in the rooms we had occupied in a few days before at Nyangwé.

The second European case was much the less severe. The symptoms—head and boneache, lassitude, slight nausea and diarrhoea, scanty febrile urine during and increasing micturition after the attack, tenderness over the unenlarged spleen, and fever noted in the first case were all present in the second, but with greatly lessened intensity.

The diary of the case is as follows:—

J. L. T. (*Chart No. 7*). (*Patient's Own Notes.*)

Dec. 3 and 4.—Felt vaguely unwell. Quinine 7½ grains each day.

Dec. 5 and 6.—Quite ill; blood examined, spirochaetes present—no malarial parasites seen.

Dec. 7 to 17.—Felt perfectly well. Quinine grs. 5 taken on Dec. 8 and 9.

Dec. 18.—Only slight malaise; small epistaxis during night. Blood not examined.

Dec. 19 to 31.—Well.

Jan. 1.—Passed a bad night; head and backache annoying. For three or four succeeding days was much troubled with neuralgia (patient not neuralgic). Blood examined, spirochaetes present.

Jan. 5 to 15.—Well.

Jan. 13.—Passed an uneasy night, slight diarrhoea.

Jan. 14.—Usual symptoms; great feeling of weakness.

Jan. 15 to present.—Patient free from symptoms, and entirely well. No malarial parasites were seen during the whole of this illness.

The Disease in Experimental Animals.

As the following abstracts of experiments indicate, the spirochaete does not kill the ordinary laboratory animals. To monkeys alone, the *Cercopitheci*, especially young animals, does it seem uniformly pathogenic. An adult rabbit (Ex. 156) was refractile. A young rabbit (Ex. 154) and a rat (Ex. 162), in whom there were grave accompanying affections, seemed more susceptible. A large guinea pig (Ex. 155) showed spirochaetes in its blood for only two days succeeding the inoculation of a large dose of heavily infected blood. In it, as in three rats (Ex. 163, 166, and 185), from whose blood spirochaetes, once present, finally disappeared, there appears to have been a temporary increase in the number of the parasites, and dividing forms were seen.

RABBITS.

Ex. 154: Rabbit, about one month old, weight 675 grammes.

Nov. 15.—Inoculated with about 5cm. blood from Case 4, showing two spirochaetes to field.

Nov. 16 to 17.—Scanty parasites present in blood. No spirochaetes were then seen until Nov. 24 and 25, when there were about twenty to a field (1-12th oil immersion objective; No. 4, ocular; Zeiss). In spite of daily examination no parasites were again seen. The animal died in convulsions on Jan. 23. The probable immediate cause of death was a very severe skin disease (?).

Preparations of blood and bone-marrow made at autopsy showed no parasites. Organs appeared normal.

Ex. 156: Adult rabbit, weight 2,497 grammes.

Much over 500 ticks, many of them certainly infected, have fed upon this animal. On Dec. 10 it was inoculated with blood containing numerous spirochaetes. Its blood was examined daily up to the end of December, and occasionally since. Parasites have never been seen.

GUINEA PIGS.

Ex. 155: Guinea pig, weight 453 grammes.

Was inoculated on Nov. 15, Nov. 17, Dec. 2, Dec. 10, and Dec. 17 with small quantities of blood containing spirochaetes, taken from patients or experimental animals. Daily examinations were made, but parasites were never seen. On Jan. 23, 4ccm. of blood, showing one spirillum to field (as before 1-12th immersion and No. 4 ocular), taken from an infected monkey, was inoculated. Parasites in very small numbers were seen during the two succeeding days and not again.

RATS.

Ex. 162: Adult rat, weight 266 grammes.

Dec. 5 to 12.—Twelve of the ticks which infected Ex. 157 were repeatedly fed on this animal. Dec. 13.—Spirochaetes seen in blood. Parasites were continually present until Dec. 19, when animal died. Death was undoubtedly largely due to a large, traumatic, subcutaneous abscess.

Ex. 163: Young rat, weight 65 grammes.

Dec. 10.—Inoculated with 3ccm. blood, containing numerous spirochaetes taken from an infected monkey. The blood was examined daily until Dec. 29. Parasites were seen in large numbers only on Dec. 12, 13, 14, 17, and 19 (not examined on Dec. 11).

Ex. 166: Adult rat, weight 168 grammes.

From Dec. 19 to 31, the ticks used in Ex. 162 (see above) fed repeatedly. The rat did not become infected. On Jan. 23 it was therefore inoculated with 3.5ccm. of blood, containing numerous spirilla, taken from an infected monkey. The blood was examined daily until Feb. 1, and since then at intervals of a few days. Very scanty parasites were seen only on Jan. 26, 27, 30, and Feb. 1.

Ex. 185: Rat, young, weight 91 grammes.

Jan. 23.—Inoculated with 2.5ccm. blood, containing many spirochaetes, from an infected monkey. Blood was examined daily until Feb. 1, and at intervals since. Parasites were seen on Jan. 24, 25, and 26.

MONKEYS.

We have been able to infect monkeys, five *Cercopithecus* (*?Schmidti*), one *Cercopithecus campbelli*, and one *Cercopithecus* (Sp. ?), with spirochaetes by the bites of ticks. Each animal was examined with negative result before the commencement of the experiment. Thirty other monkeys of the same species, caught in the same districts, and kept under the same conditions have been used for other experiments. Their blood has been constantly examined, and none have ever been found to be infected with spirochaetes.

Ex. 157: Young Cercopithecus, weight 1,586 grammes. (Chart No. 8.)

Nov. 19, 20, and 21.—Ticks (231 in all), caught in native houses at Nyangwé were allowed to thoroughly feed on this animal. On Nov. 24 spirochaetes were detected in its blood. The parasites later increased greatly in number. There was a high temperature. The monkey became very thin and weak. Anæmia was very pronounced, and death occurred on Dec. 4, after two days of utter prostration, during which the monkey scarcely moved, but remained dozing, crouched on his haunches. The autopsy was done immediately after death. Blood was very pale, and all organs anæmic. Long bone-

DISEASE.

Spirilla

Notes of Case.

