BILHARZIASIS AND MALARIA DURING THE PALESTINE CAMPAIGN.

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INTRODUCTION.

Bilharziasis and malaria will be considered in this paper entirely from the standpoint of a regimental medical officer.

A special reference will be made to the anti-mosquito campaign carried out during the spring and summer of 1918, in the vicinity of the River Auja.

A regimental medical officer's primary duty is the prevention of disease in his battalion. Lieutenant-Colonel Lelean in his admirable book "Sanitation in War" describes him as the "final link in the chain, whose duties are not only concerned with the maintenance of health and prevention of sickness, but also involve the keeping of a watchful eye upon every factor which affects the comfort and well-being of his men."

These notes were written with the hope that they may be of some interest to other regimental medical officers, faced with the same problems in dealing with bilharziasis and malaria during a campaign. The medical officer "on trek" with his battalion, with a kit possibly limited to eighteen pounds, had little facility for accurate clinical diagnosis. He had no books of reference, and perhaps only a scanty knowledge of tropical medicine. He depended largely on his own commonsense to protect the men of his battalion against infection carried by the Bulinus contortus snail and the anopheles mosquito—the best allies the Turks ever had.

No attempts will, therefore, be made to discuss the clinical side of the treatment of these diseases. Nor shall I attempt to discuss the effect of bilharziasis and malaria on the Palestine Campaign as a whole, but rather to relate my own personal experiences and observations, and to describe how my own men became infected, and what measures were taken to protect them when "in the line." These notes will therefore of necessity only cover a small portion of a very wide front, and chiefly concern the health of the 1/4 Northamptonshire Battalion, when they were stationed during 1916 in the Southern Sector of the Suez Canal defences; and when, subsequently, in 1918, they held a part of the line in the vicinity of the River Auja. I have combined bilharziasis with anti-mosquito work because we discovered infected B. contortus snails in an orange grove cistern near Mulebbis when searching, on February 10, 1918, for the presence of anopheles larvae. Official information, it may be added, was to the effect that there was no bilharziasis in Palestine and that B. contortus was not found in this neighbourhood.

We had one great advantage in the spring of 1918, namely, personal
instructions from Colonel Fowler, Major E. Austen and Captain Bahr, to whom the medical officers of the East Anglian Division are much indebted for their advice and assistance in dealing with these two problems.

Personally I do not believe that the Auja line could have been held through the spring and summer of 1918 without the active anti-mosquito campaign organized by these specialists.

My thesis will be discussed under the following headings:

I. An Outbreak of Bilharziasis in Sinai among the Northamptons in 1916.

II. The Discovery of Bilharziasis among the Orange Groves of Mulebbis in 1918.

III. A localized Outbreak of Malignant Tertian Malaria at a Desert Post in Sinai in 1916.

IV. Anti-mosquito Work in the vicinity of the River Auja during spring and summer of 1918.

I. An Outbreak of Bilharziasis in Sinai among the Northamptons in 1916.

The outbreak of vesical bilharziasis among the 1/4 Northamptons involved one officer and twenty-one men. These cases all reported "sick" between the dates November 23, 1916, and April 25, 1917, after which there were no further cases.

Movement of the Battalion.

The battalion had been in Gallipoli in 1915, and had had no previous case of bilharziasis. They were then moved to Egypt. They moved from Shallufa to Kubri, a desert post in Sinai on the eastern bank of the canal, approximately eight miles north-east of Suez on May 20, 1916. The men were here in camp under canvas, until the spring of 1917, prior to their taking part in the march across the Sinai Peninsula. The men had had no previous opportunity of fresh-water bathing in Egypt.

Methods of Infection.

(a) Sweet-water Canal. — Nineteen of the twenty-two cases can be definitely traced to bathing and fishing in the Sweet-water Canal during the last week in May, 1916, just after the battalion had arrived at Kubri.

The Sweet-water Canal runs parallel to the Suez Canal on the western bank. It was easily accessible to the men in camp at Kubri who crossed the Suez Canal by the wooden bridge, and then had half a mile to walk to reach the Sweet-water. The Sweet-water Canal is swift flowing; native villages are built along its banks, and there are swamps in many places close by. The Sweet-water Canal was known to be infected with bilharziasis which is there endemic. B. contortus snails, the host of the vesical form of bilharziasis, are found practically universally in the
Sweet-water Canal and in the swamps; but, *Planorbis boissyi*, which harbours the cercaria of the rectal form of bilharzia, and is easily distinguished by its ammonite appearance, was not found in the Sweet-water Canal near Kubri. Dr. Leiper of the London School of Tropical Medicine found *P. boissyi* in the swamps and marshes around Ismailia, but not near Suez. Both snails are common all over Lower Egypt, but in Dr. Leiper's opinion, *P. boissyi* is restricted to the irrigation channels and drains, while *B. contortus* occurs in these channels as well as in the large canals. When the Northamptonshire battalion first arrived at Kubri, men were warned, both on parade and in orders, of the danger of bathing in the Sweet-water, and this order was republished monthly in orders. Nevertheless, nearly eighty men in the battalion bathed on at least one occasion in the Sweet-water Canal, and nineteen of these men subsequently developed vesical bilharziosis.

