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PART I.

THE INCIDENCE AND ETIOLOGY OF MALARIA IN MACEDONIA.

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The history of the malaria epidemic in the Salonika army in Macedonia is now fairly well known, but a brief account of it will not be out of place here. It may be said to date from the movement of the troops forward at the end of June, 1916, to the low-lying valley of the Struma. The line finally occupied by our army extended in a curve from the mouth of the Struma river, along this as far as Lake Tachinos, and thence along the Struma river again to Lake Butkova, out of which the river bends suddenly northwards to the Rupel Pass, the gateway into Bulgaria. From Lake Butkova the line passed along the Butkova river and over the low watershed between this lake and Lake Doiran, and thence south of the lake in a south-westerly direction over the low hills as far as the Vardar river. To the immediate west of this the line was held by the French, and further west still by the Serbians and Italians. This long curve, about sixty miles in length, consisted of low-lying valley districts, and it partly enclosed a large area of hilly country which was broken in one place by the valley of the Langaza and Besik lakes and the Rendina river, a low stretch of country which extended as far as the Gulf of Orfano at Stavros, a short distance south of the mouth of the Struma itself. The line between Doiran Lake and the Vardar ran a little north of Smol, but the country south of this, between the Vardar and Lake Ardzan, was occupied by reserve troops and other units which extended over the country as far as Karasuli, the railhead of the supply railway from Salonika.

It will be seen therefore from the map that there is a circle of lakes connected more or less completely by rivers and bounded on the north by the high Bela Sika mountains, on the west by the mountains at the foot of which runs the Vardar river, and on the east again by more mountains which run down to the sea. The circle of lakes is completed by Lakes Langaza and Besik, while to the south of these and east of Salonika is more mountainous country, of which the peaks of Hortiak and Kotos are the most prominent.

To the west of Salonika and north and south of the Monastir road is the low-lying area of the Vardar delta. We see therefore that the circle of lakes is surrounded on all sides by high land, except at its south-west corner, where the Vardar loses itself in the extensive Vardar marshes. Furthermore, within this circle of lakes is enclosed an area which, as the map indicates, reaches a fairly high elevation.
Incidence and Ätiology of Malaria in Macedonia

Of the front line, described above, the section between the Gulf of Orfano and Dova Tepe ran mainly through the Struma valley, and was very low lying while the section between Doiran Lake and the Vardar was on a higher level and extended over low hills. The reserve troops of the Struma section were stationed on the foot hills or even higher up, while various hospitals, Royal Engineers, Motor Transport units and others were dotted all along the mountainous Seres road, that monument of engineering skill which formed the only channel of supply to the Struma valley. The reserve troops for the Doiran area were on the hills about Gugunci and Kilindir and also on the Janes plain, through which runs the Gjol-Ajak river. Similarly, the troops behind the Doiran-Vardar line were scattered along the hills between the Vardar and Ardzan lake as far as Karasuli, the railhead for Salonika. The valley of the Langaza and Besik lakes was not occupied to any extent, but the railhead of Guvezne on the rising ground to the north-east of the valley was the centre of supply for the Struma and was always occupied by large numbers of troops.
Looking at the elevations on the map it could be surmised at once that the whole of the circle of valleys and lakes with their connecting rivers was likely to be highly malarious, and this was unfortunately the case. The incidence of malaria on this line was in inverse ratio to the elevation, for, as already pointed out, the highest section of this line was between Doiran lake and the Vardar, and here there was less malaria amongst the troops than there was either east of Doiran lake along the Struma valley or south of Smol along the shores of Lake Ardzan. Karasuli was a notoriously unhealthy spot, as also were Causica, Lozista near Butkova lake and the swampy area at the mouth of the Struma. These places are merely mentioned by way of illustration, for every spot along this line was heavily infested with anopheline mosquitoes. It may be stated here, though the matter will be referred to in greater detail below, that A. maculipennis was the prevalent valley mosquito, while A. superpictus was essentially a hill stream species, and was found all over the high land.

To return now to the movement of the troops forward in June, 1916, it may be stated that this was undertaken from strategic considerations with which we have nothing to do. The line occupied before this was on the hills south of Lakes Langaza and Besik and along the low hills east of the Galiko river as far as Kukus. Troops, of course, also occupied Salonika as base, and were scattered west of the town on the Monastir road. Apart from the latter area, this was not a very highly malarious country—though, as we shall see later, the mountainous districts also supplied no small fraction of the total of malaria-infected individuals. For the first five months of the year 1916 there had been only fifty cases of malaria. As the troops had not yet passed a summer in the country, and as the malaria season had hardly started then, some of these cases must have been relapses of a previous infection contracted elsewhere. In June there were 90 cases, and of these 36 came from the Monastir road area, while

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1 The railway supply officer at Karasuli in 1917 was in charge of a unit of sixty men. Between July 6 and 25 thirty-nine men went down with fever. In practically every tent examined in this area on July 26 were many Anopheles maculipennis gorged with blood.

2 Between Lakes Butkova and Doiran is a low watershed, and at this point was a post on a low spur known as Dova Tepe. Mosquitoes travelling up from the swamps below and down from the hill streams infested this spot. The spur was under shell fire, and little anti-mosquito work could be done, and if it could have been it would probably have been useless on account of the extent of the marshes in the valley and the hill streams above. On June 14, 1917, the 5th Connaught Rangers occupied this place for one week and were afterwards stationed higher up with only posts on the spur. They had no nets till the end of June. On July 16 they were relieved by the 1st Leinsters, who were provided with mosquito nets, veils and gloves, and mosquito-proof shelters were used by the men on all the lower spurs. The total amount of sickness of these two units during the eighteen days, commencing at the beginning of the third week after taking up the position, was 271 for the former and 128 for the latter. The better protection of the Leinsters probably accounts for the lower figure, for they should have had more malaria in July and August than the Connaught Rangers had in June.
the remaining 54 were from the Divisions. There was thus a definite increase in June, and it is probable that had the troops remained where they were, there would have been a much greater rise in the number of cases during July, August, September, and October — the worst malaria months in Macedonia — though the figures would certainly never have reached the appalling magnitude which resulted from the forward advance at the end of June. Even the high plateau of Hortiak east of Salonika ultimately turned out to be malarious — and, indeed, this was true of all the hill country of Macedonia.