Name { Ex. 157

Age

Diet young monkey

Case Book No

[Cercopithecus

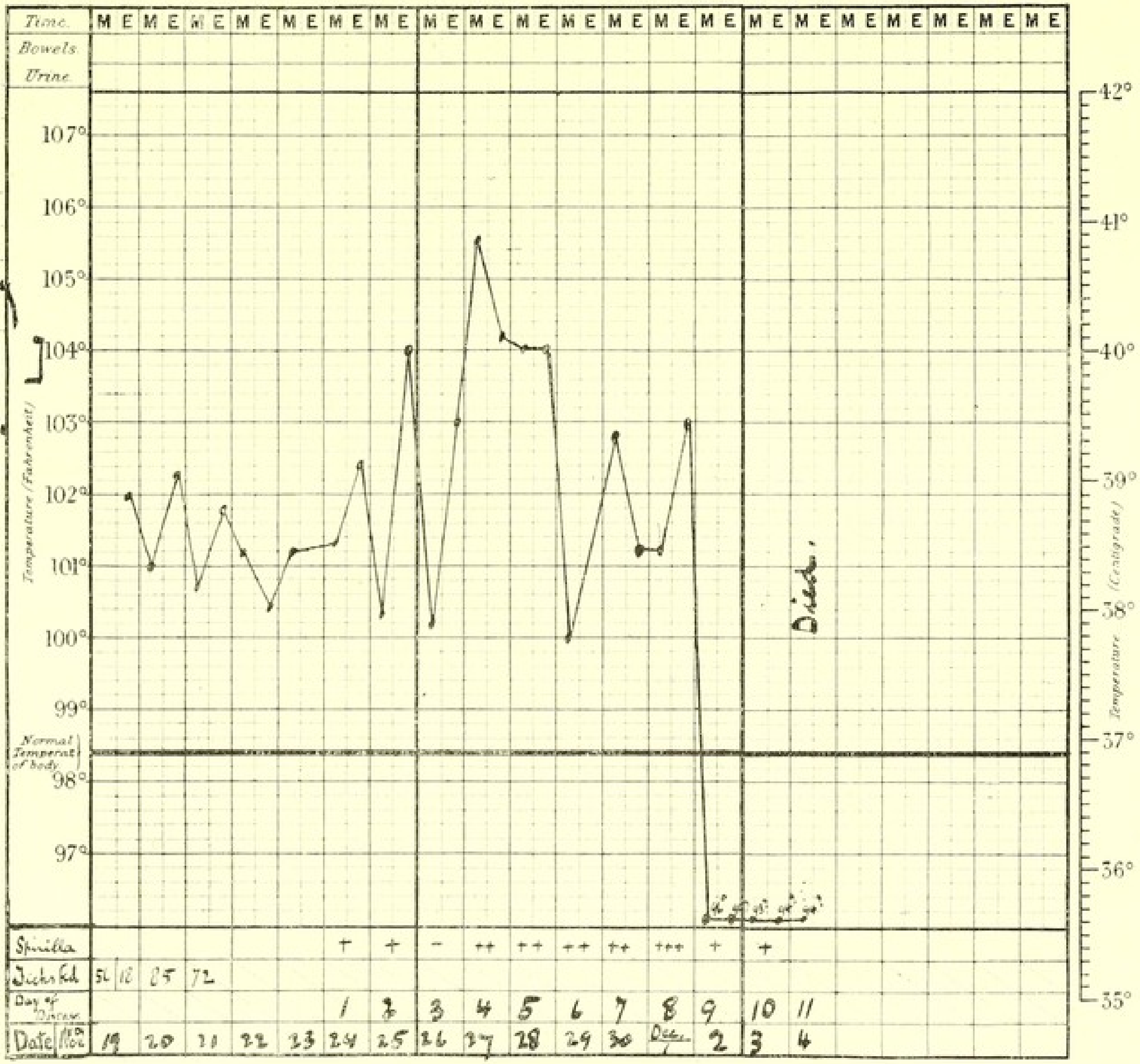
weight 3½ lbs.]

No malaria

No trypanosomata

No filariae

Chart VIII



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DISEASE.

Spirillum

Notes of Case

Name { Ep. 192.

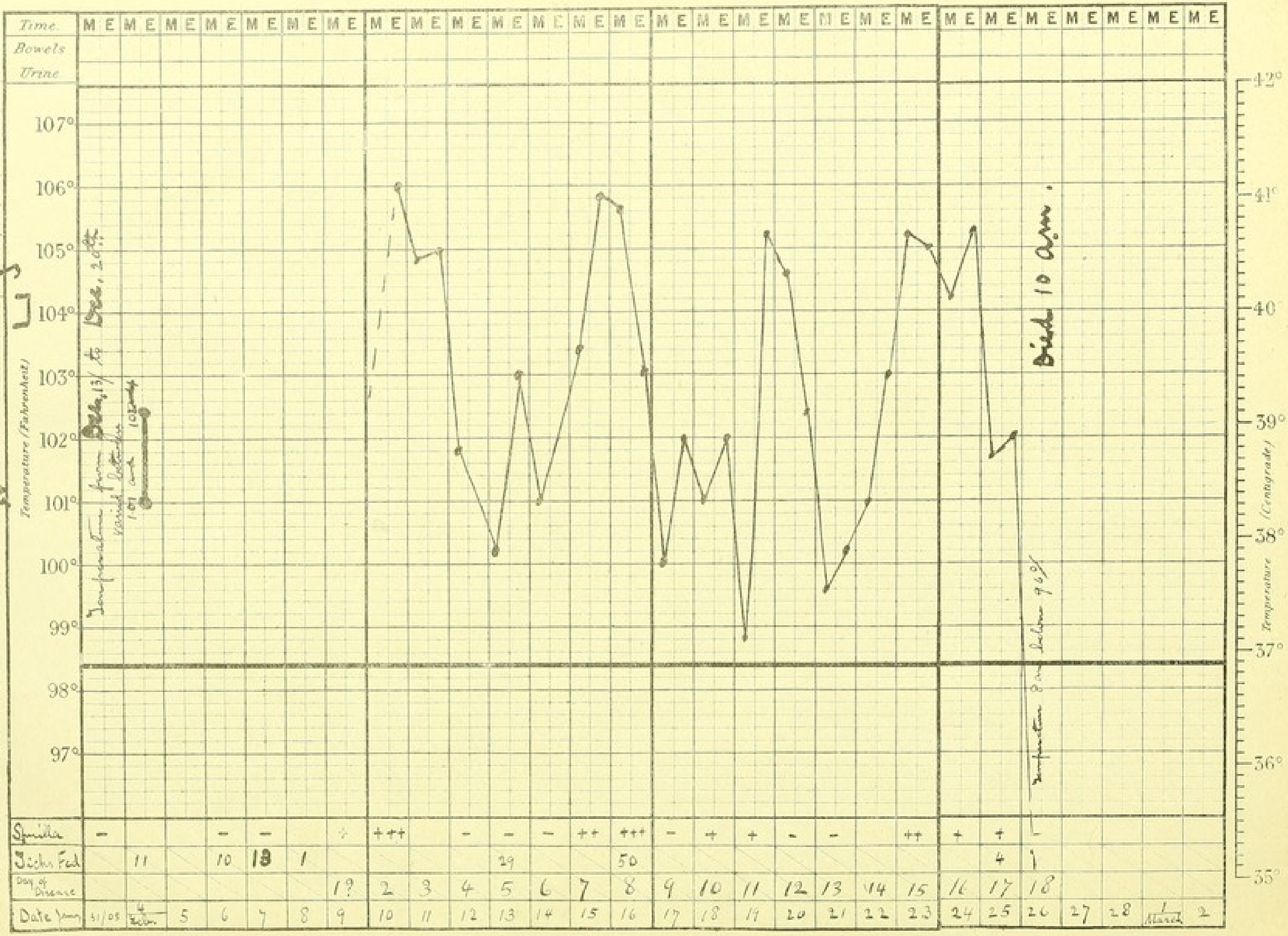
Age Monkey

Diet [Cercopithecus]

Case Book No

Chart IX

No malaria
No trypanosomata
No filariae



marrow was diffluent and chocolate coloured. Heart, kidney, and liver seemed cloudy. Spleen, enlarged, measured 7 by 2.8 by 1.7cm.; firm. No malarial parasites, trypanosomata, or filariae were seen in this animal.

Ex. 160: Young Cercopithecus, weight 1,586 grammes.

Ticks caught in native houses at Nyangwé were, on Nov. 24, fed upon a small rabbit (Ex. 154), whose blood contained many spirochaetes. On Nov. 30 twenty-six of these ticks fed upon this monkey. On the morning of Dec. 5 spirochaetes were for the first time seen in its blood. The parasites became more numerous, and were constantly present. On Dec. 10 the temperature was sub-normal, and the animal dying. It was, therefore, killed to obtain blood for inoculating exps. 155, 156, 163. No malarial parasites, trypanosomata, or filariae were ever seen in this monkey.

Ex. 167: Young Cercopithecus, weight 906 grammes.

Dec. 21 and 22.—One hundred and seventeen ticks caught in native houses at Nyangwé before Nov. 23, and not since fed, were allowed to feed upon this monkey. On Dec. 28 spirochaetes were seen in the blood for the first time, and the temperature rose. Parasites were constantly present, at first in large numbers, until Jan. 10. From that date until death on Jan. 19 parasites were absent from the peripheral blood—examined both during the day and at night. During the last few days the animal was extremely weak, hardly able to crawl, and had slight diarrhoea. The autopsy was commenced immediately after death. The animal was very thin, weight 604 grammes, all fat had disappeared. Spleen was slightly enlarged, 3.25 by 1.75cm., dark and firm. All other organs were extremely anæmic. Long bone-marrow dark red. A few spirochaetes were seen in preparations of heart blood, bone-marrow, and spleen juice taken at the autopsy. No malarial parasites, trypanosomata, or filariae were ever seen in this animal.