(b) The remaining three cases of bilharziosis can be traced to washing in a cattle trough at Kubri, the water of which was drawn from the Sweet-water Canal by pipes which passed beneath the Suez Canal to the Sinai bank, and so supplied the post at Kubri. This water was siphoned off from an area protected by barbed wire, and it was then pumped through a system of pipes under the Suez Canal. In June, 1916, there were two different systems of water supply. The supply of water for the cattle troughs did not pass through a filter bed, but was pumped into canvas troughs adjacent to the battalion football ground, and labelled "not drinking water." The drinking water, on the other hand, went through a filter bed reservoir.

On rejoining my unit from sick leave on June 3, 1916, I observed a man who had been playing football washing his face and hands in this cattle trough. This practice was at once stopped, and the matter reported. But three men, Ptes. D., J. and A., subsequently developed bilharziosis. They all stated that they had never bathed or washed in the Sweet-water Canal, but admitted they had washed in the cattle troughs at the Kubri Camp.

**Incubation Period.**

The first case of bilharziosis who reported at sick parade with haematuria was Lance-Cpl. J. on November 23, 1916, six months after infection. All the twenty-two cases were infected between the dates May 20, 1916, and June 6, 1916.

The longest period of incubation before any symptoms of haematuria started was Pte. A. (who washed in the cattle trough but had not bathed in the Sweet-water Canal) on June 3, 1916. Haematuria did not start until April, 1917. Pte. A.; three hundred and twenty-six days after infection, on April 25, 1917, was the last case admitted to hospital.

The seven cases admitted to hospital at Mazar on March 7, 1917, were discovered by the courtesy of the Anzac field laboratory, who examined eleven officers and 250 men, including any men who had run the risk of
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infection. Of the 250 men examined seven were positive, terminal-spined ova being in the urine. In five of the seven cases blood was also present. Pte. Br. and Pte. R. had no history of hæmaturia and appeared to be perfectly well, but both admitted exposure to infection. Microscopical examination of the urine showed they were positive for bilharziasis. I am unable to say whether they developed hæmaturia after admission to hospital.

Of the eleven officers examined on March 7, 1917, all were negative.

The symptoms of hæmaturia appeared to be brought on by the marching across Sinai. Men would report sick on the morning following a long march. Several cases reported sick with backache some weeks before the appearance of symptoms of hæmaturia. It is interesting to note that although four men might be infected when bathing together in the same spot, there might be a difference of twenty days in the incubation period before hæmaturia started, although the conditions as regards marching were exactly the same. Another point of interest is brought out by these cases. Although at least eighty men in the battalion admitted they had run the risk of infection on at least one occasion by bathing in the Sweet-water, only twenty-two cases developed. These were mostly group cases; for example, four men, all of whom had bathed together in the same spot on the same day, all became infected. This, in my opinion, shows that the miracidia were fortunately not present everywhere in the Sweet-water; and that to have bathed frequently would certainly have carried infection. This is borne out by the high percentage of infection amongst the natives in Lower Egypt, where from one-third to ninety per cent of the fellaheen population are infected. If men bathed together in a place where miracidia were present (presumably hatched out from eggs passed in the urine of an infected native) all developed the disease. Infection was more certain in infected pools and cisterns where infected natives had urinated when bathing, than in a fast flowing stream.

The infection was certainly a skin infection and not conveyed by drinking the water.

History of Some Typical Cases of Bilharziasis among 1/4 Northamptons.

Class A.—(1) Pte. R. 2204. Arrived in Egypt in April, 1916. Stated that in the last week of May, 1916, he bathed once in the Sweet-water Canal with Pte. C. In January, 1917, he reported at sick-parade with backache; this backache continued for two months, but he remained on duty; hæmaturia started on March 7, 1917, on which date he was sent to hospital. Positive for bilharziasis.


