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EAST AFRICAN RELAPSING FEVER.

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The notes and observations which form the subject of this publication were recorded during the latter end of 1917 and during 1918 up to October, and were compiled in the Carrier Depot Hospital, Dar-es-Salaam. The great majority of our cases were drawn from the area around Dar-es-Salaam under the supervision of the Medical Department of the Military Labour Corps, though a certain number under our charge came from more distant localities along with the various sick and wounded evacuated from the area of active military operations. The cases of relapsing fever upon which our observations are based were all natives, and among them were members of almost every tribe in East and West Africa. We have been in addition so fortunate as to obtain notes on a number of cases of the disease occurring in whites, and reference will be made to these as occasion demands in order that a perspective of the disease as extended as possible may be given. Before proceeding further let us state our regrets for the many shortcomings which we are well aware are presented by these notes; we would plead in extenuation that both of us have had many calls upon our time other than the study of relapsing fever, and that, owing to the almost complete inaccessibility of any literature on the subject, our observations have followed along such lines as appeared indicated to us at the time, and we have perhaps, unwittingly, left almost untouched subjects of considerable importance. Many of our results, especially as
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regards treatment, are of a negative nature, but we venture to include
them in detail in the hope that they may prove of assistance to other
workers who have not such abundance of material upon which to pursue
their investigations.

Epidemiology.

Incidence and Immunity.

During the periods mentioned above we have had under our care
1,500 cases of relapsing fever, all of which were microscopically diagnosed
as such. This large number can, on broad lines, be divided racially into
several large groups according to the manner in which they reacted to the
disease.

(1) European.

(2) West African: composed chiefly of natives of the following tribes:
Nigerians, Mendies, Hausas, Timinies, and natives of Sierra Leone.

(3) Central East African: comprising the great majority of native
tribes of the interior of British and German East Africa, conspicuous
among them being the Kavirondo, the Kikuyu and the Mnyamwezi.

(4) The Baganda.

(5) Coastal East African: comprising natives of the coastal areas from
Mombasa to Lindi, inhabitants of Zanzibar, and in addition certain natives
living along the main caravan routes to the interior.

We are able to record a number of general observations on the relative
incidence and severity of the disease manifested by these various groups.

It would appear that Europeans when exposed to the infection very
readily acquire the disease, which in their case runs a very severe and
protracted course, and is very frequently followed by severe complications.
True, we have met with comparatively few cases among Europeans, but
this would appear to be due to the care shown by the individual to avoid
risk of infection, and not to any tolerance of the disease once infection has
taken place. This comparative security, in our opinion, during the present
campaign, speaks highly for the general efficiency shown in the medical
supervision of white units.

The next group, the West African, showed a very considerable liability
to infection; West Africans in the Dar-es-Salaam area were housed in
quarters which proved to be comparatively lightly tick infested, but
nevertheless a very considerable proportion of the men contracted the
disease. They showed a type of the disease approximating closely in
severity with the European, with the exception that severe complications
were very seldom met with. Relapsing fever has been described as existing
extensively over wide-spread areas of West Africa, but the readiness and
severity with which these men acquire the disease in East Africa, especially
by contrast with the comparative immunity of certain East African groups,
shortly to be described, would appear to lend support to the possibility of
the East and West African relapsing fevers being specific diseases, and due to distinct species of spirochaetes.

Considering East African natives, collectively, the disease as a whole appeared in a somewhat modified or less severe form. Group 3, the large majority of the members of which were inhabitants of areas in which the disease was little if at all met with, showed a moderately severe type of disease. On the other hand, a certain proportion even of these displayed the disease only in a very slight form; such cases may well be attributed to previous attacks of the disease, acquired during their four years peregrinations in this nomadic campaign, having given rise to a certain degree of immunity.

Cases in Group 4, inhabitants of the Uganda Protectorate, were only very rarely met with, and were not of a severe form, owing perhaps to the long standing prevalence of the disease in Uganda.

The last group, Group 5, consisting mainly of coast boys, showed a marked tolerance to the disease. Owing to the exigencies of the campaign, many thousands of these boys were living under our observation for many months in quarters heavily tick infested, yet the number of cases occurring amongst them was proportionately very small; the great majority of these boys were undoubtedly repeatedly infected during this period but showed no manifestation of the disease. Taking into consideration the fact that native houses along the coast and caravan routes have for generations been heavily infested with ticks, and the disease among the inhabitants has been extremely common and widespread, we consider we are justified in assuming that infection in early childhood is the lot of the great majority of natives in these areas. By this means it is probable that a high degree of immunity is developed by the time adult life is reached, and this, in our opinion, affords the only explanation of the fact that over one-third of our untreated cases belonging to the coastal group showed only an initial rise of temperature, with spirilla in the blood, not followed by any subsequent relapse. It would appear that this immunity, though always present to a considerable degree, tends to undergo fairly rapid diminution, and it is by these abortive attacks that immunity is maintained to a degree sufficient to prevent the manifestation of the more classical form of the disease.

Method of Transmission.