Ex. 176: Young Cercopithecus, weight 1,020 grammes.

On Jan. 12 and 13 258 ticks, caught at Nyangwé, before Nov. 23, and not since fed, were allowed to feed upon this monkey. On Jan. 16, 76, and on Jan. 19, 240 of the same ticks were re-fed. On Jan. 21 spirochaetes in fair numbers, were seen in the blood for the first time. The animal died on Jan. 23. Death was largely due to rough handling while feeding further batches of ticks. Spleen was slightly enlarged, 4.75 by 3cm., dark and firm. This monkey was infected with malaria, but neither filariae nor trypanosomata were seen in its blood.

Ex. 184: Adult Cercopithecus, weight 2,380 grammes.

On January 23, the ticks which had infected Ex. 160 on Nov. 30, and had since repeatedly fed on uninfected animals, were placed on this monkey; thirteen fed. On Jan. 28, Feb. 1, 2 and 6, they had again opportunities of feeding, the monkey being bitten fifty-nine times. On Feb. 6 another lot of infected ticks were accidentally placed on this animal for a few minutes. Three or four may have punctured the skin, none fed. On Feb. 14 and 18 the monkey was bitten twenty-three times by the first lot of ticks. On Feb. 19 spirochaetes were seen in the blood for the first time, and the temperature rose. Parasites were fairly constantly present in the peripheral blood until March 7. Since then they have been absent, though the temperature remains high. The animal is still under observation.*

Ex. 192 (Chart 9): Young Cercopithecus, weight 1,020 grammes.

It was thought possible that "J. L. T." might have become infected with spirilla through his unprotected hands while doing the autopsy on Case 4. To ascertain whether a susceptible animal would become infected with spirochaetes if parasite-containing blood were placed on its unbroken skin, the hair was carefully clipped from the abdomen of this monkey, a healthy area was chosen, and, after a careful negative examination—with a lens—for cuts and abrasions, a few drops of blood containing many spirochaetes—from Exps. 162 and 163—were placed upon the unbroken skin. The blood was covered with a damp chamber to prevent its drying, and was removed after thirty minutes. This was done on Dec. 13, 15, and 17. The blood was examined daily until Dec. 27. As no parasites were seen, the animal was thought to be uninfected, and it was decided to use it for a second experiment.

* October 23rd, 1905. Temperature constantly elevated (malaria). Blood frequently examined; no spirochaetes seen until May 13th, 1905 (T. 107.2) one to field. None were again seen, though blood was constantly examined, and on August 23rd the animal died in convulsions (no spirochaetes found at autopsy). ? Cause of death, slight broncho-pneumonia.

It was desired to determine whether young ticks hatched from eggs laid by known infected parents, were capable of infecting a susceptible animal at their first feed.

Young ticks reared in the laboratory were allowed to feed upon this monkey. With the exception of eight young ticks which fed on Feb. 7, all the ticks used were hatched from eggs laid on Jan. 12 by one of the ticks which infected Ex. 157. The accompanying chart indicates the number of ticks fed, the temperature and the results of examination of the peripheral blood for spirochaetes. The animal was found to be infected on Feb. 9, and died, much exhausted, on Feb. 26. No autopsy was done.

If this monkey was infected, as we believe, by the tick bites, it may be assumed that ticks are not merely mechanical transmittors of the spirochaetes, but are alternative hosts in which developmental changes take place.*

Ex. 194: Cercopithecus, weight 2,265 grammes.

It was desired to determine whether young ticks hatched in the laboratory and fed on an animal infected with spirochaetes were capable of transmitting the parasite to a susceptible animal at any succeeding feed, twenty-four hours, at least, intervening between the infecting and transmitting feed. (This experiment was commenced before a successful result had been obtained in Ex. 192.)

Ticks were fed on Feb. 6, 7, 10, 23, March 2, 4, 16, and 19. The monkey was bitten 136 times in all. On March 21 spirochaetes were found for the first time in the blood. The temperature, previously rather irregular, mounted definitely. The animal became much prostrated, and lost weight rapidly. The temperature remained high; spirochaetes were constantly present in enormous numbers, and the animal died on the night of March 27 (weight 1,815 grammes).

We have, therefore, been able to infect, in all, eight animals with spirilla by the bites of ticks—seven monkeys and one rat.

To exclude the remote possibility of the parasite being introduced with dust into the wounds made by the ticks' bites and infection thus produced, on four different occasions 115 small incisions were made in the abdomen of a young Cercopithecus (weight 907 grammes), and earth taken from jars in which much-infected ticks were kept, and from tick-infested houses at Nyangwé was rubbed into the cuts. The animal never became infected.

The incubation period, that is, the interval elapsing between the bites of ticks able to infect at the time of biting† and the appearance of parasites in the peripheral blood, as a rule, is five days.

The Spirochaete.

When the parasites are numerous they can easily be seen in fresh preparations of blood as rapidly-moving spiral threads. When they are scanty perhaps the best method of demonstrating their presence is the searching, with a high power, of thick, dehaemoglobinised blood-films stained by some modification if Romanowsky's method or with a weak solution of carbol-fuchsin. Centrifugalizing the blood is not nearly so good for the demonstration of spirochaetes as for trypanosomes.

The parasites seen in all our cases have the same morphological characteristics. In preparations coloured by modifications of Romanowsky's stain (Leishman's or Stephens and Christopher's) (10) the spirochaetes are seen to stain unevenly, and to vary greatly in length. The results of the measurements of twenty spirochaetes in slides of blood taken from Case 8, for the most part on March 5, are as follows:—Largest 43 μ., smallest 13 μ., average of ten smallest 19 μ., average of ten largest 35 μ., Y-shaped, apparently divisional forms, and groupings of pairs, trios, and tetrads of spirochaete strongly resembling, in their arrangement, the multiplying indifferent

* October 17, 1905. This experiment has since been, twice, successfully repeated.

† Occasionally the bites of ticks, later shown to be infective, have repeatedly failed to infect a susceptible animal.

forms of *Spirochaete Ziemanni*—as figured by Schaudinn—(12)—are frequently seen in films taken from either patients or animals. With the time, instruments, and technique at our disposal, we have, to our regret, been so far unable to observe in animals and ticks developmental processes of this spirochaete similar to those which Schaudinn has demonstrated with *Spirochaete Ziemanni* in the owl and mosquito.

Distribution of the Human Tick in the Congo Free State and some Notes on its Binomics.

Livingstone says: "Before the Arabs came bugs were unknown" . . . one may know where these people have been by the absence or presence of these nasty vermin; the human tick, which infests all Arab and Suaheli houses, is to the Manuema unknown . . ." (2); and again, while at Nyangwé, "My new house is finished—a great comfort, for the other was foul and full of vermin; bugs (Tapasi or ticks) that follow wherever Arabs go made me miserable" (3). Our observations tend to confirm his assertion. Perhaps one of the reasons for which ticks are more often found in Arab than in native houses is that the Arabs make better, drier buildings, and live in permanent villages. Native huts are temporary affairs and a slight cause, one or two cases of sickness, is often enough to make a community leave their homes and build a village elsewhere.

In October 1903, a list of questions was sent for us by the Free State Government to its various districts. Information concerning the human tick was asked for. Since our arrival in the Congo and during our long journey up the river from Léopoldville to Kasongo we have constantly searched for the ticks. From the information thus collected we are enabled to construct the accompanying sketch map which shows the distribution of the human tick in the Congo Free State.

We have indicated every locality from which specimens have been received, or ticks are said, on reliable authority, to exist. Where it has been necessary to indicate places at which ticks are not known to exist squares, not circles, have been used to mark their position.