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(6) Second Lieutenant W. Went fishing with his servant, Pte. Es, on June 4, 1916, in the Sweet-water Canal but did not bathe. Stated he got his feet wet by slipping into the water from the bank. It is interesting to note that the cercariae evidently passed through Second Lieutenant W.'s puttee. Second Lieutenant W. reported sick, with haematuria after a long march on March 31, 1917. Stated he had had occasional haematuria for the previous two months. Reported positive for bilharziasis.


List of Hospital Admissions for Bilharziasis, 1/4 Northampsons, 1916-1917.

<table>
<thead>
<tr>
<th>Reg. No.</th>
<th>Name</th>
<th>Date sent to hospital</th>
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<tbody>
<tr>
<td>5410</td>
<td>Lance-Cpl. J.</td>
<td>23.11.16</td>
</tr>
<tr>
<td>5404</td>
<td>Pte. T.</td>
<td>26.11.16</td>
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<tr>
<td>3881</td>
<td>Pte. P.</td>
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<tr>
<td>1813</td>
<td>Lance-Cpl. S.</td>
<td>29.12.16</td>
</tr>
<tr>
<td>4936</td>
<td>Pte. L.</td>
<td>6.1.17</td>
</tr>
<tr>
<td>6415</td>
<td>Pte. D.</td>
<td>10.1.17</td>
</tr>
<tr>
<td>5417</td>
<td>Pte. Es.</td>
<td>16.1.17</td>
</tr>
<tr>
<td>2449</td>
<td>Pte. B.</td>
<td>20.1.17</td>
</tr>
<tr>
<td>3992</td>
<td>Pte. G.</td>
<td>6.2.17</td>
</tr>
<tr>
<td>5186</td>
<td>Pte. V.</td>
<td>11.2.17</td>
</tr>
<tr>
<td>4151</td>
<td>Pte. As.</td>
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</tr>
<tr>
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<td>Pte. C.</td>
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<td>5425</td>
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</tr>
<tr>
<td>4387</td>
<td>Pte. De.*</td>
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</tr>
<tr>
<td>4054</td>
<td>Pte. Je.*</td>
<td>6.3.17</td>
</tr>
<tr>
<td>4040</td>
<td>Pte. Bs.*</td>
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</tr>
<tr>
<td>10968</td>
<td>Pte. Br.*</td>
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<td>Pte. R.*</td>
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<td>2244</td>
<td>Pte. F. W.</td>
<td>7.3.17</td>
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<tr>
<td>-</td>
<td>Second Lieutenant W.</td>
<td>31.3.17</td>
</tr>
<tr>
<td>-</td>
<td>Pte. A.</td>
<td>26.4.17</td>
</tr>
</tbody>
</table>

All these were cases of vesical bilharziasis with terminal-spined ova. There was a history of haematuria, except in the cases of Ptes. Br., R., and De.

Class B.—Three cases infected from washing in the cattle trough at Kubri.

Pte. D. Arrived in Egypt in May, 1916; never fished or bathed in Sweet-water Canal, but he washed in cattle trough at Kubri, near battalion football ground, in June, 1916. He reported sick, with backache for three weeks, which was continuous. He never passed blood. He was sent to hospital and was diagnosed as bilharziasis microscopically on March 6, 1917.
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Pte. J. Arrived in Egypt in September, 1916; never bathed or fished in the canal, but washed in water, taken from the Kubri cattle troughs. Stated he had had occasional haematuria for two months before he reported sick; was sent to hospital March 6, 1917, and diagnosed microscopically as bilharziasis.

Pte. A. Never bathed or went to the Sweet-water Canal, but washed in cattle troughs the first week in June, 1916; haematuria started in March, 1917. Was sent to hospital and diagnosed as bilharziasis, April 25, 1917.

There were no cases of rectal bilharziasis. The lateral-spined ova of Schistosoma mansoni were never present, nor did we find P. boissyi in the Sweet-water Canal.

II. Discovery of Bilharziasis amongst the Orange Groves of Mulebbis, 1918.

Mulebbis is the flourishing Jewish colony north-east of Jaffa. It was occupied by the East Anglian Division after the battle of Bald Hill on December 24, 1917. Our information, as already noted, had been that no bilharziasis existed in Palestine, and that B. contortus snails were not found in this neighbourhood; but after the unfortunate experience of the Northamptons on the Suez Canal, we were always alert for the possibility of bilharzial infection, although the order with regard to bathing had been discontinued after the crossing of the Sinai Peninsula.