At the end of June, as stated, the troops were moved forward more or less to the line indicated above. There was practically no provision made for protection against mosquitoes, but there was some attempt to protect against infection by the administration of quinine, six grains per diem. The Division which occupied the Doiran-Butkova section took up this line at the end of June, during which month there had been only four cases of malaria. Before entering the line the troops were given quinine daily, but its administration cannot have been carried out very systematically. Within twelve days of their arrival cases of malaria occurred and the admissions quickly mounted to over 100 a day, giving a total of 1,861 for the month of July. One Battalion (2nd East Surreys) entered the valley approximately 800 strong and left with 200 when the Division moved to the high land behind after a stay of six to seven weeks. The march back of half a day caused a further eighty to fall out sick. For the whole Division during the seven weeks there were 4,700 cases of malaria — though four weeks previously as many troops as could be spared had been moved to the hills behind. The history of the other units of the Division was a similar one. 1 At the end of August the Division again occupied the valley, and the cases of malaria rose at once, giving the following monthly figures:

<table>
<thead>
<tr>
<th>Month</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 1</td>
<td>4</td>
</tr>
<tr>
<td>July 2</td>
<td>1,300</td>
</tr>
<tr>
<td>August 3</td>
<td>2,500</td>
</tr>
<tr>
<td>September 4</td>
<td>1,600</td>
</tr>
<tr>
<td>October 5</td>
<td>1,100</td>
</tr>
</tbody>
</table>

At the end of August, when the original Division again entered the valley, two other Divisions took up positions in the line east of this one. They had a similar experience, so that the troops in the section from Doiran to the sea contributed over 15,000 cases of malaria to the sick list of the Army. The troops of the two Divisions in the Doiran-Vardar section were not so heavily infected as those in the Struma valley, though they contributed well over 8,000 cases up to the end of 1916.

1 During the seven weeks the 2nd Cheshires had 780 cases, the 3rd Middlesex 354, the 2nd East Yorks 320, the 2nd East Kents 300, and the 2nd East Surreys, just mentioned, 514.
On the lines of communication there were over 4,000 cases, which in itself is a proof that, quite apart from the Struma valley and the Doiran-Ardzan areas, malaria was very widely spread throughout the whole of the country.

During this year, 1916, large numbers of infected troops were evacuated to Malta and the United Kingdom, where they continued to have relapses. In all there were over 30,000 cases of malaria in 1916. These unhappy experiences caused the military authorities to think seriously about the following year and all the well-known methods of malaria prevention were undertaken. When the troops first occupied the front line the villages dotted along the fertile valleys were still occupied by their native inhabitants, who themselves were ridden with malaria. They undoubtedly constituted the foci from which our troops were infected in the first place. The villages were then evacuated but there were so many infected individuals and carriers amongst our own men by this time that there was ample material for mosquito infection without the necessary intervention of the native. It was shown by Captains Adams, Wilkin, Hele and Treadgold, who conducted investigations under the direction of Colonel Dudgeon during the winter of 1916-17, that a very high percentage of men who had previously had malaria still harboured parasites in their blood. Thus of 977 men of one series examined, 216 showed *Plasmodium vivax*, 24 *P. falciparum*, and 1 *P. malariae*. A later series of 828 men gave *P. vivax* in 222, *P. falciparum* in 9, and *P. malariae* in 1, while a third series of 1,031 men gave *P. vivax* 251, *P. falciparum* 0, and *P. malariae* 0. These figures not only show the high percentage of carriers amongst the troops in the line but illustrate a point to be mentioned later, namely, the tendency for the *P. vivax* infections to persist during the winter while the *P. falciparum* infections tend to disappear spontaneously or as a result of quinine.

Arrangements were made for the drainage of swamps and clearing of streams, larvae were killed by oiling and other methods, mosquitoes were destroyed in buildings and dug-outs by fumigation and spraying, mosquito nets were introduced on a large scale (there had been an almost complete absence of these in 1916), mosquito-proofing of huts and dug-outs was commenced, the men were taught the dangers of the mosquito, the methods of avoiding infection, the use of the protective appliances supplied to them—mosquito nets, head nets, gloves, shorts which could be turned down, repellents, and the reason for the administration of prophylactic quinine. It was still necessary to occupy the line of the previous year and it was arranged that a minimum of troops was to stay on the low ground, and as many as possible were to camp on the high land enclosed by the circle of lakes already mentioned.

It is evident to anyone who comprehends the problem of anti-mosquito work that to completely exterminate the mosquito from the whole of this vast area was an impossible task. Under peace conditions it would require
thousands of labourers whose sole duty was this particular work, elaborate schemes of drainage would have to be undertaken and millions of pounds spent on carrying this out. Even then it is doubtful if anything very satisfactory could be accomplished in less than five or more years of continuous work. Our troops, however, were not under peace conditions and they not only had to conduct a war but had to fight the mosquito as well. The whole Struma valley was the front line and it, with the streams, rivers and lakes, formed vast marshes which were under the fire and observation of the enemy. Much of the drainage and clearing work could only be carried on at night and even if this were done, beyond the line there was enough untouched breeding ground to supply sufficient mosquitoes to infect the whole Army. Though a great amount of very careful work was accomplished in the front line area it was evident that the men could only be satisfactorily protected by the contrivances used to prevent their being bitten by mosquitoes. On the other hand the hill country enclosed by the front line on which the troops not required in the valley were encamped, the district between the Vardar river and lakes Ardzan and Amatova, the large plain of Janes through which the Gjol Ajak runs south of Doiran, and the whole of the base area, including the marshy tracts of the Vardar Delta, the valley of Lakes Langaza and Besik, and the high land south of this together with the Salonika area itself, were not subject to the interferences of the enemy and could be dealt with according as labour was available. In these areas behind the line it was evident that there was more prospect of carrying out uninterrupted work in such a way as to bring about a definite mosquito reduction. The work, to be effective, had to be on a vast scale and had to be done by the troops themselves or local labour hired for the purpose. The whole occupied country was divided into areas, which were under the supervision of anti-malaria officers, and every unit had to contribute labour. The work was commenced early in 1917 and extended through the summer under great difficulties. It was recommenced in 1918 on a much larger scale and with additional native labour in the form of anti-malaria squads, so that the amount of anti-mosquito work in this year was at least ten times as extensive as that carried out in 1917.1