The main Arab routes into the Free State have been indicated diagrammatically by straight red lines. It must be understood that the Arabs overran the southern part of the Free State before reaching the Upper Congo at Nyangwé. Maniéma then became their stronghold, from which expeditions were sent out. They never penetrated far to the west of the Congo. The Free State prevented them from following the Congo further down than its confluence with the Aruwimi. Their progress to the north was checked, near Avakubi, and to the north-east, near Béni, by powerful native tribes. They were practically confined, in the Free State, to the territory now called the Oriental province.

Ticks seem to have come into the Free State by two routes; from the East Coast, with the Arabs, into the Oriental province, and into the Cataract region, with traders, from the Portuguese territory to the south, where ticks have existed since Livingstone's time, at least.

The rivers are the present highways. Old and present caravan routes used by Europeans, along which ticks are known to occur, are indicated by dotted lines. A glance at the map shows that ticks are found, particularly, along much travelled roads. How easily they may be carried in even a European's luggage is well shown by our experience on leaving Nyangwé, where we were well lodged in well-built houses. Although the ticks are plentiful in many of the Arabised villages along the Congo between Kasongo and Ponthierville, they are quite unknown in the native villages an hour's walk inland. The rest-houses for native travellers are always the most infested. At Kumba, Lokandu, and Ukungwa, the points furthest down the river at which we caught ticks, the rest-houses alone seemed to be infested. At Kumba the native paddlers of the town said they did not recognise, and seemed to have no fear of, the tick. Dr. Christy, in Uganda (11) and the Rev. W. Holman Bentley in the Lower Congo have also found that rest-houses are particularly liable to be infested.

Mr. Bentley believes that human ticks were a chief cause of the great mortality which existed among the Lower Congo porters in the old days when the whole commerce of the Free State was carried over the caravan route between Matadi and Léopoldville.

Names given to the ticks in various localities are as follow:—In the neighbourhood of Léopoldville *Bifundikala*, and, by the Batéké, *Bimpusi*. It exists along the Kwango river, at least between Popokabaka and Francis Joseph Falls, among the Basumbo and Bayaka people. At Popokabaka it is called *Mouyata*. The common name throughout the eastern part of the State is *Kimputu*. Very occasionally an educated man uses the Suaheli word *Papasi*.

In infected houses the ticks are found in the dust and cracks of mud-floors, particularly in dry places near the hearth, in bed-platforms, or immediately inside the door-sill, just where the natives are accustomed to sit down. They may hide themselves in the cracks and crevices of mud or grass walls, and even in the thatched roofs.

When ticks are disturbed they often curl up their legs as if dead. So lifeless do they seem that one might easily be deceived, especially since they sometimes remain motionless for hours.

Ticks can crawl rather quickly. In sand the body of a large one leaves a smooth, central furrow, with the sharp, crab-like tracks of the claws on either side. They seem to be largely nocturnal in their habits, and certainly do not feed quickly enough to get much blood from any but a sleeping person. A big female may remain, firmly fixed, feeding on a monkey for two or three hours before it finally drops off, as large as a cherry, distended and bloated with blood. Others may fall off and attempt to crawl away after half an hour's feeding. In feeding (Pl. 3, fig. 2), the tick first firmly fixes the forelegs, and then, depressing the capitulum, buries its mouth-parts in the host. The bite of even a small tick is painful. In monkeys, immediately after feeding, a small crust of sero-sanguinolent fluid forms at the site of the bite. Surrounding it is a roseola about two millimetres in width. Two hours later the central clot is surrounded by two concentric zones, each two millimetres in width; the first colourless, the second ecchymotic. Six hours later the clot has become almost black, and is placed at the apex of a slight, colourless weal, bordered by an ecchymotic zone about a millimetre and a half in width.

It has been said that ticks bite most frequently between the toes, in the axilla, etc. Our experience indicates that they bite, indifferently, every part of the body.

Often, while still feeding, the whitish secretion of the Malphigian tubes is passed from the anus. At the same time clear fluid, in fairly large quantities may ooze intermittently from between the bases of the first and second pairs of legs. We have never seen fluid exude from any other situation than this ; yet, in spite of careful search—no sections made—we have never been able to find any trace of an opening.

Spirochaetes have never been seen in this fluid.

In coitus the male lays hold of the posterior margin of the female, and, turning on his back, crawls forward, beneath the female, until the genital pores are in opposition. Pairs are often found and remain for hours *in coitu*.

The productivity of the females is certainly increased by large feeding. The number of eggs laid at a time seems to vary greatly. Dissection shows that only a few eggs are mature at one time : ovipositing therefore goes on slowly. On two occasions ticks have been seen to be ovipositing during three days. In each instance only seventy eggs were laid. Our ticks were frequently disturbed, and for this reason, perhaps, the eggs have been usually found in small groups of ten or twenty. Females kept apart for observation have, however, been found to lay from ten to twenty eggs at intervals of from one to two weeks. The largest number of eggs laid at one time was 139. The females have sometimes, but by no means always, died while, or after, ovipositing.

The eggs adhere to one another as they are laid, and look, under a low power, not unlike bunches of glistening, golden-brown grapes. Their covering is soft, smooth, and highly refractile. Their shape is slightly ovoid, the average dimensions being 881.172 by 776.376 μ. The largest egg measures 959.4 by 841.32 μ., and the smallest 767.52 by 664.2 μ. In sandy soil the eggs may be deposited either upon or beneath the surface. The average temperature and the average humidity for the three months during which we have had ticks under observation have been as follows:—

	Temperature		Humidity Percentages of Saturation		
	Maximum	Minimum	6 o'clock	11.45 o'clock	12.45 o'clock
1904 December	29·6° C	19·7° C	94	76·1	76
1905 January...	32·3° C	19·5° C	95	71·5	74
February	29·9° C	20·1° C	94	72·1	77

Under these conditions eggs take but twenty days to hatch ; the shortest period noted was eighteen, and the longest twenty-three days. Occasionally, for no apparent reason, a quarter, or even more, of a batch of eggs has failed to hatch.

In about seven days' time the egg becomes more ovoid, and, with a low power (a 3 objective; No. 2 ocular; Zeiss, stereoscopic), the hexapod larva can be seen to be forming within the translucent shell (Pl. 1, fig. 2). At about the thirteenth day the egg-shell splits, nearly always posteriorly, in the sagittal plane. It measures at this moment 1.03 by 9mm. A hexapod larva (Pl. 1, fig. 4), which moves its legs but cannot crawl, may now be extracted from the shell. Normally the egg-case and its contents become batter, and the larva's skin wrinkled Pl. 1, fig. 7). Air enters beneath the egg-shell and the larval skin so that the young tick and his coverings form a dull, white disc. If the egg-shell be removed, it can be seen that the tick is about to moult. Its tegument has split anteriorly, sometimes laterally, in the usual line of ecdysis at the junction of the dorsal and ventral surfaces; and curled up within the hexapod larval skin can be seen the eight-legged nymph. When ecdysis finally takes place, the nymph throws off egg-shell and larval cast together. It usually emerges by getting out one of its hind legs first, and then, often turning around inside its casings, dragging its body out after. The measurements of ten nymphs taken just after leaving the shell were, average 1.02 by 0.87mm., the largest 1.10 by 0.96mm., the smallest 0.98 by 0.8mm.

The newly-hatched nymph (Pl. 1, fig. 8) has no genital pore, and the adult position of the stigmen is indicated by a small white spot and pit. Its capitulum is partially retractile, and is visible from above. Their bodies, under a low power, are translucent. Freshly-hatched nymphs usually do not feed at once. As a rule only three or four days later do they readily suck blood. From observations extending over two months, based on ticks hatched in the laboratory from infected parents, but fed upon uninfected animals, it seems that if food is plentiful a young tick grows rapidly. The intervals between the moults seem to vary very considerably; but in the two months after it leaves the shell the tick may moult three times and come to measure, roughly, 5 by 2.5mm. If food is lacking, growth is much less rapid.