In February, 1918, I took over the duties of brigade sanitary officer; and in connexion with the strenuous anti-mosquito campaign started at this period under the able management of Colonel Fowler, it was my duty to examine all wells, cisterns and marshy areas. These wells were marked on an enlarged 1/20,000 map, and numbered with a number and letter indicating the area they belonged to. This was first done by boards, but these were frequently stolen by Bedouin, and it was found better to paint—in the dry season—the letter and number on the well or cistern itself. Cresol formed a useful substitute for paint. These places were visited weekly, and a register kept showing the date of visit, whether oiled, presence of larve, or anything else of interest.

On February 10, 1918, Cpl. Loveday and myself were visiting a cistern in an orange grove belonging to Madame Pascall, map ref. Selmeh I in 20,000, F.26, B.55, a mile south-west of Mulebbis, on the left-hand side of the Jaffa-Mulebbis road; a few days after we had started the anti-mosquito work. The orange and lemon groves with which Mulebbis is surrounded are each irrigated from large cement cisterns, resembling school swimming baths, the water is pumped into them by modern machinery from an adjacent deep well. These cisterns are often never completely emptied for seven or eight years.
A few cisterns contain fish placed there by their owners with the object of keeping down mosquito larvae. These fish appeared to be Egyptian perch and were usually three or four ounces in weight. I do not consider that they were of much use. The fish were too large, and anopheles larvae were very seldom found in any open cistern. Culex more commonly bred there, but these open cisterns were not the favourite breeding spots for mosquitoes. On the other hand the small fish about the size of a minnow found in the springs and swamps of El-Mirr certainly keep down the larvae, and may be observed to do so experimentally. Madame Pascall's cistern contained a few of the large fish, also culicine larvae, and to our surprise a number of B. contortus snails crawling on the bottom and sides of the cistern among the algae with which the bottom was covered. The snails were sent to Major Austen, who identified them as B. contortus; he had not, however, the facility for examining the snails' livers to prove their infection.

Between February and August, 1918, we examined daily hundreds of cisterns, wells, swamps, and mosquito breeding places, including the River Auja. But although we searched most carefully we only found the B. contortus in three of these open cisterns near Mulebbis, in one deep well adjacent to a cistern, and in a pool near the village of Kafrana, though limnea snails were most plentiful, especially in the River Auja. Major Austen found B. contortus in Burak-Leil only, a pool near El-Jelil, subsequently obliterated in course of anti-mosquito operations by 21st Corps.

Three cases of bilharziasis were traced to Madame Pascall's cistern, and one to another cistern half a mile north of Mulebbis, which also contained bullinus snails. These cisterns were all treated with cresol, danger boards posted, and a guard placed over them; they were also emptied.

I am unable to explain why these particular snails should only be found so locally, and cannot be found in the River Auja or in the wadi pools with the two exceptions already reported.

As soon as we had discovered the snails we went to the manager of the estate, Bornstein, who lived in this garden, and found that both he and the native boys working in the garden all had symptoms of bilharziasis. Their histories are most interesting and are appended. The same evening we procured specimens of urine from these cases, and rode into Jaffa in the hope of finding a microscope there. Captain Stewart, of the 77th Casualty Clearing Station, very kindly confirmed the diagnosis in each case, and found the terminal-spined ova of S. haematobium without even the necessity of centrifugalization.

History of the Mulebbis Cases.

(Infected Jews.)

(1) B., a Russian Pole, aged 35, who had worked near Mulebbis for the last twelve years, and always lived there, stated that two years ago he had haematuria, but was now "cured by drinking plenty of cognac." He had
never been to Egypt, but had washed and bathed in Madame Pascall's cistern. He said that the Arab boys, who came from El Yehudie, after working on the estate for about a year always passed blood. That in the summer they swam in the cistern. He remembered that seven years ago an Egyptian native was employed in the orange grove who had haematuria; there was never any case as far as he knew before this. The cistern had not been completely emptied for eight years. Captain Stewart, 77th Casualty Clearing Station, reported that B.'s urine teemed with terminal-spined ova of *S. hæmatobium*.

(2) M., aged 20, a Jew, lived all his life in Mulebbis; has an orange grove next to Madame Pascall's. Three years ago he swam in Madame Pascall's cistern; six months later he passed blood after micturition; was sick for two years, but stated that he cured himself by drinking cognac. Captain Stewart reported the presence of many terminal-spined ova, also blood in the urine.

(3) G., a Jew from Mulebbis, stated that he had never been in Egypt; born in Poland; had lived in Mulebbis the last fifteen years, worked in Madame Pascall's orange grove, and bathed in her cistern with the Arab boys there six years ago; some months later he passed blood after micturition. He is thin and anæmic. He saw a doctor in Jerusalem four years ago who told him he had bilharziasis and that if he drank plenty of cognac it would cure his complaint; has not had haematuria the last two years, and says he is cured. Captain Stewart reported that no ova were found, but many oxalate crystals were present.