Investigation of the cases of relapsing fever admitted to hospital has shown clearly that the distribution of the disease coincides very closely with the distribution of *Ornithodoros moubata*. Wherever the latter occurred, cases of the disease in greater or lesser numbers were always met with. Further, an increase of the latter in one area has been noted to precede any large increase in the number of cases from that area. For example, the Invalid Camp, Carrier Depot, Dar-es-Salaam, had for many months been to all intents and purposes free from ticks, only some three or four cases of the disease having occurred there during a period of
four months. In July, 1918, a few cases occurred, and investigation of the bandas (= native hut) showed that many of them had become heavily infested with ticks; a rapid increase in the number of cases followed, some seventy-five porters acquiring the disease in six weeks out of a total of about 400 living in these quarters. Immediate steps were taken to render the men's quarters free from ticks, with the result that no further cases occurred after the incubation period had passed, during which those men infected previous to prophylactic measures developed the disease. The converse holds true; camps and areas which did not contain *O. moubata* never yielded any cases of relapsing fever, the single exception being a case of a white British rank who contracted the disease after only three weeks' residence in East Africa, all of which time he spent at a camp near the sea. Here thorough search failed to reveal ticks, and the manner of his infection must remain a mystery.

The possibility of there being carriers of the causative organism other than *O. moubata* was not lost sight of. Bed bugs, lice, fleas, and chiggers, all common inhabitants of porters' quarters, came under suspicion, but no evidence could be obtained to incriminate them; it has been noted throughout our investigations that the number of these various pests bore no relation to the incidence of relapsing fever. Further, a considerable number of fleas, lice, and bed bugs have been examined microscopically, the result being absolute failure to identify *Spirillum duttoni* in any of these. It is possible, however, that by the bite of any of these insects infection may be directly conveyed from an infected to a non-infected person; the same holds true for biting flies and mosquitoes, but there would appear to be no evidence from our observations of the organism maintaining an existence in these insects for any length of time. Hence it is our opinion that *O. moubata* was the only carrier of the infection in the Dar-es-Salaam area whereby the disease was spread.

It is not proposed to enter into a minute description of *O. moubata*. The following observations of its habits, etc., are, however, of great importance in the provision of measures necessary to control and eradicate the disease in infected camps. These ticks are extremely resistant to heat and to germicides, and appear to be able to exist for very long periods deprived of food and air. We have had some specimens without food in test tubes sealed with paraffin wax for over nine months, which are still alive, and a case has been quoted to us of ticks remaining alive in a bottle for four years without food. Their habitat is essentially the loose sand of the floors of the native houses; when the floors are beaten hard, they are usually found in the earth around the poles supporting the house, as owing to the action of the wind on these poles the earth immediately around them becomes slightly loose; we have seldom found them at a depth greater than six inches, either in the soil or around the poles. Statements to the effect that ticks were to be found in banda roofs in Dar-es-Salaam proved to be without foundation as far as we could ascertain, prolonged
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search of many roofs in the Military Labour Corps area produced nothing but a varied collection of fleas, lice, etc. Ticks manifest great antipathy to light, remaining in the sand throughout the day, and only appearing to feed on the inmates of the house at night; the presence of a lamp even appears to afford a considerable amount of protection.

Eggs are deposited in the sand; from observations on ticks kept in test tubes, it would appear that each tick lays some one hundred to three hundred eggs, in batches at short intervals; these eggs hatch out into ticks after an interval of about sixteen days; the nymphs are complete replicas of the full-grown insect, except that they are of a light brown colour and have relatively longer legs; they possess four pairs of legs from the moment of hatching out. As regards the ticks collected from various areas, between six and seven hundred were examined microscopically (for method see Appendix 2), and of these twenty-nine per cent were found to be infected with S. duttoni. Taken generally those collected from different camps all showed much the same percentage of infection, with the exception of those obtained from the West African Carrier Depot, Dar-es-Salaam, a camp which yields a particularly small number of ticks proportionate to the number of cases of tick fever occurring; these ticks were, however, very heavily infected, no less than fifty-five per cent harbouring the spirillum. It is highly probable that our estimates of the percentage of infection are considerably on the low side, as, owing to the numbers to be dealt with and the dearth of skilled assistance, only a comparatively cursory examination could be given to each slide (the Germans are reputed to have found over fifty per cent of ticks infected along the main caravan routes of German East Africa). A number of eggs were also examined microscopically for spirilla, all with negative results.

Incubation Period.

We have experienced considerable difficulty in endeavouring to determine the duration of the interval which elapses between the infection of the patient by the bite of O. moubata and the first attack of the disease, as indicated by rise in temperature and the presence of spirilla in the peripheral blood. Reliable histories of being bitten by ticks at any particular time are almost impossible to obtain from natives; again, the great majority of our cases have been exposed to infection so freely for prolonged periods, as to render absolutely valueless any suggestion of an admitted bite being the cause of infection. We are of opinion, however, that what appears to be the generally accepted period of ten days is on many occasions very much shortened. The following are a few of the instances which lend support to this surmise: (1) A native who had been employed as a ward boy on the hospital ship "Dongola," a position in which exposure to infection would be extremely unlikely, was transferred to duty at Carrier Depot Hospital, Dar-es-Salaam, and three days after landing from the ship developed relapsing fever. (2) A native who had
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been for a long time in the post-mortem room, Carrier Depot Hospital, assisted at a post-mortem on a case of very acute relapsing fever, that had died with an enormous number of spirilla in the blood; this autopsy was performed within one hour of the patient's death. After an interval of three days the post-mortem boy developed relapsing fever; he stated most emphatically that his quarters were entirely free from ticks, which proved to be the case on examination. In fact there would appear to be every indication that he acquired the disease at the autopsy. (3) On two occasions large drafts of boys arriving for duty from uninfected areas were placed in quarters which subsequently proved to contain large numbers of infected ticks. As soon as cases began to occur among these boys examination of their quarters led to the detection of the ticks, and the boys were at once removed to uninfected quarters; unfortunately many