A full-grown female, filled with eggs and blood, may measure 12 by 10 by 7mm. After the nymphs first moult the stigmen is easily distinguishable, but the genital pore is still absent. The measurement of twenty young ticks at this stage gave, average 1.47 by 1.22mm., largest 1.92 by 1.37mm., the smallest 1.34 by 1.07mm. It is only after the second moult that the sexual pore is seen as a very slight depression in the middle line of the ventral surface on a level with the bases of the first pair of legs. Cleavage of the skin for ecdysis always takes place along the line indicated in the diagram (Pl. 3, fig. 3). The split usually commences anteriorly. The feet and ventral surfaces are first freed, then the dorsum, and the perfect cast is left. Either dorsal or ventral half of the moult may, however, remain attached after the other moiety has been thrown off.

It is impossible to say how long the ticks live, or for how long they remain infective. Ticks caught on October 24, and kept without food, are still alive, and have freely reproduced. Ticks caught before November 23, still alive (March 28, 1905), and have freely reproduced. Ticks caught before November 23, at Nywangé, and kept without food, were able to infect a monkey with spirochaetes 1¾ months later.

Ticks are not without natural enemies. Rats eat adults with avidity, and ants carry off young ones and eggs. We have lost ticks in both ways. On one occasion over two hundred young ticks were carried off in a single night by small ants.

We add the following scanty working notes on the anatomy of *Ornithodoros*, and on the presence of spirochaetes in its organs, in the hope that they may be useful to others interested in this subject.

There is a most curious piece of anatomy in the adult tick which, for want of a better name, we have termed the (?) "pulmonary sac." Just above the base of the proboscis is a slit which communicates with a wide membranous tube ending in a paired body, or, rather, a closed sac, whose walls are at first thin, near its attachment to the tube, and distally are thickened and thrown into folds. The accompanying diagram (Pl. 4, fig. 1) illustrates this point.

It is curious that we have never seen these ticks excrete dark-coloured faecal matter. It is always white-coloured secretion of the malpighian tubules which is passed by the anus. This fact may, in some part, be explained by the exceeding fineness of the tube running from the under surface of the "stomach" to the central cul-de-sac of the cloaca. The diagram (Pl. 4, fig. 2) is very schematic, but it will serve to illustrate the course of the alimentary tract.

The position and rough structure of the salivary glands are indicated in a diagram (Pl. 4, fig. 3). The appearance of the salivary duct is very characteristic.

A batch of ticks caught at Nyangwé (November 23rd, 1904) were fed upon one of our infected monkeys. They were kept without further feeding, and one was dissected every day or two. Living spirochaetes were found in their stomachs and malpighian tubules up to five weeks after their feed on a known, infected animal. (It must be remembered that these ticks were naturally-infected adults.) Occasionally very many more spirochaetes were found in the tubules than in the stomach. In some preparations of stomach or malpighian tubules no parasites were at first seen; but if a little human serum, taken from one who had never had tick fever, were added, in from 8 to 24 hours the preparations became fairly crowded with spirochaetes.

As we have noted on page 13, we have so far been unable to follow out in these ticks Schaudinn's masterly observations. We have also been, up to the present, unable to find in the bone-marrow, spleen juice, or blood of monkeys or human beings infected with these spirochaetes forms resembling the large macro- or microgametes, described by Schaudinn in his work.

From the facts here presented we conclude that:—

(1). Tick fever is clinically identical with relapsing fever, and has for pathogenic agent a spirochaete.

(2). The spirochaete is probably *Spirochaete Obermeieri*.

(3). The tick, *Ornithodoros moubata*, can transmit the spirochaete from animal to animal.

(4). The transmission is not merely mechanical, but some developmental process is carried on in the tick.

(5). A considerable degree of immunity or tolerance to the spirochaete can probably be acquired.

* March 28th, 1905. We have just seen two other European cases.

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ON THE EXTERNAL ANATOMY OF ORNITHODOROS MOUBATA

ON THE EXTERNAL ANATOMY OF ORNITHODOROS MOUBATA (MURRAY)

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(WITH TWO PLATES)

A consignment of the ticks referred to in the previous paper on the Human Tick Fever seen on the Upper Congo was forwarded from the Congo Expedition by Drs. Todd and Dutton. The ticks arrived at their destination on June 8th, after a journey of three months duration. The majority of the animals had died during transit, but seven examples were still living, and with them were found a number of fertile eggs, larvae in various stages of development and several active nymphs. Dr. H. E. Annett kindly handed the whole consignment over to me with the request that the species should be determined, and that if any further details could be added that they should be given in an appendix to the Report of the Congo Expedition. The material to hand afforded ample means for the study of the external anatomy of this species, and as the larva and nymph do not appear to have been described, or the characteristics of the adult female very clearly defined, it seemed desirable that as full an account as possible should be given in order that future investigators may have a more ready means of determining this highly important, but somewhat obscure, member of the Argasidæ.

Ornithodoros Moubata, Murray.

(Plates 1, 2).

Ornithodoros moubata, Murray, Economic Entomology. Aptera p. 182, No. 31, two figures, 1877.

Nec *Ornithodoros savignyi* (Audouin), Neumann, Mem. Soc. Zool. France, IX., p. 26, 1896 (*ubi. synon*).

Ornithodoros savignyi, var. *cæcus*, Neumann, *op. cit.* XIV., p. 256, 1901.

Ornithodoros moubata (Murray), Pocock, Thompson Yates, and Johnston Laborotories Report, Vol. V., Pt. I., p. 188, pl. XV. 1903.

Ornithodoros savignyi, var. *cæcus* (1), (Neumann), Lancaster, Journ. of Trop. Medicine, p. 124, 1905.

Adult female: Dorsum dusky-brown, with irregular confluent blotches, rarely lines, of dusky ochreous-yellow; in some examples the blotches were confined to the anterior region, in others they extended almost to the posterior margin; underside usually somewhat paler than the dorsum, abdominal region largely occupied by dull orange-ochreous blotches, which gradually merge into the darker ground colour. Legs and rostrum of a pale,

(1) Calman, who contributes the article, gives the name *caecum*, evidently in error.

translucent, ochreous-white. Sculpture of dorsum fairly constant, but less pronounced in a partly engorged female than in the old and shrivelled examples. Capitulum (Pl. 2, Fig. 3); hypostome not much wider at the base than at the anterior third, margin converging inwards, teeth in three bilateral rows; mandibles (Pl. 2, Fig. 4, 4a), when fully extended, reaching to the second articulation of the palpi, digit with a blunt terminal tooth, exterior apophysis with two widely separated teeth; *interior apophysis bidentate*; palpi tapering towards the extremity second joint much the longest, sides of all the segments highly chitinised. Derm cells (Fig. 5, 5a) large, irregularly ovate, with one or two extremely minute spines at or near the margin, each cell surrounded by a band of dark chitine, the latter character being much more pronounced in the region of the posterior margin. Stigmata (Fig. 6) lunular, peritreme finely pitted and strongly chitinised. Dermal secretion glands (Pl. 2, Fig. 7) irregular in outline and variable in size, the subcutaneous tubes attached to these organs are branched and appear like bundles of muscular fibre; there is a group between the base of the capitulum and coxa 1, another between coxa 1 and 2, and a third between coxa 3 and 4, there is also a long bilateral series commencing immediately posterior to the genital pore. Legs (Pl. 2, Figs. 8, 8a, 8b, 8c) normal. Margin of genital pore deeply crenulated.