(4) G., a Pole, aged 17; born in Poland; has lived in Mulebbis for the last seven years, and works in the orange groves, but has not worked in Madame Pascall's; bathed in cisterns in the summer, but has not bathed in Madame Pascall's; never had haematuria. Captain Stewart reported him negative for bilharziasis.

(Infected Arabs.)

(5) H. I., Arab boy, aged 15; lived all his life at El Yehudie and worked in the orange groves; for the last six years at Madame Pascall's orange garden. During the last three years has passed a few drops of blood after micturition. Was paddling in Madame Pascall's cistern at the time of our visit; admitted he had urinated into cistern. Reported positive by Captain Stewart.

(6) A., aged 13, has worked in Madame Pascall's orange grove for the last five years, and passed blood four years ago; now works in another orange grove; is very sick and anæmic. Reported positive by Captain Stewart.

(7) M., Arab, aged 16; lived all his life at Kafrana, and worked in the orange groves of Mulebbis; has bathed in several cisterns, but never in Madame Pascall's. Has bathed in cistern 7B. Stated does not pass blood.
Reported positive by Captain Stewart. 7B was a cistern in an orange grove half a mile north of Mulebbis, which contained B. contortus snails. The snails were also present in the neighbouring deep well. The well was uncovered, but the snails in it were less likely to be infected than those in the open cisterns where the Arab boys bathed. The snails in the well were identified by Major Austen as B. contortus.

Y., an Arab, aged 20; lived all his life at El Yehudie, and worked in Madame Pascall's orange grove, but never bathed or drank from the cistern because he "knew it was bad water"; no history of haematuria. Urine reported negative by Captain Stewart.

Prevention.

(1) All infected cisterns, including thirty others in the vicinity, were emptied. The water was first treated with cresol: one cubic centimetre to four gallons of water. The infected cisterns, until they were emptied, were labelled "Dangerous to handle this Water," and a guard was posted over them.

(2) The anti-malarial squads were warned of the danger of handling these snails, and were told to drop the snails into 1 in 10,000 cresol solution. Rubber gloves indented for were not available.

(3) Strict divisional and battalion orders were published forbidding men washing or bathing in these cisterns except in the Auja, where no bullinus snails could be found, though limnea snails were exceedingly plentiful. I am quite unable to explain why we were unable to find bullinus except in the places mentioned. There were none in the Abuzeitun Marsh, although we searched for them daily.

Instruction.

(4) Lectures were given to every battalion, which it was compulsory for officers and N.C.O.s to attend, and at which bullinus snails were shown. In addition there were lectures on malaria, relapsing fever, and fly prevention. Small exhibitions were opened in Mulebbis and Wilhelma, and an orderly conversant with the work was always on duty to explain the specimens shown and the diagrams exhibited. We were surprised at the amount of interest the men took in this work. Moreover, these places were constantly visited by all ranks as well as by Jews in Mulebbis, who, although they had the most primitive ideas with regard to sanitation, were keenly interested in the prevention of these diseases.

Summary.

(1) The Mulebbis outbreak of bilharziasis was very localized. We examined the Jews in Mulebbis who were working in the orange groves, but with the exception of the cases reported none were infected. We also examined Arabs from El Yehudie and Kafra and found them negative.
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with the exception of those reported. Bullinus snails were only found in one pool out of many near these two villages, and there was no evidence to show that this was infected. Bullinus was only found in one other pool by Major Austen.

(2) We never found the lateral-spined ova of S. mansoni, nor did we find the host of the rectal form of bilharziasis, P. boissyi, in the Mulebbis area.

(3) There are possibilities of the spread of bilharziasis in Palestine. During the war there must have been many bilharziasis carriers, especially among the Egyptian natives of the Egyptian Labour Corps and Camel Transport Corps.

A spread of bilharziasis would be disastrous for Zionism and for the many colonists who will settle in this fertile country. Very stringent measures are required to prevent this. The greatest care should be taken to prevent infected persons from urinating or defecating near water, and so prevent the ova hatching out. The orange grove cisterns should be emptied and cleaned annually, and bathing in them prohibited. The Arabs and Jews working in them should be systematically examined. Special care should be taken not to employ natives who are infected or who come from infected countries. This local outbreak can be entirely traced to an infected Egyptian native employed seven years previously, and well illustrates this danger.