![Chart I](http://militaryhealth.bmj.com/)  
**Chart I.**

![Chart II](http://militaryhealth.bmj.com/)  
**Chart II.**

Two charts showing daily incidence of relapsing fever in two groups of uninfected boys placed in infected quarters.
boys had by this time become infected, and after varying incubation periods manifested the disease.Charts I and II show the number of cases occurring daily, plotted against the number of days elapsing between the boys entering the infected quarters and the manifestation of the disease.

From these charts it would seem that out of a total of seventy-four cases which occurred, one patient manifested the disease after three days residence in the infected quarters; that no further cases occurred until the sixth day, when one was seen; from the seventh day onwards, cases appeared with frequency on, to the sixteenth day, forty-three cases, or fifty-eight per cent of the total, occurring on the ninth to the twelfth day inclusive; eighteen per cent occurred before the ninth day, and twenty-four occurred between the thirteenth day and the seventeenth, after which no cases occurred. The interpretation of these figures must remain somewhat indefinite, since there is no guarantee that all these patients acquiring the disease were infected on the first night of arrival in the infected quarters; in fact we consider this very unlikely. This fallacy would tend to reduce the above incubation period figures to even shorter periods; on the other hand, it appears to us that a very fair idea of the incubation of the disease may be obtained from a broad-minded study of these charts.

The Spirillum.

We are fully aware that many obscure problems still exist with regard to the spirillum of African relapsing fever, such as method of division, the fate and the possible pleomorphism of the organism during the apyrexial period, and its exact relationship to the spirilla of relapsing fevers of other countries, as interpreted by means of the cross-immunization experiments; such points being beyond the scope of the present paper, we will confine ourselves to such observations as appeared noteworthy to us during a routine examination conducted mainly for diagnostic purposes of a great many thousands of blood slides containing spirilla. First, we would point out that the organisms observed by us showed very great variation both in length, breadth and morphology. The majority conformed to a type 20 to 35 microns long and 0.25 to 0.35 microns in breadth, straight or slightly curved, and showing five to nine spirals; shorter forms down to 6 microns were met with commonly, while, more rarely, types reaching even to 55 microns were seen. Variation in breadth was much less common; occasionally, however, a thick type was seen very noticeably broader than the average, sometimes reaching a breadth of 0.6 microns; these forms tended as a rule to be short in length, and showed very regular and usually somewhat pronounced spirals. The difference appeared to us to be so pronounced that the occasional cases showing it were carefully observed at subsequent relapses; the resulting evidence is strongly in favour, in these cases, of the same type tending to recur in each relapse to the exclusion of the common thin type, suggesting the possibility that we were dealing with more than one specific type of organism in Dar-es-Salaam.
The greatest variations were, however, observed as regards morphology: quite often the same stained slide showed a number of different shapes, the common one being a tendency on the part of the organism to assume a circular or a looped disposition; this of course only holds in the case of dried stained specimens; it was not observed in wet specimens examined. These looped and circular forms appear, however, to be very characteristic of the African type of relapsing fever, and were met with to a greater or less degree in a large proportion of the films examined. Two other types appear to be worthy of mention, one a short medium form, in which the spiral is very close, as many as ten spirals occurring in an organism of twelve microns in length; these organisms were extremely thin and delicate, and were very rarely met with. The last type was one in which the spirilla appeared to a large extent to have lost their spirals, at any rate the latter were very slightly marked, and the organism showed more the appearance of waves than of spirals. A tendency of this latter type to dissolution was sometimes noted, especially at the termination of an attack or at a period within a few hours following a dose of salvarsan. An idea of the various types described above is best obtained from the plates appended, which was compiled from actual specimens observed under the microscope.

As regards these various types of spirilla described, we are able to put forward a few observations on their occurrence at different phases of the disease. Firstly, the organisms are in a very great majority of cases much more numerous at the first attack than at the relapses, showing a tendency to progressive diminution in numbers at each relapse, until at the last relapse very careful search is needed to detect them at all. Again, the number of spirilla is greatest during the first few hours of the rise of temperature; they may be demonstrated in the blood some hours before the temperature actually rises; show maximum numbers during the first twenty-four hours of the attack, and then gradually become fewer. We have frequently been unable to demonstrate spirilla in the blood during the twenty-four hours previous to the crisis, and when present at this time they were only seen in small numbers (see Chart IX). We have endeavoured to ascertain the approximate numbers of spirilla present in the peripheral blood; in the first attack the average would appear to be about 10,000 per cubic millimetre, though in many cases, even of marked clinical severity, the number of organisms was very much less, perhaps as few as 500 per cubic millimetre only being found; not infrequently, cases were met with showing a very much higher spirilla count, up to 50,000 per cubic millimetre being fairly common. Finally, a very rare class of case was met with on several occasions in which spirilla in enormous numbers were observed, in at least one case the organisms being quite as numerous as the red corpuscles; they were in these cases always of a particular type—very long, the majority being from thirty to forty microns, slightly thinner than the average organisms met with, showing
Drawings of actual Microscopic Fields, showing the appearance of the Spirilla of African Relapsing Fever in Thick Blood Films stained by Azur II-Eosin Method.