1 The extent of the work and the amount of labour involved is well illustrated by the following estimates for 1917-18. In one Divisional area 47,906 yards of canalization were done and 37,106 square yards of ground cleared in one month. In the base and line of communication area: new trenches cut, 479,991 yards; old trenches renewed, 1,670,506 yards; number of pools drained and filled in, 9,690; water surface oiled, 1,197,192 square yards; brush-wood cut, 869,815 square yards. Very roughly the line from the Gulf of Orfana to Lake Doiran was sixty miles in length and this extended continuously through low-lying A. maculipennis breeding ground which varied in width from five to ten miles, giving an area of about 450 square miles. The hill country behind this line, all of it potential breeding ground for A. superpictus, is, if estimated on the flat map, at least three times as great. It resulted therefore that anti-mosquito work, except in certain localities, could only be done in patches and in most cases the good effect was lost owing to the untreated areas around these.
At the end of the first malaria season of 1916 the worst cases of the disease had been removed to Malta or the United Kingdom but, as we have seen, there were large numbers of carriers left behind amongst the men, especially in the Divisions. These carrier cases continued to relapse and formed admissions to hospitals during the first five months of the year. There were about 150 admissions for the first week in January and these increased fairly regularly till the middle of March when there were about 600 admissions a week. They remained fairly constant till the middle of June when there was a marked increase.
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Though there had undoubtedly been many primary cases of infection before this, during May and June and possibly the latter part of April, the bulk of these admissions were relapse cases. Some of the supposed primary cases were really first attacks of malaria in men who had been infected months before. Such latent infections were later recognized as of quite common occurrence. From the middle of June onwards the numbers rose rapidly till they stood at about 4,500 for the first week in September. There was then a steady fall to over 600 for the last week in December. This enormous figure of over 70,000 for the year 1917 can be partially explained by the occurrence of the unrestricted submarine warfare and the impossibility of sending the sick away. Cases which otherwise would have been evacuated had to be kept and they returned to their units and came back again to hospital, some of them many times in the course of the year, so that a single case might account for many admissions. There is no record, as far as I am aware, of the actual number of infected individuals in the Army. During the year the number of troops in the Army was reduced by the removal of a Division and early in 1918 there was a further reduction by another Division.

The history of the year 1918 is a similar one, except that the number of already infected individuals was very much higher than at the beginning of 1917, as evidenced by the increased number of winter cases of malaria. Thus for the first week in January, 1917, there were 150 admissions to hospital of relapsing cases, for the first week of January, 1918, there were about 650. The figure then rose again till in the middle of March there were about 1,500 admissions per week and this level was maintained with slight elevation up to about 1,700 till the time of the rapid rise at the middle of June of the previous year. It was realized that the Army was saturated with malaria and that unless something drastic was done the sick rate and mortality would be higher than it was in 1917. Accordingly the famous Y-scheme was devised whereby a careful inspection of all the troops in and out of hospital was made, their malaria history and general physical condition being considered with a view to weeding out the badly

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1 In the period July to October, 1916, the admission rate for primary malaria per 1,000 of strength was calculated as 219, while for the same period in 1917 it was 256. The total number of admissions to hospitals and casualty clearing stations for the period January 1, to October 31, 1917, was 60,199 or 805.8 per 1,000 strength. In 1916 the corresponding figures were 28,254 and 242.7. The number of days' service lost through malaria was well over one million in 1917 and close upon two million in 1918.

The admissions for malaria per 1,000 of strength for the period November 1, 1915, to October 31, 1916, were as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Admissions per 1,000 strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1, 1915, to April 30, 1916</td>
<td>0.34</td>
</tr>
<tr>
<td>May 1, 1916, to October 31, 1916</td>
<td>237.28</td>
</tr>
<tr>
<td>1, 1916, to 30, 1916</td>
<td>56.83</td>
</tr>
<tr>
<td>1, 1917, to 31, 1917</td>
<td>277.85</td>
</tr>
<tr>
<td>1, 1917, to 30, 1918</td>
<td>162.75</td>
</tr>
<tr>
<td>1, 1918, to 31, 1918</td>
<td>253.82</td>
</tr>
</tbody>
</table>

These figures represent only a part of the truth. Thousands of cases of malaria were treated in field ambulances or in the men's own units without being admitted to hospitals, to which the above figures refer.
infected individuals who were of little service to the Army. These men were evacuated by the newly opened up overland route via Itea and Taranto. As will be seen, this scheme had a very marked effect on the malaria admissions. Instead of the figures rising as they did the previous year of 1917 they fell, and varied between 1,000 and 1,600 per week till the end of October, when there was a gradual but steady decline to a little over 500 for the last week of December. The Y-scheme not only reduced the number of cases by the removal of the most heavily infected individuals and so undoubtedly prevented each of these men coming into hospital several times but also got rid of the worst carriers, who would have been responsible for the infection of vast numbers of mosquitoes. In all, over 25,000 men were sent away and it can hardly be an exaggeration to suppose that during the summer and autumn these men, if they had remained in Macedonia, would have contributed fifty or sixty thousand admissions to hospital. Had this been the case the total number of entries for the year 1918 would have been considerably higher than in 1917. As it was, from the time that the great summer rise had occurred in 1917 and might have been expected to occur in 1918 there was actually a fall in the admissions and no definite rise occurred. It has been claimed by some that this failure of the summer rise to appear was a proof of the efficiency of the anti-mosquito measures adopted. It seems to me that there is no evidence of this whatever. Mosquitoes unfortunately still remained in many places where most energetic work had been carried out and there can be no room for doubt that the relative improvement was due practically entirely to the removal of the most debilitated cases.

The malaria incidence of 1918 was affected very seriously by the outbreak of influenza in September. Some confusion in diagnosis inevitably occurred, for so many men had latent malaria which was lighted up by the influenza that it was in some cases difficult to decide which was the primary disease. Thus of over 100 autopsies performed by Captain Taylor on cases which had been diagnosed as influenzal pneumonia eighty-three per cent showed definite evidence of previous malarial infection. It was only in a very small percentage of these that the diagnosis was found to be in error and that active malaria, and not influenzal pneumonia, had been the direct cause of death. This figure of eighty-three per cent shows furthermore to what a large extent the army of Macedonia had become infected with malaria.

Following the influenza outbreak, and partially concurrent with it, was the great advance into Bulgaria at the end of September. The figures for malaria show a rise from about 1,100 to nearly 1,600 per week to the beginning of October and then a fall to the end of the year.

The foregoing is a brief outline of the history of malaria in the Salonika army for 1916, 1917 and 1918. No one was prepared for the great epidemic of 1916 in the Struma valley and practically no precautions were taken there—it is doubtful if they could have been. In 1917 the whole anti-
malaria campaign was organized and placed on a working basis while in 1918 it was improved and practically every conceivable method was in operation, so that the work reached as high a level of perfection as seemed possible for an army in time of war in a mosquito-infected country like Macedonia.