Every facility was given by Madame Pascall and by the Jews in Mulebbis to conduct this research.

III.—A LOCALIZED OUTBREAK OF MALIGNANT TERTIAN MALARIA AT A DESERT POST IN SINAI IN 1916: INFECTION BY SINGLE MOSQUITO.

History of Outbreak.

The 1/4 Northamptons were stationed at Kubri in Sinai doing canal defence duty in the Southern Sector in June, 1916. There had not been any previous cases of malaria in the battalion when in Egypt.

On June 25, 1916, two officers, Lieutenant D. and Lieutenant B., with 140 men, were sent from the desert post at Kubri to garrison Baluchistan post, which consisted of trenches and a few mud huts on the eastern bank of the Suez Canal, two miles south of Kubri. This post had been built and garrisoned previously by a detachment of Gurkhas who were known to be malaria carriers. On July 8, 1916, Lieutenant D., one of the two officers, was thrown from his horse, and was admitted to the 18th Stationary Hospital at Suez with a fractured collar-bone. When in hospital on July 10, 1916; he had a rigor, temperature 106° F., and was diagnosed microscopically as malignant tertian malaria.

On July 9, 1916, Lieutenant B., the remaining officer, had a rigor, and was sent to hospital. He was diagnosed as malignant tertian malaria. Both were primary cases. There were no further cases at this post.
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Method of Infection.

We inspected the post carefully on July 9, 1916. These two officers both slept in the same dark mud hut. The rafters of this hut were carefully searched and we discovered and killed a female speckle-winged anopheline mosquito, A. pharoensis.

The best method of catching mosquitoes was taught me subsequently by Colonel Fowler, and was extremely useful in searching native huts. A flash lamp was used, and a piece of cotton-wool saturated with chloroform was placed at the bottom of an empty shaving-stick box. This was used to slip over the resting mosquito and enabled one to preserve the specimen for identification later. The men of the garrison of Baluchistan Post slept in the open; none complained of being bitten by mosquitoes. The water supply of the post was brought from Kubri by barge and stored in two large covered tanks: at the time of inspection there were small pools under these tanks where the water had dripped, but we were unable to find any anopheline larvae. Subsequently the tanks were abolished and a pipe system from Kubri substituted.

A careful search was made subsequently for adult mosquitoes, but no more were discovered after the first visit. The men at the post were paraded on two consecutive days weekly for the following six weeks, and given fifteen grains of quinine sulphate at each parade as a prophylactic. None of them contracted the disease.

Conclusions.

The infected anopheline mosquitoes were probably brought by the water barges from Kubri. There was a swamp on the western bank three miles away where anopheles were breeding at the time, and a serious outbreak occurred among Hyderabad Lancers who were stationed near the swamp. This was investigated by Captain Bahr and anti-mosquito measures were taken.

The only subsequent case in the battalion at the Kubri camp was on June 26, 1917, when Serjeant S. was bitten by a mosquito on the train journey to Suez, twelve days before his admission to hospital. The diagnosis was malignant tertian malaria.

IV.—Anti-Mosquito Work in the Vicinity of the River Auja in the Spring and Summer of 1918.

The area under observation from February to August, 1918, discussed in this paper is approximately eight square miles, and is shown on the attached map. It contains the prosperous Jewish colony of Mulebbis, the German agricultural colony of Wilhelma, and on the plain the native villages of Ferrekhieye el Mirr, Fejja, Rantie, Nebitari, El Yehudie, and Kafrana, while east of the Ludd-Tulkeram railway line in the rocky high
Metalled road from Jaffa to Jerusalem.
Road passable for wheeled traffic.
Ludd—Tulkeiram line.
Scale 1 inch to 2 miles.

The right-hand square illustrates the position of places discussed in thesis.
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The villages of Medjel-Yaba, Mezeirah and Kule. These hill villages are quite different from the villages on the plain.

The northern boundary of this area was the River Auja, which rises among the ancient ruins of Ras el Ain, held at this period as one of our strong posts in the Auja line of defence, and occupied by the East Anglian Division during these months.

The Auja rises by a great number of small springs; in winter the flat ground between Ras el Ain and El Mirr is very boggy and almost impassable. These springs are a hotbed of anopheline larvae, which are present in numbers in the clear water away from the swift-flowing current, sheltering beneath the papyrus roots or under old tree stumps. They can be best be found by scooping up the water with a white enamel soup ladle. The Auja banks were covered in March with thick high vegetation, five feet in height: there were many overhanging trees and willows projecting into the stream, under which anopheline larvae could be found. They were more frequent, however, in the springs and shell-holes when these were sheltered by vegetation. At the village of El Mirr the Auja is joined by the Wadi Lejja on the south, while at this spot on the north it is joined by the Wadi Baba. Two miles farther west the Wadi Ischar joins it from the north.