Fig. 1 shows an infection of moderate severity.
Fig. 2 shows masses of Spirilla, as met with in rare fulminating cases.

Drawings showing the various types of Spirilla met with in the blood in African Relapsing Fever.

Types 1 and 2 were those commonly seen.

no tendency to looping, but very commonly arranged in clumps and masses; so far as we were able to ascertain by staining methods, these long forms consisted of single individuals, there being no indication that two or more were joined together terminally; they appear to be produced when sudden and very prolific division of the organisms takes place, and our inference is that this division is longitudinal rather than transverse. As the organisms disappear from the blood towards the end of the attack, we have often noticed a tendency for them to show signs of breaking up, as instanced by

![Chart III](http://militaryhealth.bmj.com/jramc-33-02-01/1August1919) Untreated case complicated by benign tertian infection. Shows daily blood examination with presence of spirilla in apyrexial period on two occasions.

![Chart IX](http://militaryhealth.bmj.com/jramc-33-02-01/1August1919) Shows presence of spirilla over five days in a relapse; also tendency of the organisms to become fewer as attacks proceed.

irregularities in staining and in morphology. By the time the temperature drops to normal at the end of the attack spirilla can only rarely be found in the peripheral blood; during the apyrexial period they are not to be found until within some twelve hours of the onset of the next relapse, except on very rare occasions. As regards this latter point, daily blood examination of a number of cases throughout the whole disease has shown that very occasionally—certainly not in more than one per cent of slides examined in the apyrexial period—odd spirilla may be met with. When
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present they were only found in thick blood films after prolonged search, and were always of the very short type. Chart III shows the result of the daily blood examinations in such cases. As regards the fate of the organisms during the normal apyrexial period we are without evidence upon which to base an opinion. We can only state that we have found no indication of the spirilla undergoing a granular metamorphosis, while the occasional presence of a spirillum in the apyrexial period might be held to suggest that after the destruction of the great majority at the crisis a few remaining organisms of intensified resistance betake themselves to the internal organs, where they undergo some form of cycle before taking on active multiplication previous to the next relapse. No punctures of internal organs were performed by us to verify this surmise. Examination of thin films showed no tendency of the organisms to take up a position within the red and white corpuscles; quite commonly however we observed a spirillum attached by one end to a leucocyte (almost always to a polymorph) the remainder of it lying free.

Considerable numbers of specimens from material other than blood were examined for spirilla during life; organisms were never found in the sputum, except in cases showing severe bronchial symptoms, and then only rarely; in fact we are of opinion that such spirilla found were not true inhabitants of the sputum, but had gained access to it in the blood present in the rusty sputum of such cases. The cerebrospinal fluids of some acute cases were examined, but none showed the organisms in life; one very acute case which died very early in the disease showed very considerable numbers of spirilla in the fluid taken some two hours after death at post-mortem; this was open however to the fallacy of blood contamination at autopsy, and also to that of post-mortem migration. As noted elsewhere no spirilla were found in the urines examined at various periods of the disease.

The Clinical Manifestations.

The following description of a characteristic attack of relapsing fever is drawn from our experience of some 1,500 cases occurring in natives. Many variations from this representative type occurred, some manifesting acute symptoms of the gravest severity, others merely showing a slight febrile condition indistinguishable from a mild attack of malaria, but the great majority closely followed the course about to be described. It should also be clearly understood that our description refers in the main to the period in the disease coinciding with the first rise of temperature. The symptoms observed in the relapse tend to follow along the same lines as those characteristic of the initial attack, but are, as a rule, much less severe in character; they will be dealt with in detail at a later stage.