The possibility of an outbreak of malaria in the area occupied by the Army before the June advance in 1916 to the Struma valley had been recognized by the authorities. Surveys had been made, spleen indices of the natives in the Langaza valley had been taken, and a good deal of drainage work, especially along the Monastir road, was in progress. Unfortunately an arbitrary limit had to be fixed to any work here, so that the good results which might have been expected were spoilt by the vast extent of breeding-ground immediately beyond.

To estimate the relative effect of the various anti-malaria measures which were adopted is a very difficult matter. As regards those directed against the mosquito breeding places the only test of efficacy is the reduction in the number of mosquitoes. It is undoubtedly true that the destruction of a single breeding place and the larve in it will reduce the number of mosquitoes, but when we realize that along the front line or the circle of lakes referred to above only a very small fraction of the total breeding ground within a mile of the troops could be dealt with we can understand that though the number of mosquitoes was slightly reduced this could have little effect on the incidence of malaria. The chances of infection will not increase in direct proportion to the number of mosquitoes after a certain limit. When the number of mosquitoes attacking an individual amounts to hundreds, if not thousands, the reduction of these by a small proportion will hardly lessen the man’s chances of infection. It matters little whether he is bitten by ten or only five infected mosquitoes in a single night. It would thus appear that the clearing measures undertaken in the long line of swamp regions in the valleys can have done very little to reduce the number of mosquitoes and practically nothing to lessen the incidence of infection. Of the front line the Doiran-Vardar section was an exception to the general rule that the line was in low-lying swampy valleys. Except to the south of Lake Doiran where there was a good deal of marsh, but not nearly as extensive

1 Along the south shore of Lake Doiran was an extensive marsh nearly a mile in length. It was covered by trees and thick brush-wood with swamps and tall grass interspersed. The strip seemed to be below the level of the lake and had apparently resulted from the digging out and piling up of earth to form the railway embankment years before. The positions on the low hills overlooking the lake were infested with mosquitoes from the marsh. In 1917 the position here was occupied as follows:—

12th Lancashire Fusiliers .... June 10 to 26
14th King’s Liverpool .... „ 26 „, July 12
7th South Wales Borderers .... July 13

During June there were practically no mosquito nets but this was rectified at the end of
as around the other lakes, the line passed over the low hills between the lake and the Vardar river. In this section the conditions were very much like those which obtained on the high land within the circle. Instead of the extensive swamps formed by the lakes and rivers overflowing their banks in the low-lying valleys the country was a system of hills and gullies. The hills, except in certain places such as Stavros, were devoid of forest, so

June and during July great care was taken in the use of nets, veils, gloves, etc. Quinine was given, ten grains twice weekly, while the troops nearest the lake had ten grains every day. The following were the sick admissions to field ambulances for eighteen days commencing from the beginning of the third week (two weeks allowed for incubation period of malaria): Lancashire Fusiliers 252, King's Liverpool 156, South Wales Borderers 58. It might have been anticipated that the figures would rise in July and August but the better protection had made the difference.
that rain was not held up. They were green in the spring and early summer but the grass was quickly withered by the sun and the general aspect became that of a brown, dried-up country. The small valleys and gullies between the hills remained green and often contained trees and brush-wood which concealed the water running beneath them. In every gully there was a stream which was a rapid torrent in the winter or during sudden storms of summer but which soon became a mere trickle, forming rocky pools green with algae, or little reedy marshes, according to the nature of the ground. A typical hill stream in Macedonia commenced as a spring high up near the summit of some mountain two or three thousand feet above the sea. Such a spring was often converted into a fountain by the natives as a water supply for some neighbouring village or for the
convenience of shepherds or other wanderers. The overflow from the spring or fountain, the built-in part of which frequently harboured mosquito larve, especially *A. bifurcatus*, as well as frogs and newts, formed the source of the stream. Around the fountain there was generally an overgrown marshy patch of ground in which larvæ and frogs abounded. The stream trickled away between the rocks, forming the numerous tiny grass-grown pools in which larvæ thrived. It was quickly joined by other tiny streams and gradually became larger. It would flow across a comparatively level stretch of grass forming marshy patches of various sizes or

![Rocky pool harbouring *A. superpictus*, frogs, snakes, water-boatmen and other creatures.](image1)

![A hill stream crossing the barbed wire near Lake Doiran, in process of being cleared.](image2)

little reed-bordered ponds swarming with frogs, snakes, water boatmen and culex and anopheles larvæ. Further on it would pass through dense brush and be followed only with the greatest difficulty. Here in the deep shade anopheles larvæ and other living creatures were not as plentiful as in the open reaches. Lower down, the stream would break in a small cataract in stony ground or fall over a ledge into some deep rocky pool. In the shade
the rocks were overgrown with moss and ferns and the pool would harbour the ubiquitous frog, many species of which abound everywhere, snakes and even fish, all of which lived in harmony with the ever-present mosquito larvae. Below the pool the stream would start on its course again, always joined by others on either side. On sandy or gravelly soil it would suddenly disappear completely below the ground and only be traced again a hundred yards or more lower down the gully. In the interval pools and marshy patches might still indicate its presence. Finally it would become large enough to receive such a name as the Gumus dere, Orljak dere, Copachi dere, regular little rivers which broke from the hills on to the plain. In the winter-time and in the spring and early summer these rivers continued their course across the valley into the Struma river, not omitting, however, to spread out over the plain into extensive marshes. As the summer advanced the hills dried up and less and less water descended. The streams were reduced to tiny trickles and when the valley was reached the water disappeared underground and only reap­peared in the plain in the swamps and marshes, which were helped in their formation, in many places, by the level of the valley being below that of the river itself. High up in the hills in the summer-time water still appeared at the source and the endless ramifications of the tiny stream system still persisted, with its small pools and marshes always harbouring frogs and mosquito larvae, even as high up as 4,000 feet above the sea.

It can well be imagined that to deal properly with such an endless system of streams would entail a stupendous expenditure of labour. In times of peace the country is only used as a grazing ground for sheep and goats. The rocky nature of the soil, except in patches here and there, renders it useless for other purposes so that any expenditure of labour from an anti-malaria point of view is hardly worth considering. It was only when occupied by an army liable to infection that the question presented itself.