These wadis began to dry up in the hot season, and by April consisted of a chain of pools, some of them sixty yards long and four feet deep. These pools, surrounded by high grass, were a very favourite breeding place for both culicine and anopheline larvae. In the pools in the Wadi Lejja many of the anopheline larvae were bright green, possibly because they fed on alge. These green larvae were very delicate, and we were never able to bring them home alive to hatch them out, although we tried keeping the bottles cool with a wet flannel jacket.

The River Auja was part of our front line, and both Ras el Ain and Medjel Yaba were daily shelled. On one occasion several men belonging to an anti-mosquito working party were wounded here.

The Wadis Ischar and Baba were in front of our line, and it was necessary to take an armed guard when doing anti-mosquito work on these wadis. The Royal Army Medical Corps personnel and the anti-mosquito squads of the battalions in the line carried out their work very thoroughly and often under difficult conditions. Sgt. Miller of the Sanitary Section did especially valuable work.

One of the most difficult problems was the Abuzeitun Marsh on the southern bank of the River Auja, three miles west of Mulebbis. In the hot weather this marsh was four hundred yards square, with many springs. It consisted of a peaty, quaking bog covered with sedge, and somewhat resembled parts of Wicken Fen. This was the worst mosquito breeding spot in the area. Anopheline larvae could always be found in this marsh, and were only kept down by very vigorous anti-mosquito work. A. sinensis, A. algeriensis and A. maculipennis adults—the two latter, first
identified by Major Austen, could also be found here, occasionally in great numbers. In July, when examining with Colonel Fowler a small native cistern adjacent to a native house near the marsh, we found the wooden walls which covered the cistern almost black with adult maculipennis mosquitoes. *A. maculipennis* hatched out a month later than the other two varieties.

Mulebbis was not occupied by our troops until December 24, 1917, after the battle of Bald Hill, and Medgel Yaba was not captured by the 1/10 Londons until March 12, 1918.

The native population was completely evacuated from Ferrekiye, El Mirr, Feijja, Nebitari and Rantieh, and the German colonists from Wilhelma were sent to Jaffa.

The remaining native villages remained occupied. Our troops were billeted as far away from these villages as possible, and were hidden chiefly in orange groves and among olive trees. They were also billeted in Wilhelma and in Mulebbis.

**Organization of Anti-mosquito Campaign.**

From January 26, to February 2, 1918, Major Austen came down into this area to investigate mosquito breeding and to instruct the sanitary officers in charge of the work. He spent five days at Mulebbis as a centre, and three days at Wilhelma, and examined 65 wells and 47 cisterns in the area, but 30 wells and 11 cisterns were dry. During this period he did not find a single anopheline larva, although twenty-six per cent of the wells at Sarona nearer the coast were breeding them. Breeding did not start in the Mulebbis area until nearly a month later than in the coastal sector at Sarona.

This area was divided up into four sectors and placed under the three brigade sanitary authorities and the divisional sanitary officer. At first these officers moved their areas whenever their brigade moved, but this was found to be an unsatisfactory arrangement and interfered with the oiling and the anti-mosquito work. Later a divisional anti-mosquito officer was appointed, who did not have any sanitary duties, but devoted his whole time to anti-mosquito work. He was in charge of the River Auja, the wadis and the Abuzeitun Marsh, and supervised the anti-mosquito work of the brigade sanitary officers. Each brigade sanitary officer residing at an advanced dressing station had under him an anti-mosquito squad, consisting of an N.C.O. and six specially trained men, whose duty consisted in finding and labelling wells and breeding places, and oiling them. Their equipment consisted of 2 buckets, 100 feet of rope, 6 hand syringes for spraying, and 6 white-enamelled iron soup-ladles for examining water for larvae. There was an ample supply of paraffin and green oil available for spraying. In June the malaria question became so acute owing to the difficulty of keeping anopheline larvae in check, that it was found necessary to train six further men in each infantry battalion for anti-mosquito work.
These men carried out their duties in the front line, often under fire, under the supervision of their battalion medical officer.

_Routine employed in examining a Well or Native Cistern._

At least three dips were made with the bucket lowered into the well, and the water in the bucket was then ladled out and examined. I do not consider that this was a thorough examination, because we have found anopheline larvæ present in a native cistern after nine successive negative dips. The larvæ dart to the sides of the cistern as the bucket hits the water; moreover, these native cisterns in the rocky hills stretch for many yards underground.