The attack is usually preceded by a series of more or less constant prodromal symptoms. Of these the most commonly noted are:
Lassitude: This is a well-marked and very constant symptom, and is frequently present twenty-four hours before the temperature actually rises. There is a marked inclination on the part of the patient to lie still in bed well covered with blankets, and considerable irritation is shown if there is any interference with his comfort. This feeling would appear to be very real to the patient, and even in cases where all question of malingering can be ruled out it is constantly present. Headache: This is of a neuralgic type and frontal situation, and is often very severe; in a small number of cases vomiting has been observed accompanying the headache. Vertigo is also often present. The headache may be felt even though temperature is not raised, and in many cases the presence of a headache at or about the time when the rise in temperature is expected is a sure indication that an attack has begun. It persists while the temperature is rising, disappears often before the height of the fever has been reached, and is absent during the fall of the temperature as the attack passes off. Vague pains of a rheumatic type, easily controlled by aspirin, are very common. They are also prodromal and appear before the expected rise of temperature, persisting if untreated during the whole length of the attack, but diminishing in severity as the temperature falls again to normal. The common sites of the pain are the shins and ankles; the back, ribs, hips and thighs are also frequently affected, while the shoulders, neck, and arms are relatively seldom involved. Less common prodromal symptoms of an attack are rigors, shivering, and a feeling of coldness in the extremities of the limbs. In our experience a rigor is very rare, and the nearest approach to it is a general feeling of coldness in the hands and feet, accompanied by goose-skin over the surface of the trunk. These prodromal symptoms of more or less severity usher in the attack and are constant in all racial types. The temperature rises suddenly, usually in the latter half of the day, and there is often a difference of several degrees between the morning and evening temperature. The height varies, but temperatures of 102° to 104° F. are common, while 106° F. has been noticed on occasions. The headache which has been persistent up to the present usually now disappears, and the patient is fairly comfortable. Delirium as a direct result of high temperature has never been noticed. The patient tends to lie in bed well covered up with blankets drawn over his head. The temperature remains up for a variable period, usually for three days, and maintains a fairly constant level, though the morning temperature may show a lowering of one or more degrees compared to the previous and subsequent morning levels. This produces a saddle-back form of chart, and its presence is almost always an indication that bronchitis, either slight or severe, is present. After remaining raised for two to four days the temperature drops, usually during the night, to subnormal; from this point marked subnormal temperatures are very frequent. Immediately preceding crisis, some twenty-five per cent of our cases showed a slight kick of temperature which rose ½° to 1° above the highest temperature
previously registered during the paroxysm; this was observed to occur only in the first attack and first relapse. During the fall of temperature profuse sweating takes place, but it is unaccompanied by the extreme collapse so frequently met with in Europeans. In our experience collapse following the crisis is extremely uncommon in natives. The crisis is always accompanied by profuse sweating and by the clearing up and disappearance of headache, if it has persisted so long, body soreness and lassitude. The patient has a good sleep and wakens with a marked sense of relief and well-being. The question of bronchial trouble during an attack of this severity will be treated in greater detail later, but it may be noted here that in all cases where a rise of temperature persists over a period of several days bronchitis of varying severity, accompanied by cough and expectoration, is a marked symptom. During the attack the urine is scanty and high coloured, as in most febrile conditions. The appetite is absent during the paroxysm, but quickly returns when the temperature falls to normal. At this time constipation is the rule, accompanied by furred tongue, bad smelling breath and foul mouth. Diarrhœa, though mentioned by some observers as a sequel to a paroxysm of fever, has not been noted amongst our cases. When present it was of independent origin and frequently due to errors of diet.

The first relapse occurs at intervals which vary from four to eighteen days, but the average duration of the interval may be taken as ten days. It is ushered in by more or less the same symptoms as the first attack, but usually these are less severe and less complained of by the patient. The rise of temperature is sudden and occurs again in the afternoon or evening. The temperature reached may exceed that observed in the first attack but its duration is relatively shorter; it seldom remains elevated more than twenty-four hours and the crisis is sudden, the temperature falling to normal or subnormal in a matter of a few hours; there is no saddle-back form of chart in a typical relapse. In this type bronchitis is not common, and cough, if present, only exists for a short time and is very slight in character. Crisis is again accompanied by sweating, and after a sleep the patient is and feels fairly well.

A second varying interval is now followed by a second relapse possessing, in most cases, all the features characterizing the first relapse, but in a minor degree. The number of relapses varies in each individual case and will be discussed in greater detail later, but it may be noted here that as relapse follows relapse there is a general tendency for each to be less severe and, finally, if left untreated, the last relapse may be only appreciated on the chart by a persistent subnormal temperature, after the ordinary apyrexial period, rising to normal and falling to its subnormal state. Such slight kicks of temperature are proved to be of spirillar origin by the demonstration of the organism in the blood at these times. Chart IV is a characteristic type of untreated African relapsing fever.

We have given above a general description of the main clinical
manifestations of a typical attack of relapsing fever; we will now state our observations on the reactions which the individual organs may show in the course of the disease.

**Lungs.**—Bronchitis is a well-marked symptom and often a very severe complication of tick fever. It occurs chiefly during the severer and more prolonged attacks of the disease when the temperature is raised and spirilla are present in the peripheral blood. In the vast majority of cases it is present in more or less severity in the first paroxysms of fever, and while it may occur in second or later attacks, it seems to be less pronounced as the disease tends to run its usual course, so that in the later spasms of temperature it is usually entirely absent. As was noted in the clinical description of the disease, first attacks almost invariably are accompanied by several days of temperature, the degree and height of fever being more or less evenly maintained over two or three or even four days. Such attacks show well-marked bronchial distress and are accompanied by cough and expectoration varying in degree with the amount of congestion present. The degree of bronchitis may roughly be classified into three groups:

1. **Slight bronchitis.** In this type there is a slight cough, some pain or discomfort in the chest, a slight degree of embarrassment in breathing, and if the chest is examined carefully a few rhonchi and moist rales are heard at the base of the lungs. There is no alteration in the percussion note of the chest in uncomplicated cases. This slight degree of bronchitis is most common in second or later relapses when the temperature shows a relatively sudden rise, maintaining a high level only for a few hours and falling to normal by crisis. With the fall of temperature all physical signs of bronchitis disappear, together with the cough, though expectoration occasionally persists for a day or two longer; breathing becomes normal and discomfort ceases.