In coping with such an extent of streams it was first necessary to obtain an accurate chart of the whole system, including all the little tributaries, many of which were often difficult to discover and trace. Brushwood and grass had to be cleared away, a clean cut channel had to be formed by digging, blasting, removal of rocks and boulders, and by opening up pools; water had to be siphoned off, areas of depression filled in, the edges of the stream lined with stones—and all this had to be done for every stream and its tributaries right up to the source of each. When the work was completed it had to be constantly watched and repeated, the channel brushed out and the edges oiled or cresoled, for the work was constantly damaged by horses, cattle, sheep and men, but most of all by the sudden downpours of rain which occur in the summer months. A tiny stream would be converted in a few minutes into a roaring torrent, undoing in an hour the work of many weeks. The summer downpours had one advan­tage. All the streams were suddenly flushed out and millions of larvae
were washed away and destroyed. It was always very difficult to find mosquito larvae in the streams for a week or two after a thunderstorm. It was in country of this nature that camps were placed, but it was only possible to deal with the streams in a limited radius round each. With sufficient labour it would be no impossible task to keep an area like this free from mosquitoes, but unless the work extended for very much farther than half a mile mosquitoes would wander into the area from beyond. Mosquitoes in Macedonia will travel a mile or more—very much farther than the limit of range formerly attributed to them.

Stream work of the kind described above was carried out over the whole of the high land occupied by the troops in addition to that just referred to in the Doiran-Vardar section, in fact over the whole country directly south of the Struma valley and on either side of the Seres road, on the hills to the west of Lakes Ardzan and Amatova, and on the large Hortiak plateau, the great summer hospital area south of Lakes Langaza and Besik.

The plain of Janes with the Gjol Ajak river afforded a district of a somewhat different kind, as also did the plain of Sneve south of the mountains between Doiran and Butkova. The former was an extensive tract of country reaching from Janes across to the shores of Lake Ardzan and northwards as far as Gugunci and Kilindir, where it merged into the hills (see map). This plain was cut into by the Gjol Ajak and numerous streams which, on account of the flat country, were often invisible till approached. In certain places only pools occurred and numerous marshes existed which were much more extensive and unmanageable near the reed-bordered Ardzan Lake. A great amount of anti-malaria work was undertaken in this district by the very energetic officer in charge, Captain Cassidy, who has described some of his experiences and endeavours in the little book by Willoughby and himself, entitled "Anti-Malaria Work in Macedonia among British Troops." It is probable, though no figures are available, that there was a definite reduction in mosquitoes as a result of the measures adopted here. At any rate Janes, at the edge of the plain, had little malaria. Yet in 1918, when on a visit to this district, I found numerous A. maculipennis breeding in pools along the channel of the Gjol Ajak south of Kilindir and even in old oil cans belonging to the kite balloon section. And again in the small river west of Kilindir the same mosquitoes were breeding in a stretch of a mile or more which was inspected. A site on the banks of this river had been selected as a convalescent camp, and A. maculipennis was taken in buildings close by.

Another district in which anti-mosquito measures were strenuously undertaken was in the Dudula area on the Monastir road between Salonika.

and the Galiko river and beyond it. Large numbers of troops occupied this area—the large ordnance depot, the railways, motor transport, concentration camps, hospitals and endless other units. The ground was cut up by numerous streams which formed marshy tracts in the low-lying ground. Canals were cut, the marshes drained, pools filled in and constant supervision rendered it so far mosquito-free that it could be taken that most of the mosquitoes which appeared had migrated from the districts beyond.

The beautiful Hortiak plateau on account of its elevation was selected as a suitable site for summer hospitals. Here again the country was hilly and the plateau, itself high up, was surrounded by hills, with countless streams draining on to it. Very energetic measures were adopted here in 1918, as the year before there had been many cases of malaria amongst the hospital personnel. In spite of this mosquitoes remained very prevalent and could always be caught in numbers in the hospital marquees. As an illustration, the following catches were made by Captain Cummins at one of the general hospitals on the plateau:

<table>
<thead>
<tr>
<th>Date</th>
<th>A. superpictus</th>
<th>A. maculipennis</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 23 to 31</td>
<td>1,473</td>
<td>10</td>
</tr>
<tr>
<td>August 1 to 31</td>
<td>3,909</td>
<td>42</td>
</tr>
<tr>
<td>September 1 to 25</td>
<td>3,910</td>
<td>59</td>
</tr>
</tbody>
</table>

These figures represent only a very small fraction of the total number of mosquitoes which had remained in the tents in the morning. In this district it was impossible to deal with all the streams in the surrounding country—this would have required thousands of labourers—and the mosquitoes constantly migrated to the treated area occupied by the hospitals.

Beyond the Dudula area, where most of the energetic work was carried out, and about three miles farther along the Monastir road near the bridge over the Vardar was the 41st General Hospital used mainly for the treatment of Serbs. This hospital was surrounded by mosquito breeding ground and, as was to be expected, was highly malarious. For 1917 the hospital staff gave the following figures for malaria: officers 12, sisters 39, personnel 182. The incidence of malaria amongst the nursing sisters throughout the force was fairly high. Apart from those exposed to infection on night duty there was always a great chance of their being bitten by mosquitoes on the ankle and leg. Mosquito boots were rarely worn, and for some reason best known to themselves women have a great reluctance to overclothe this part of the body.

The Hortiak plateau, 2,000 feet above the sea, was a lovely spot which on account of its lower summer temperature was selected as a site for summer tented hospitals. The prevalent mosquito was A. superpictus and the figures of malaria incidence amongst the hospital staffs showed that even at this elevation there was no immunity against the disease. The 48th General Hospital was half way up the Eurenzik road leading to the plateau and thus at a lower level. In 1917 two officers and eight sisters suffered from malaria. Amongst the personnel there were 3 cases in July, 29 in August, 31 in September, 3 in October, 1 in November, and 1 in December. On the plateau itself the 61st General Hospital had 49 cases amongst its personnel and 5 amongst the sisters, while the 49th General Hospital lost from its personnel from June to December the following numbers: 1, 2, 26, 39, 13, 5 and 2. In August 14 sisters went down with malaria, in September 15.
Again at Guvezne, the busy railhead north-west of Lake Langaza, was a district at the foot of the hills rising along the Seres road. A large amount of anti-mosquito work was carried out, yet from the beginning of September to October, when the clearing measures were well advanced, thousands of *A. superpictus* were seen and collected from the hospital tents. It is probable that here also the mosquitoes were not locally bred but had descended from the hill streams which lay above Guvezne.

About September 24 a field ambulance moved on to the site just vacated by a casualty clearing station at Labanah. The streams around the area had been constantly treated and watched and practically no mosquitoes were breeding within half a mile at least of the site, yet on the day following its arrival over 700 *A. superpictus* were collected from the seven marquees of the newly arrived field ambulance.