Nymph (Pl. 1, Fig. 8): Colour, pale ochreous-brown, legs translucent white with, in certain lights, a faint, pale ochreous tinge. Form broadly ovate. Dorsum thickly studded with minute papillae, increasing in size posteriorly, forming a regular crenulated fringe at the margin. Sculpture of dorsum somewhat resembling that of the adult females. Capitulum (Pl. 2, Fig. 2) partly projecting beyond the margin. Hypostome with two bilateral rows of teeth, basal pair minute, the remaining teeth are large and equal in size; mandibles strong; digit blunt, terminal. Palpi broad, stout, third segment the shortest, apical segment about equal in length to the second, and bears two or three short spines at the tip, all the segments have a broad marginal band of dark chitine. Legs (Pl. 1, Figs. 9, 9a) sparsely spinose, rather long; leg i. (Fig. 9) of seven segments, Haller's organ present; legs ii.-iv. (Fig. 9a) of eight segments, with the femora more dilated outwardly than in leg i. Anal orifice placed a little posterior to the insertion of leg i. Vaginal orifice absent. Spiracles minute, placed opposite insertion of leg iii.

Larva (Pl. 1, Fig. 4) sub-circular; colour dull purplish-brown, varying somewhat in intensity according to the age of the individual; but at or near the period of ecdysis the cuticle becomes more opaque and greyish in tone. At this stage, immediately posterior to the anal orifice, is a comparatively large, subcutaneous arrow-shaped, or Y-shaped, patch of white granular matter, evidently secreted by the nymph, which at this period has reached an advanced stage of maturity. Segmentation of legs not clearly defined after maceration in potash; femoral area of each leg with three pairs of equidistant spines; there are also a few isolated spines on the regions of the other segments; terminal tarsal segment (Fig. 5) of each leg broadly obtuse; claws short, stout, and curved. Haller's organ placed immediately posterior to the terminal tarsal articulation. Capitulum (Pl. 2, Fig. 1) within the anterior margin in the earliest stage, but in more mature larvae it projects slightly beyond; base of rostrum on the dorsal area with two rather long stout spines; hypostome with two broad bilateral angular teeth, on the anterior third; mandibles extending considerably beyond the apex of the hypostome. Palpi (Pl. 11, Fig. 1) broad and stout, extending beyond the fully-extended mandibles; each of the second and third segments with one minute, and one long stout spine, there are also two or three minute spines at the apex of the terminal segments. Margin of abdominal area finely and regularly crenulated; cephalo-thoracic area also crenulated, but more faintly so and less regular. Dermis (Pl. 1, Fig. 7) with fine wavy lines. Spiracles apparently absent.

Ovum (Pl. 1, Fig. 1): In addition to the "golden brown colour" described by the authors, an irregular faint whitish polygonal reticulation and interrupted radiating streaks showed through the cuticle in the freshly laid examples. For particulars regarding the development of the ova see Report ante p. 15 and also the notes on the habits of the species in this appendix.

When treated in a 10 per cent. solution of boiling potash (KOH) the eggs containing the mature larvae changed to a rather bright red colour, and instead of softening under the treatment became hard and opaque. It was found necessary, therefore, to express the fluids from the body before maceration in the potash; otherwise it was found impossible to examine the structural details.

The adult female of this species may readily be distinguished from *O. savignyi*, not only by the absence of eyes, as has already been pointed out by Pocock (*l.c.*), but also by the presence of the *interior bidentate apophyses* and the apparently narrower base of the hypostome. The authors of the Report of the Congo Expedition (p. 15) have called attention to the singular fact "that a clear fluid, in fairly large quantity, may oose intermittently from between the bases of the first and second pair of legs." They were, however, unable to find "any trace of an opening." I find, on examination, that there are groups of glands in the situations indicated, and also a third group between the base of the capitulum and the first pair of legs, and in addition to these there is a long bilateral series immediately behind the vaginal opening. All the glands have subcutaneous tubes, which later are finely branched and, as already stated in the diagnosis, these organs have much the appearance of bundles of muscular fibres. I find also that a group of similar organs exist in *Ixodes hexagonus*, Leach, but in this species the subcutaneous tubes are comparatively short and unbranched, and they bear a very striking resemblance to the so-called tubular spinnerets found in the Lecanid group of the Coccidae.

It is important to note that the co-types (3) which were kindly identified by Pocock (*l.c.*) as *O. moubata*, are still in the collection of the School of Tropical Medicine. Some specimens of the latter were prepared for microscopical study, and were found on examination to be specifically identical with the specimens recently received from the Congo Expedition. There should be no doubt, therefore, as to the correct identity of the species. I have placed Neumann's var. *cæcus* as a doubtful synonym, as, unfortunately, I have not been able to consult Neumann's original description, but Pocock (*l.c.*) considers it to be the same as Murray's *O. moubata*. On the other hand, Ray Lancaster (*l.c.*) has quite recently (1905) identified some examples of Ornithodoros from Angola, West Africa, as belonging to Neumann's var. *cæcus*.

Seeing that the specific characters of *O. moubata* are now found to be so markedly distinct from *O. savignyi*, there should be no difficulty in clearing up these somewhat important discrepancies by those who are in possession of the types.

The authors of the Report on the Congo Expedition are to be congratulated on the discovery of the life cycle of *Ornithodorus moubata*, which has not been hitherto observed. In many respects the habits of this species are not unlike those of *Argas persicus*, but so far as I have been able to ascertain the inert character of the larva of *O. moubata* is unique among the Ixodinae, in that it passes the whole of its life within the egg.

Three original drawings illustrative of the development of the larva and nymph accompanied Drs. Dutton and Todds' report, but they were so damaged in transit as to be useless for reproduction.

Experiments with the Ticks Imported from the Congo Expedition.

Experiment 1, June 19.—Thirteen nymphs were placed in a hollow bamboo, which was fastened to the axilla of a young Macaque monkey (*Macacus cynomologus*). The ends of the tube were securely corked, and a large section was cut away, providing the young ticks with ample means of access to the host. As a further means of precaution against admission of light, the tube was covered with a thick cloth. Under these conditions the ticks were allowed to remain on the host for a period of five hours. Result—nil. All the ticks refused to feed.

Experiment 2, June 19.—Five adult female ticks were put into a tube similar to that in which the nymphs were placed, and fastened to an adult Macaque, but as the ticks refused to feed they were subsequently removed and placed together on the monkey in the hollow below the knee of the left leg, and carefully covered with a chamois leather. One of the ticks almost immediately attached itself to the host; this took place at about 1.30 p.m., and the female left the host, fully engorged, at 3 p.m.

Observations on the Engorged Tick and Her Progeny.

The female became very restive after feeding, and made repeated attempts to escape from the bright sunlight. She was put into a Petri dish on a deep layer of dry sand, in which she rapidly buried herself, and was subsequently placed in a dry incubator at an even temperature of 29C. After laying the first batch of eggs, she was removed from the Petri dish and placed in a partly hollowed out banana and enclosed in a cardboard box. The animal immediately left the banana and took up a position in a broad groove, where she was partly concealed, in which position she remained fixed and inert until long after the third batch of eggs were laid. No attention was paid to the banana; indeed, she made a hasty retreat from the fruit and got as far away from it as the limits of her cage would permit. Two additional batches of eggs were laid, both lots being protected for a few days beneath the body of the parent, but both lots finally slipped from beneath her and fell, intact, to the bottom of the box. She defaecated three times during the period of egg laying, the white fluid like faeces, when dry, left a white deposit resembling French chalk in texture. The actual process of egg laying was not observed. The length of the tick before feeding was 7mm.; after engorgement 11.50mm. The weight before feeding was .0270grms., after engorgement .2602grms., or an increase of about ten times her original weight. This was not a very marked increase, as compared with certain other species of female ticks, which are known to increase to about thirty times their original weight after engorgement. Batches of eggs were laid on the following dates—during the night:—

June 29.—First batch of 17 eggs. These were found in a little cluster at the bottom of the Petri dish.

July 2.—Second batch of 51 eggs laid. These were protected for a few days beneath the body of the parent.

July 10.—Third batch of 26 eggs laid. These were also protected by the parent for a few days.

Development of the First Batch of Eggs.

June 30.—First day—subcutaneous reticulation evident. Poles slightly cloudy.

June 31.—Second to fourth day—no change.

July 3.—Fifth day—subcutaneous reticulation more distinct.