2. The second type of bronchitis met with in tick fever attacks shows all the signs of acute bronchitis. There is a burning pain in the chest, particularly post-sternal, a sense of oppression about the chest and most distressing cough. The expectoration is at first scanty and frothy, but later becomes more mucopurulent and abundant.
The breathing is not markedly whistling or noisy in character, and physical examination shows many rhonchi and moist râles over the whole chest; the breathing is rough, and rhonchi and râles are heard during both respiratory periods. There may not be any alteration in the percussion note provided no other lung complications are present. This condition also clears up rapidly when the temperature falls, and in a matter of a few hours the patient is well and experiences no inconvenience in breathing or pain on movements of the chest walls. Chart V shows this condition.

(3) The third and least common of the three types of chest complications met with is what we have ventured to call the pseudo-pneumonic type. In this condition the temperature rises suddenly, remains at almost a constant level from three to four days, showing little or no evening variation, but resembling the type of temperature met with in pneumonia. It may continue for several days, when by sudden crisis the temperature falls and the attack finishes. The signs shown by the patient closely resemble those of early pneumonia. There may be slight dullness and characteristic fine crepitations, passing on to almost typical tubular breathing; the vocal resonance is increased. The patient shows many of the signs of early pneumonia: dyspnoea, pain in the chest, increased frequency of breathing and pulse-rate. Cough is persistent and annoying, and the sputum is mucopurulent, and often contains exuded blood. Restlessness and general distress are also marked. After the most careful physical examination these cases show all the signs and symptoms of early pneumonia; and in our experience many of these cases have been admitted to pneumonia wards, and not until blood examination has been made has the true nature of the case been diagnosed and appropriate treatment adopted. By sudden crisis or rarely by a lysis extending over thirty-six hours, the temperature falls to normal, and the patient after a sleep wakens much improved. The sudden and complete clearing up of the physical signs in a patient apparently about to enter upon the consolidation stage of a pneumonia is a most startling and dramatic event; in no case under our care did an actual pneumonia with consolidation occur, although such appeared to be inevitable on many occasions. As regards the pathology of this condition, it would appear that the lung goes through just such early changes as are seen in ordinary lobar pneumonia. Several cases that have come to the post-mortem table have shown a condition of the most intense congestion involving the whole of both lungs, but most marked at the bases, while it has several times been a question as to whether actual consolidation had occurred or not, but we have always been able to answer this in the negative. Cases have come to post-mortem in which the fall in temperature, with consequent almost entire alleviation of bronchial symptoms, has preceded death by thirty-six hours; in these the upper lobes appeared quite clear, but a considerable degree of congestion was still seen at the bases, despite absence of symptoms. Repeated examinations of the sputum of such cases during life demonstrate the presence of spirilla in
a few cases; speaking generally, however, the latter appeared to be present rarely, and only in small numbers. A notable increase in mixed pyogenic cocci (staphylococci, streptococci, and pneumococci) was always present, and leucocyte counts of cases with severe bronchial symptoms nearly always showed a leucocytosis of 12,000 to 15,000 white cells per cubic millimetre, of which 75 per cent. to 90 per cent. were polymorphonuclears.

Charts V and VI illustrate the acute bronchial condition.

![Chart V](chart_v.png)

**Chart V.**—Second and third relapses showing prolongation due to bronchial condition. Note saddle-back type of temperature indicative of bronchial conditions in relapsing fever.

![Chart VI](chart_vi.png)

**Chart VI.**—First attack, showing pseudo-pneumonic type of temperature.

The Heart.—Observations made on the heart and its action during an attack of tick fever were all largely negative. There appeared to be no definite and constant symptom present which would be of any diagnostic value. During an attack of fever the heart presented only those signs commonly met with in high temperatures, and these in very minor degree. The pulse was quickened and full, but such slight changes were of a very transient nature and passed off quickly whenever the temperature returned to normal. Certain of our cases died in the first attacks with a very high temperature; the temperature mounted higher and higher and death supervened very rapidly with the temperature still rising. These attacks were of the acutest nature and presented the signs of an acute toxæmia; death appeared to result from heart failure. Post mortem, the heart
in such cases revealed an organ very relaxed and flabby, slightly dilated, and the muscle on section showed a surface pale, and very soft. The substance was easily torn, and cloudy swelling markedly present. We would mention here that our conclusions on the pathological morbid appearances of the various organs were based only on naked eye observations, as sections were not available owing to the lack of a microtome. In a second type of fatal case death ensued suddenly within the twenty-four hours following an attack. The temperature had fallen to normal and there was no indication that a fatal result would ensue beyond a slight degree of cardiac weakness in no way more severe than that to be expected in cases where the sudden crisis occurs with consequent rapid fall of temperature. Death took place in these cases usually after the second or third attack of fever. Post mortem, the heart was relaxed and flabby, dilated, with a slightly increased fatty deposit on the surface. On section the cut surface was of a pale yellowish tint, soft, friable, and with a degree of apparent fatty infiltration in the muscle. This again is a condition not incompatible with a toxemia resulting in heart failure. In cases where the disease was more or less resistant to treatment, and relapses had been present over a long period, evidence of heart changes were present. These appeared to be more or less directly the outcome of myocardial changes, and the symptoms produced closely resembled those of dilatation, though in a minor degree. At no time did any of our cases manifest marked cardiac distress requiring urgent treatment and it was only when a systematic examination of the circulatory system was made that these signs and symptoms were elicited. The action of the heart in these cases was feeble, and the pulse soft and rapid, and in one or two cases only was irregularity noticed. Most of the cases showing these signs were fatal and one would hold out a bad prognosis in cases where signs of cardiac dilatation were detected.