These illustrations serve to show that anti-mosquito work, even in districts which were not the most difficult to deal with, failed to eradicate the mosquitoes. So many were still present that it is a question to what extent, if any, infection was diminished by these measures. It can be well imagined that in the more difficult Struma valley and along the chain of lakes in the front line clearing work applied to the merest fraction of the whole can have only very slightly reduced the number of mosquitoes.

The spread of mosquitoes over long distances was not realized at the beginning of the campaign. They were believed to fly not more than a quarter of a mile and a clearance of half a mile around a camp was considered sufficient to protect it. The mosquitoes spread for at least a mile and it may be two or three miles when a gentle breeze carried them. Of this there is ample proof. For example on the hills west of Ardzan lake with a gentle south-easterly breeze large numbers of *A. maculipennis* and *A. sinensis* would travel up the hills and invade the tents of the units stationed there. These mosquitoes did not breed in the hill streams but only in the marshes along the shores of the lake. Similarly it was found near the mouth of the Struma that the galleries occupied by our troops on the low hills overlooking the swamp were infested with large numbers of *A. maculipennis* which could only have come from the marshy district at least a mile away. A mile limit would in many cases prove sufficient but in October 6 and in December 2. At another hospital (87th General) stationed at the foot of the hills at Vertikop about eighty kilometres west of Salonika the malaria incidence was high. The mosquitoes here were *A. maculipennis* from the plain and *A. superpictus* from the hills. In 1917 amongst the personnel, non-commissioned officers and men, there were forty-five primary cases and sixty-nine secondary. In 1918 the figures were 55 and 94, giving totals of 114 and 149 for the two years. In 1918 there were twenty-three primary cases and six secondary amongst the sisters. In 1918 the establishment had been reduced to 210.

The position at this point was in low hills on the left bank of the Struma near its opening into the sea but the galleries were constantly infested with mosquitoes which wandered up from the marshes below. The incidence of malaria was very high here, this
Incidence and Aetiology of Malaria in Macedonia

even that will not exclude the mosquitoes which wander farther afield. The half mile clearing limit round the units separated from one another by two or three miles left tracts of untouched breeding ground which rendered the measures almost valueless.¹

It is probable that in certain areas some degree of infection was avoided as, for instance, along the Monastir road, round about Janes and in the Doiran-Vardar section, but even here this must have been very slight. In most places little or no good was done and it probably would have been better to concentrate energy on direct protective measures. The enforcement of the clearing work had, however, one advantage. It was an object lesson to everyone of the dangers of the mosquito, and taught each man

¹It is now generally recognized that mosquitoes will travel very long distances, even up to ten miles. In this connexion it is worth while to record an experience in Mesopotamia. The deep draught steamers running up the Persian Gulf, on account of a bar across the mouth of the Shat-el-Arab, had to anchor ten miles from shore and transfer their freight to shallow draught steamers. On one occasion when anchored here a breeze from the shore brought on to the ship thousands of house-flies, dragon-flies and other insects which must have travelled ten miles over the sea. I was informed by a medical officer on a hospital ship running on this route that on one occasion a similar invasion by mosquitoes — A. pulcherrimus — had taken place. I believe this observation has been recorded by Major R. E. Wright in a paper entitled "The Distance Mosquitoes can Fly" (Bombay Natural History Society, xxv, No. 8, 1918).
that the bite of a mosquito, which could necessitate such an expenditure of labour, was something to be avoided.

**Quinine Prophylaxis.**

The question of quinine prophylaxis is a very controversial one. Undoubtedly the consensus of opinion in Macedonia was that it was worthless. Still there were some medical officers who believed that the men under their care were protected from infection by the regular daily dose of the drug. Exact figures are very difficult to obtain and a great deal of confusion has arisen as to the precise meaning of the term quinine prophylaxis. It certainly covers two distinct conditions—the dose of quinine which may be expected to prevent infection and the dose which will prevent an attack in an already infected man. The former is the true meaning of prophylaxis and it is generally assumed, though there is no evidence to support it, that the quinine circulating in the blood destroys the sporozoites directly they are introduced by the mosquito. If quinine actually prevents evident infection it may very well be that the sporozoites are untouched, that they invade the red blood corpuscles in spite of the quinine and that cure is effected by the quinine before the parasites have reproduced sufficiently to bring about an attack. If this latter view is correct then prophylactic quinine acts by treating the very earliest phases of infection and this is in line with the generally accepted view that the earlier a case of malaria comes under treatment the better is the chance of success.

Another question which requires an answer is the relation of the dose of infective material to the amount of quinine required to prevent infection. It is quite possible that prophylactic quinine will prevent infection in a man who is only occasionally bitten by infected mosquitoes, and that it will not do in cases where daily injection of large numbers of sporozoites occurs. This may be merely due to the fact that, even when very great care is exercised in giving quinine daily, intervals of a few days are bound to occur when quinine is not taken. Though this must have happened very frequently in Macedonia, yet there were thousands of instances where infection first showed itself in men taking quinine quite regularly. There are no figures to show what percentage of these were certainly not infected before commencing the prophylactic quinine. That a daily dose of quinine will kill sporozoites injected, say, once a fortnight, and not kill the larger number injected every night, or even ten times nightly, is difficult to understand. However large may be the number of sporozoites injected in a single night, compared with the whole volume of blood plasma containing quinine they are but the smallest particle. If the Atlantic Ocean were poisoned so that a hundred fish were killed when introduced, it is inconceivable that the result would be any different if, instead of a hundred, a thousand times this number, or more, had been exposed to the poison, unless we assume that there is an occasional fish here and there with an idiosyncrasy against the drug. We do know that quinine will cause the
disappearance of the vast majority of the malarial parasites in the human body, but that some survive is proved by the frequency of relapses. This may be due to the relative insusceptibility of a small number of the organisms. This is certainly the case in trypanosomiases, in which, if the forms susceptible to a drug are constantly killed off, more and more insusceptible forms appear, till finally, by a process of natural selection (the survivors always producing larger numbers of resistant forms), a whole race of insusceptible trypanosomes results.