July 5.—Sixth day—form decidedly flattened. Legs and capitulum of larva showing faintly through the cuticle of the egg.

July 6.—Seventh day—Form unchanged. Legs more evident.

July 7.—Eighth day—"Arrow-shaped, patch of secretion" formed *beneath* the cuticle of the larva, near anal orifice.

July 8.—Ninth day—egg shell split. Larva fully formed.

July 14.—Tenth to fifteenth day—cuticle of both egg and larva increasing in opacity, finally forming a dull white disc.

July 15.—Sixteenth day—nymphs hatching. Several examples were seen to escape from the larval exuviæ anteriorly.

Development of the Second Batch of Eggs.

Although these were laid four days later than the first batch, some of the nymphs appeared simultaneously with those of the first batch—i.e., on July 15.

Development of the Third Batch of Eggs.

These were laid twelve days after the first batch, or eight days after the second batch, and the first nymph appeared on July 18, just three days later than the earliest appearance of the nymphs from the first batch.

It should, however, be noted that the nymphs from all three batches were quite erratic in their appearance, as examples from each lot of eggs continued to emerge over a period of twelve days, the last appearing on July 27th.

EXPLANATION OF PLATE I.

Fig. 1.—Egg First day. x circa 40.

Fig. 2.—Egg at about the eighth day, showing the split cuticle, the sub-lying larva, and the "arrow-shaped" sub-cutaneous patch of secretion (ventral). x circa 40.

Fig. 3.—Egg at about the tenth day, with the posterior portion of cuticle broken away (dorsal). x circa 40.

Fig. 3a.— A similar example seen in profile. x circa 40.

Fig. 4.—Larva removed from the egg (ventral). x circa 40.

Fig. 5.—Tarsus of the larva. x 250.

Fig. 6.—Marginal fringe of the larva (a) and nymph (b) at the period of ecdysis. x 250.

Fig. 7.—Dermal markings of the larva. x 250.

Fig. 8.—Nymph (as seen in optical section after maceration in potash). x 25.

Fig. 9.—Leg i of the nymph. x 50.

Fig. 9a.—Leg iv of the nymph. x 50.

Fig. 10.—Posterior margin of nymph, showing character of large derm cells (stained preparation). x 250.

EXPLANATION OF PLATE II.

Fig. 1.—Capitulum of larva. x 250.

Fig. 2.—Capitulum of nymph. x 250.

Fig. 3.—Capitulum of adult female. x 75.

Figs. 4, 4a.—Mandibles of adult female, *ap.* inner bitentate apophyses. x 250.

Fig. 5.—Derm cells of adult female (stained preparation). x 200.

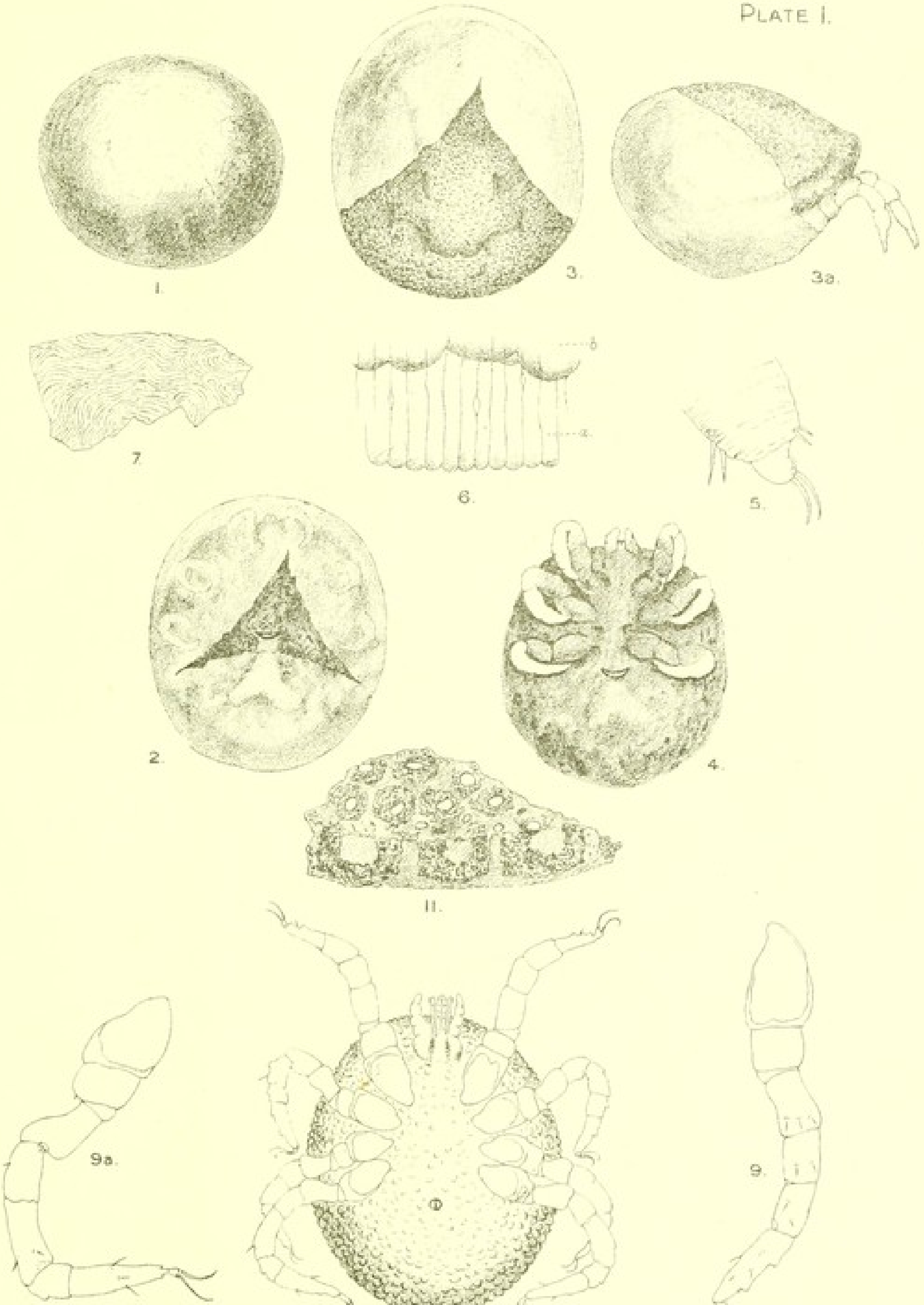
Fig. 5a.—Unstained preparation of same. x 200.

Fig. 6.—Stigmen of adult female, with its finely pitted peritreme. x 200.

Fig. 7.—Secretion glands of adult female. x 250.