The Liver.—It has been our experience that the liver during an attack of relapsing fever does undergo in practically all cases some form of change. This may be so slight that no signs of any variation from the normal may be observed by the patient, and it is only noticed when careful investigation of the organ by the physician is made. On the other hand, cases have come under our notice in which there is a very marked degree of discomfort over the hepatic region and considerable pain and tenderness are experienced. All these changes, whether slight or severe, coincide with the rise of temperature during an attack or a relapse, and take the form of enlargements of the organ. In slight cases careful percussion of the liver is necessary to demonstrate enlargement and very deep palpation is required to elicit pain or tenderness. In severe cases enlargement is easily elicited and may even be visible to the eye, while pain occurs over the hepatic area with every respiratory movement. The condition presents in such cases all the signs and symptoms of acute hepatitis; the possibility of amoebic infection was
excluded. Accompanying this condition jaundice in varying degree is often present; in slight cases it also requires to be carefully looked for before it is recognized; while in severer cases a very deep jaundice is the rule. In all our fatal cases where death could be proved primarily to be due to tick fever, jaundice was a pronounced feature of the condition, and at autopsy on all such cases deep bile staining of the tissues and other evidence of acute jaundice was found. It must be born in mind, however, that jaundice is not necessarily a feature of an attack or relapse, and that while it does very frequently occur yet it is not such a constant symptom as pain and swelling of the liver. A certain percentage of severe attacks were unaccompanied by jaundice, but in these enlargement of the liver and tenderness of that organ were present: It would appear that in fully sixty per cent of our cases enlargement of the liver accompanied by pain and tenderness was present during the attack or relapse. There would appear to be little or no change of a permanent character in the organ as a result of the attacks, except in very prolonged and severe cases where the liver was definitely enlarged and pale, but distinctly firm in consistency. The enlargement and pain quickly disappears after the attack has passed off and during the apyrexial period a normal condition of the organ is usually found. Epistaxis has been noted in four cases, and in none of these cases did it bear any relation to the temperature. In one it occurred during a spasm, in the others during an apyrexial period; it was severe in three cases, slight in one, but in all cases was easily controlled by plugging the anterior nares.

The Spleen.—The spleen in cases uncomplicated by malaria did not in the vast majority of instances present any striking feature. In a certain number of these cases slight tenderness and fullness over the splenic area was complained of when the temperature was high, and an attack of spirillum fever was present. At such times percussion and deep palpation showed a distinctly tender and slightly enlarged spleen. This quickly disappeared as the temperature fell to normal, and during the apyrexial period a normal condition of the organ was present. On the other hand, in cases where malaria was in evidence, involvement of the spleen, at times when spirilla rises occurred, was a well-marked feature. The presence of malarial organisms in the blood of a patient suffering from relapsing fever seems to exaggerate any tenderness of the spleen, and in such cases where the presence of malarial parasites could be demonstrated in the blood in conjunction with those of spirillum fever the tenderness and fullness over the splenic area was often a source of much discomfort to the patient. In one case extreme pain and tenderness were complained of during a spirillum rise, and in this case malarial parasites were demonstrated abundantly present in the blood. It would appear from our observations, which would seem to differ on this point from those recorded by other observers, that in the general run of cases of tick fever the spleen is not influenced to any great extent, but that, on the other hand, when the two diseases occur at
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the same time the spleen may show quite marked tenderness and enlargement, requiring treatment. Post mortem the organ does not show any striking naked eye appearances except in cases where well-marked malaria is also present, and in such the spleen simply shows changes due to malarial invasion, and examination of stained films from this organ immediately after death does not indicate it as an all-important reservoir for spirilla. The characters of the spleen in the few fulminating cases mentioned previously are noted elsewhere.