If we assume that the malarial sporozoites are similar to the blood forms, as regards the action of quinine, then there will be a small number of sporozoites which will not be killed by the drug taken prophylactically. There may be only a few resistant forms amongst the total sporozoites injected by a number of mosquitoes. If an individual is being bitten by only a small number of infected mosquitoes, the chances of his acquiring malaria will be very much diminished if he has quinine in his system, for it will be only very rarely that resistant sporozoites will be injected. If, however, he is being constantly bitten, he will almost certainly be infected, for amongst the large number of sporozoites injected there will be some resistant forms. This, of course, is highly speculative, but it will explain the view that infection is more likely to occur when the sporozoite dosage is high, and also that quinine—will act better as a prophylactic when the exposure to infection is not of long duration, as, for instance, during a short stay in an infected area. When exposure extends over long periods, and the incidence of infected mosquitoes is high, then prophylactic quinine will have little value.

It is, nevertheless, true that in Macedonia quinine failed to prevent infection in thousands of cases, but there is again nothing to show that the quinine did not protect at least a small number of individuals. The incidence of malaria was so enormous that it is supposed that without quinine it could hardly have been any higher. Was the expenditure of money and labour involved in this administration of prophylactic quinine on so vast a scale worth while? The consensus of opinion was that it was not, and my personal opinion agrees with this.

On the other hand, the regular administration of daily quinine undoubtedly acted by preventing relapses in already infected men. To what extent this occurred is difficult to judge. Furthermore, this suppression of a manifest infection had the immediate advantage of keeping men in the line, but sooner or later attacks of malaria occurred, the treatment of which was more difficult on account of the previous continual dosing with quinine. Here again the question arises whether this was due to an acquired resistance by the parasite, the isolating by selection of a particular quinine-resistant strain, or whether it was due to some acquired capacity of the body to get rid of or store up quinine so that it failed to reach the parasites at all. The bad effect on the general health of an individual of continuous dosage with quinine over long periods has to be considered.
In the winter of 1916-17, when the investigation into the number of carriers was being made, the regular administration of quinine was temporarily stopped to render the finding of malaria parasites more easy. The result of this was an immediate increase in the number of malaria cases. The quinine was accordingly recommenced and the malaria rate fell.

The amount of prophylactic quinine given varied at different times and places. Five to six grains a day was the dose chiefly given in 1916—10 grains a day, 10 grains on two days of each week, 20 grains, and even in some units 30 grains a day was tried. Sometimes a double dose was given on one day a week. None of these methods of preventing malaria gave any encouragement. In one case a very large body of men in the winter of 1917-18 were placed on a twenty-four days' course of quinine—thirty grains a day, combined with iron and arsenic tonic. It was hoped that a large proportion would be cured of their infection. The immediate effect was a fall in the malaria admission rate, but this gradually mounted again till before the course was completed it was as high as it had been originally. After the course the figures were higher still. This experiment was an attempt at cure, and was not truly a prophylactic measure.

It may be argued that no really scientific test was made with groups of men under identical conditions with and without quinine, though this was attempted. Men previously infected and men with no infection received quinine alike but there was such a mass of material to observe that the general view that quinine did very little, if anything at all, to lessen malaria amongst the troops in the line must have been correct. It is highly improbable that any variation in the time of administration of the prophylactic dose would have affected the result. As it happened, the quinine was most usually taken, at any rate in 1917 and 1918, as an orange-flavoured solution of quinine sulphate in the evening, before the evening meal, and this is the time which is considered to be the most favourable, so that the greatest concentration of quinine in the blood may be at night.

We have considered above the anti-larval measures adopted and quinine prophylaxis and both of these were disappointing in their results. The third and last method of avoiding malaria is that of the protection of men from the bites of mosquitoes. In 1916 very little was done in this direction; in 1917 there were great advances, while in 1918 the state of affairs was still further improved.

Mosquito nets, of all methods of malaria prevention in case of emergency, such as occurs when troops are moving about, are of the greatest importance. By the proper use of a net, provided the individual can remain within it all night—not always possible of course in time of war—the number of mosquito bites can be reduced to nil. It is my opinion that the mosquito net did more to prevent infection than all the other methods of malaria prevention together. Head nets and gloves were of limited use though they were definitely advantageous in certain places. In the front
line for men on guard duty or patrol they obscured vision too much, though they were used and must have prevented many mosquitoes from injecting sporozoites. In the hospital tents, however, they were worn with benefit by the orderlies who were on duty all night. For instance, at a casualty clearing station at Karasuli the tents were full of mosquitoes at night, especially when the wind blew from the direction of Ardzan or Amatova lakes. Here to remain in a tent long without protection meant certain infection. Mosquitoes had to be constantly brushed off the neck and hands. The head net and gloves could be, and were, used with advantage here. It was at Karasuli that the importance of the proper use of the mosquito net was brought home to me. I had examined a man during the day and found his blood harbouring numerous crescents. On visiting him at night he was asleep and a patch of bare skin lying against the net was simply covered with *A. maculipennis* and *A. sinensis*.

![Fig. 7.—Bivouac mosquito-net as supplied to the troops in 1918. The net is intended for two men and is covered by the two bivouac sheets. The front slides up and down the guy-rope.](image)

Large numbers of mosquitoes were collected from the tents all over Macedonia and it was always a most disconcerting feature of such collections that a very high percentage—sometimes well over seventy—of the mosquitoes had evidently fed during the night. This can only have occurred because the nets were not properly used or were themselves unsatisfactory. Of mosquito nets there were mainly two types. The bivouac net was modified and altered till in 1918 a very serviceable pattern was evolved. Each net was devised to take two men who entered at one end, which was weighted so that it automatically fell to the ground as it ran on rings along the front guy-rope. From the point of view of mosquito protection a single smaller net of the same pattern for each man would be a distinct advantage. The other type of mosquito net was that used in buildings, tents and hospitals. This was the bell net pattern fitted to a wooden hoop hanging over the head. These nets are difficult to
keep adjusted and it appears to me that the rectangular net with the calico strip around the base would not only afford a greater protection but would be more economical of material. The fixing of these nets in parallel rows on cords would not be a difficult matter. A further point is that the supply of nets in each unit should exceed that of the number of men, so that a damaged net could be at once handed in for repair.

Fig. 8.—Mosquito-proof shelter near the Doiran front.

Fig. 9.—Camouflaged mosquito-proof shelter near the Doiran front.

Repellents of various kinds were generally employed. It was recognized that for men at work or on patrol in the Struma valley or other parts these had very little effect in preventing mosquito bites for longer than half an hour after application. Apparently it was the grease, rather than any ingredient, that the mosquitoes did not like and when this had been washed away by the perspiration which streamed from the men in the hot summer
nights the mosquitoes renewed their attacks. The men accordingly took tins with them and the application was renewed at intervals during the hours of watch or patrol and probably did something to diminish the number of bites.