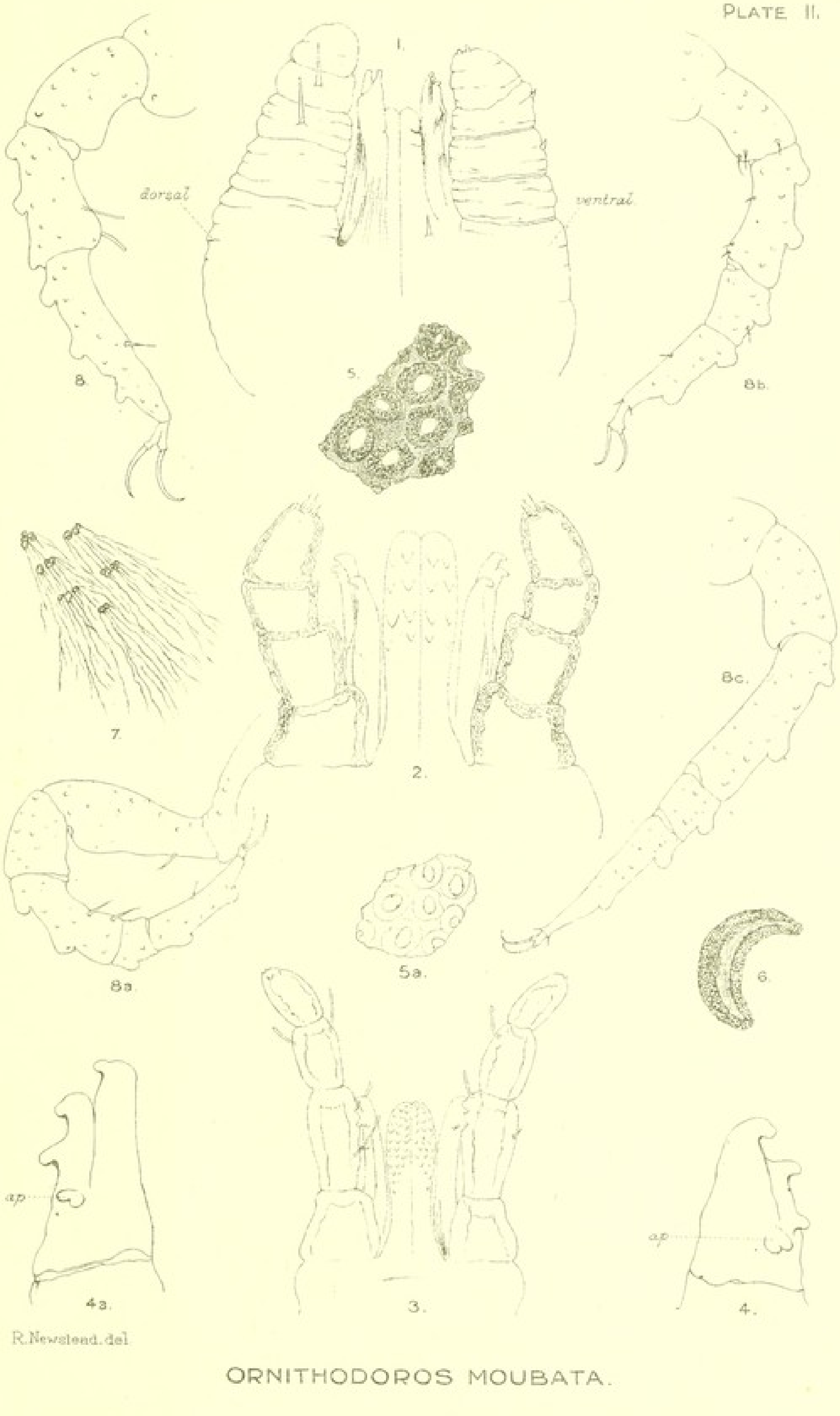
Figs. 8, 8a, 8b, and 8c.—Leg i, ii, iii, and iv of adult female respectively. x circa 25.

PLATE I.



R. Newstead del.

ORNITHODOROS MOUBATA.



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ORNITHODOROS MOUBATA.

Fig 2. Ticks feeding on Monkey, Experiment 176

Fig. 1. To show enlarged spleen in Case IV

Fig. 3.
Line of ecdysis in adult tick

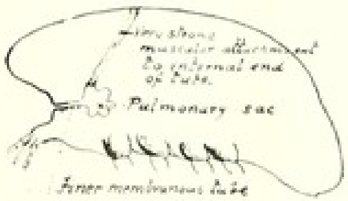


FIG. 1.
Rough diagram showing position of (?) 'Pulmonary sac'

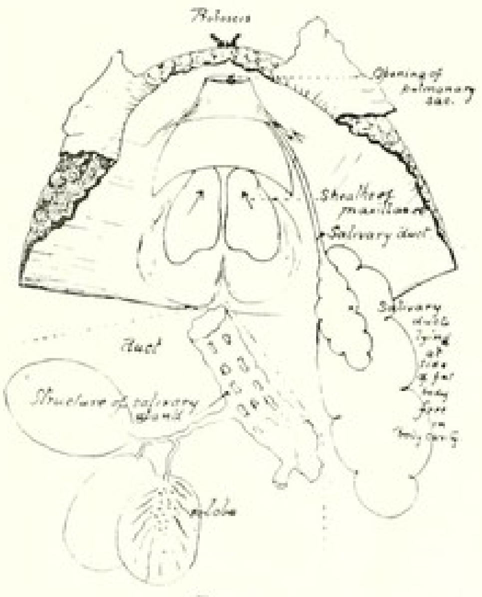


FIG. 3.
Rough diagram showing relative position of salivary glands and (?) 'Pulmonary sac'

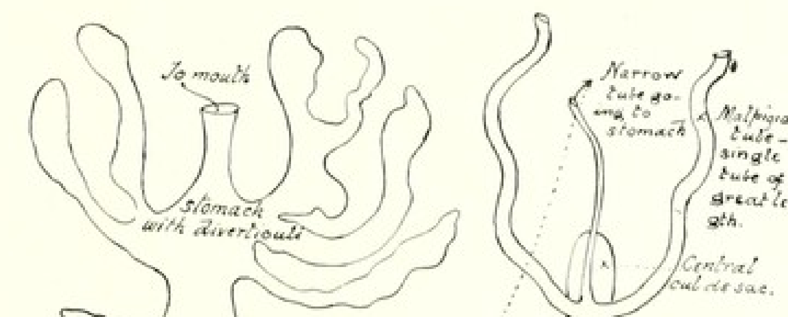
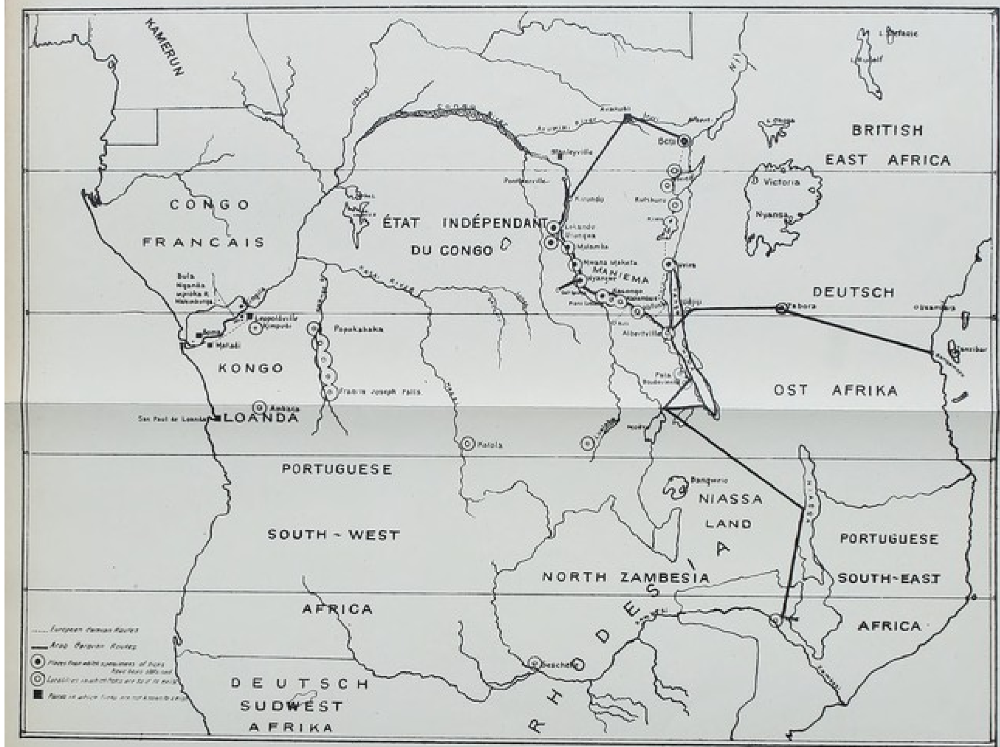


FIG. 2. Diagram of alimentary tract with diverticuli. Tube between stomach and cloaca very much finer than shown in diagram


KAMERUN
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DU CONGO
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DEUTSCH
OST AFRIKA
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