The Blood.—A large number of total leucocyte and differential leucocyte counts were made with a view to determining what blood changes, if any, occurred during the disease. As a preliminary, examination was made of fifty natives uninfected with relapsing fever but in other respects similar—i.e., both classes had been equally exposed to malaria, worm infection, etc., conditions which might tend to bring about variations in the blood picture. The averages are seen in the table appended:

<table>
<thead>
<tr>
<th></th>
<th>Total Leucocytes</th>
<th>Polymorphs</th>
<th>Lymphocytes</th>
<th>Hyaline and Transitional</th>
<th>Eosinophil</th>
<th>Mast cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal natives</td>
<td>5,500</td>
<td>52'0</td>
<td>19'6</td>
<td>21'5</td>
<td>6'5</td>
<td>0'4</td>
</tr>
<tr>
<td>Relapsing fever, tempera-</td>
<td>5,600</td>
<td>57'6</td>
<td>16'0</td>
<td>21'0</td>
<td>5'0</td>
<td>0'4</td>
</tr>
<tr>
<td>ture high, no bronchial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relapsing fever, apyrexi-</td>
<td>5,500</td>
<td>51'5</td>
<td>16'4</td>
<td>27'0</td>
<td>5'0</td>
<td>0'1</td>
</tr>
<tr>
<td>al period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relapsing fever, high tem-</td>
<td>15,000</td>
<td>81'0</td>
<td>8'0</td>
<td>9'0</td>
<td>1'5</td>
<td>0'5</td>
</tr>
<tr>
<td>perature, with marked</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>bronchial symptoms</td>
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</tbody>
</table>

It will be seen that the average number of leucocytes in normal natives is low, about 5,500 per cubic millimetre; this total was not raised appreciably in patients suffering from relapsing fever either during the period of high temperature or during the apyrexial period. The very slight increase in the polymorph count (52 per cent normal to 57'6 per cent) seen in cases of high temperature does not appear to us to possess more than accidental significance, the same applying to the slight increase of hyalines (21'5 per cent normal to 27 per cent) in the apyrexial period. It appears, in fact, that the only blood change to be noted occurs in cases with high temperatures which show marked bronchial symptoms, and in these there is a definite leucocytosis of from 10,000 to 15,000 per cubic millimetre, of which some seventy-five per cent to eighty per cent are polymorphonuclears. The Wassermann reaction was performed on the blood in a series of cases, one set of them in the acute attack, one set in the apyrexial period, and one set in convalescence. The reaction in all these cases proved to be negative.

The Urine.—A number of urines were examined at various periods in the disease; at the paroxysm, during the apyrexial period, and during convalescence; none showed any abnormal characteristics beyond the presence of a trace of albumin in a certain number at the time of high
temperature; centrifuged specimens stained by various methods showed no evidence of spirilla. The characteristic urines containing abundant albumin, red blood corpuscles, casts and spirilla, described by Dudgeon as occurring in his Macedonian series, were never met with by us in the African type, and examination of the kidney post mortem in fatal cases showed remarkably little change in this organ.

Fulminating Cases.

There is a very rare type of fulminating case which merits careful consideration. We are able to record nine cases belonging to this group, all of which were fatal, their history being one of very acute onset, followed by coma and death within twenty-four hours of the manifestations of illness. Clinical details of these cases have been very difficult to obtain as by the time the patients arrived under our care coma had supervened and death followed very shortly. We have seen three such cases ourselves and to Captain J. W. A. Wilson, R.A.M.C., we are indebted for details of six more which occurred at Carrier Depot Hospital, Morogoro. The details of one of our cases are as follows:

The patient was admitted to hospital during the morning with a temperature of 100°F.; he complained of no particular symptoms beyond headache, and was provisionally placed in a malaria ward. During the day a routine blood examination was made, and the patient's blood was found to be teeming with spirilla—at least five million organisms to the cubic millimetre being present; many of these organisms were massed together in clumps of several hundreds. During the evening he became comatose, his temperature rose to 102°F. and he developed a very intense degree of jaundice; death ensued at 10 p.m. the same night.

Captain Wilson's cases were so startling that, as a routine, blood films were prepared in the admission room from all cases showing temperature, as it was found that several patients died before ordinary routine blood examination could be made. He informs us that every case of this kind showed enormous numbers of spirilla in the blood, as was observed by us, and further states that the clinical similarity of these cases with cerebral malaria was almost exact, except that intense jaundice was seen in the spirilla cases. Post-mortem examination showed the tissues deeply bile stained, the gall-bladder and its ducts being apparently normal; the liver was considerably enlarged, soft, and showed a marked degree of early toxic change; the spleen showed very characteristic change, being somewhat enlarged, and so extremely soft and pulpy that before being opened with a knife it resembled nothing so much as a bag of water; smears made from the pulpy contents showed large numbers of spirilla when the examination was made shortly after death, but in cases which were not examined until an interval of several hours had elapsed, the spirilla had all disappeared; this rapid post-mortem disappearance of the organisms was similarly noted.
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in the other organs and in the blood. The lungs invariably showed throughout a condition of very acute congestion bordering on pneumonia, most intense at the bases; the heart muscle was pale, but the degeneration noted in cases of longer standing did not appear to be marked; the kidneys similarly were extremely pale and bile stained. The brain and cord showed a very intense congestion; section of the brain showed the minute intracerebral vessels, presenting the appearance of innumerable small punctate hemorrhages. We consider that these data, both clinical and pathological, showed a very close association with the findings observed in cerebral malaria: at any rate, we have little doubt that the masses of organisms present in the blood before death was sufficient to cause mechanical obstruction of the smaller cerebral vessels, and the condition of coma supervening before death lent support to this assumption. We are led to the conclusion that the toxins present in the blood of such very acute cases are not the only factors concerned in bringing about death.

(To be continued.)