During 1917, and especially 1918, a great deal of screening of buildings, galleries and dug-outs was carried out, and in 1918 a large number of light, mosquito-proof huts made of canvas, wood and gauze were put up so as to enable the men to enjoy recreations without the danger of being constantly bitten. These were most useful, as the men could sit in them before retiring for the night. The benefit derived from these huts must have been very great and one or more of them, according to the size of the unit, might be considered as part of the necessary equipment wherever it would be possible to use them. In some places mosquito-proof wards were constructed in the hospitals as, for instance, at a casualty clearing station at Karasuli, and in these malaria cases were not only protected from the mosquitoes more effectively than by the use of mosquito nets alone in tents, but were treated more efficiently and with less danger to the attendants at night. Such wards could have been adopted with advantage on a much larger scale, for it is just as important to protect the infected individual from uninfected mosquitoes as the uninfected individual from infected mosquitoes.

There were many minor devices, such as the turn-down shorts to protect the knees at night, mosquito swats to kill the mosquitoes in the tents in the morning—a very important point, for many of them were full of blood—sprayers for various fluids to kill mosquitoes, fumigation, mosquito traps, the formation of trap pools and numerous others. It is impossible to consider all these and indeed they do not differ from the devices used in anti-malaria work elsewhere.

Looking at the whole campaign against the mosquito one cannot help feeling that under the conditions which actually prevailed in Macedonia—and this is probably true of any campaign in a highly malarious country—if all the energy and money expended had been directed entirely to the protection of men against mosquito bites the malaria would not have been more, but probably less, than it was. In the case of a campaign in a mosquito-infested land these measures alone, if thoroughly carried out, would give a greater degree of protection than if the labour and expense were divided amongst this and other methods, such as those of clearing, or quinine prophylaxis, which may be very useful in times of peace or permanent occupation but have proved disappointing in Macedonia in time of war.1 The money expended on prophylactic quinine alone would have

1 In this connexion a paragraph from James's most interesting and opportune book on malaria ("Malaria at Home and Abroad," p. 199) is of interest—

"Perhaps we must make allowances for the frailty of man as well as for the williness of the mosquito, but whether this is true or not, practical experience is to the effect that it is usually best to concentrate all available effort on one carefully selected method which can then be brought to a high degree of perfection."
supplied thousands of mosquito-proof huts and hospital wards and almost unlimited quantities of necessary gauze. It would have given each man a separate mosquito net instead of compelling him to share with another, and would have enabled these to be replaced at once when damaged—always supposing of course that the necessary materials could have been obtained, and they probably could have been if their necessity had been insisted upon. A sufficient supply of all these things should be regarded as part of the necessary equipment of an army entering a malarious country. A mosquito net to protect against the mosquito is as much a necessity as the sun helmet to protect against the sun.

I have noted a danger which has frequently arisen. In rest camps both for officers and men even when a sufficiency of nets was available there has been delay in their issue. Troops arrive late at night either by ship, train, or on the march, and it is often impossible to supply nets to the men till next day or even later. There seems to be no reason why the tents or buildings for their reception should not be arranged with permanently fixed nets, as in a hospital ward, so that protection can be afforded at once. The argument has been that the men bring the nets with them, but in practice this arrangement more frequently leads to exposure than otherwise. I quite realize that arrangements of this kind would require special organization and extra staff.

It has been mentioned above that the line west of our extreme left on the Vardar river was occupied by the French. They shared Salonika with us as a base and were exposed to malaria much as we were though, with the exception of part of the Vardar delta, they occupied more hilly country and escaped the terrible exposure of the Struma valley. Like us, the French suffered badly from malaria and they carried out anti-malaria measures, including the administration of prophylactic quinine much on our lines. I think it is true that they reduced their malaria admissions by sending away infected men, even during the period of unrestricted submarine warfare, more freely than we did. In a paper on malaria in Macedonia an account is given of the anti-malaria work carried out in the French Army in 1915, 1916 and 1917.1 Prophylactic quinine was given generally and its administration was controlled by a system of inspection of the urine. At any time a sample of urine could be demanded of a man, and this was tested with the Tanret reagent for the presence of quinine, which should be invariably present if the daily dose of prophylactic quinine was being properly administered. Mosquito nets were provided for the troops, but never to the extent seen in our Army. Mosquito-proofing of buildings, dug-outs and other dwellings was undertaken, but here again this protective measure was developed on a much larger scale in our own area. Similarly, anti-larval measures were carried out energetically in

certain localities, but the British Army did this work on a much larger scale and more universally than did the French. We have seen how difficult it is to judge of the effect of these measures, for we had a greater amount of malaria in 1917 than in 1916, yet the paper now under consideration states on p. 469, that it is easy to realize the enormity of the task which was imposed on each sectional medical officer, a task, however, which was perfectly carried out on their part, as the following results show:

For every sixty cases of primary malaria occurring in 1916, there were only seven in 1917. That is to say that all the improved measures adopted by the French in 1917 had reduced their malarial infections by about 90 per cent. We are not told how this figure was arrived at, but after our own experience one cannot help feeling that it is a very liberal and optimistic estimate of the effect of their anti-malarial measures.

In a paper written by four medical officers of the Macedonian army, some figures of the incidence of malaria are given. For the period, December, 1915—December, 1916, inclusive, there were 31,727 admissions to hospital for malaria. Of these, 17,614 were evacuated to France, and 667 died, leaving 13,446 in the country. Of the total admissions about 19,000 were regarded as primary attacks, and 12,000 as secondary or relapse cases. In the period January to November, 1917, the number of admissions was 34,544, of which about 3,000 were considered primary cases, and 31,000 secondary. It is difficult to reconcile these figures, for if at the end of 1916 there were only 13,446 known cases of malaria in the army, how is it that in 1917 there were 31,000 cases of secondary malaria? The only way the figures can have been arrived at would be from the statement of individual soldiers, who would maintain that they had had previous malaria but had not been admitted to hospital. An attempt was made in our own army to obtain such information, but it was found so unreliable that it had to be abandoned. No account is taken of possible recovery and reinfection, so that it appears to me that the estimate of the number of primary cases for 1917 must be far too low. The general figures, however, agree with those of the British Army, for there were more admissions for malaria during 1917 than in 1916.

The Serbians suffered badly from malaria, though probably not so badly as we did, as they occupied a more hilly country. Our enemy, also, was not immune, for I was informed by a Bulgarian doctor after the armistice that at one time there were 23,000 in hospital with malaria.

(To be continued.)