_Clerical Work._

Malarial registers were kept by all battalion medical officers, who had to report weekly to the A.D.M.S.: (a) the number of men on the register who had had malaria; (b) the number of men undergoing three months' quinine treatment. In addition, the regimental medical officer had to notify the A.D.M.S. of any suspected case of malaria sent to hospital, showing where the man had been stationed during the previous fortnight, and indicating whether he was a primary or secondary case, and whether he had taken his three months' quinine treatment after leaving hospital. He had also to report whether mosquitoes were present in the vicinity.

The brigade sanitary officer in charge of his anti-mosquito area kept a register of wells, cisterns and breeding places, which were mapped and labelled, and rendered a weekly return to the A.D.M.S., showing wells oiled and the presence of larvæ. He had to prepare a map of his area. The 1/20,000 maps were enlarged four times and then were charted with wells and cisterns. The A.D.M.S. at his office kept spot maps showing where primary and secondary cases of malaria occurred. These maps were flagged to show the positions where anophèles were breeding at certain dates, and also the location of cases of malaria in the division.

_Method of Oiling Wells._

Wells that were not in use for drinking were sprayed every seven days with equal parts of paraffin and green oil by means of a hand spray, until there was a thin scum of oil floating on the surface. If the wells were used for drinking purposes, the green oil was omitted. Cattle would not drink water sprayed with the green oil, which was heavy and sank to the bottom.

At first wells were oiled every ten days, but we found by experiment that this was not sufficient to prevent the larvæ breeding in the wells again! Stitt, in his "Tropical Diseases," p. 33, says that once a fortnight is sufficient, but this we found to be inadequate. It was useless to oil swamps unless the reeds had been cut first or burnt down. In oiling the swamps at Abuzeitun, half a dozen natives were made to spray in a line; but the natives, whether Egyptian or Indian, were not reliable, and had to be constantly watched.
Drip cans were not a success. For oiling channels we tried sinking a sandbag containing tow saturated with green oil and paraffin. Another method was the sealing of native wells, undertaken by the R.E.; and some wells were pumped dry. We found that mosquitoes did not breed in orange grove wells which contained rotting oranges, for the oily scum on the surface formed a natural method of oiling.

Clearing Vegetation and Canalization.

Pools and shell holes were filled in on a large scale; hundreds of men were employed on this work in the spring of 1918. The pools left in the wadis, a very favourite breeding place, were filled in. Some of these were sixty yards long by four feet deep, and protected by high grass. The Abuzeitun Marsh was one of the most pestilent and difficult places to drain. A large median drain was cut, after the sedge had been burnt, and branch drains were cut every four yards. The main drain ran for three miles until it emptied into the River Auja; this facilitated the oiling of the marsh. This work was done mainly by natives of the Egyptian Labour Corps. The River Auja was cleared admirably by the 34th Sikh Pioneers from its source at Ras el Ain to the village of Ferrekiye. All roots and tree stumps were removed from the river. The bank was completely cleared for six feet up on either side, and springs were canalized. The Wadis Ischar, Raba and Lejja were treated in a similar manner.

Varieties of Mosquito Breeding Places.

(1) Orange Grove Cisterns, resembling open swimming baths, were practically never infested by anopheline larvae, but about four per cent contained culicine larvae. There was no protection for larvae.

(2) Orange Grove Deep Wells.—These were deep wells from which the water was pumped by machinery into the cisterns. There were two types of well, that in the Sarona district being often arched over, with a dwelling-house above it, in which natives live who tend the gardens. Twenty-six per cent of these wells near Sarona were found by Major Austen to contain anopheline larvae as early as the end of January, 1918. On the other hand, the wells in the Mulebbis area, which were more exposed and had no natives in their vicinity, did not contain anopheline larvae in January or February, 1918, and very few ever became infected. This, in Major Austen's opinion, may be due to the fact that Sarona is nearer the coast, and there may be a coastal species of anopheles in the wells there; or perhaps the Sarona wells are more protected than those at Mulebbis and have natives living near them.

(3) Native Cisterns.—These are found in the hilly country east of Ludd-Tulkeram line, and are very numerous, as many as fifty or sixty being found near each native village. They are not true wells, but are artificially cut out of the limestone rock. In some cases, as at Mezeirah, they hold up to 28,000 gallons. They extend many yards underground, and have
several rounded openings, from one to three feet in diameter. The water, probably rain water from the rocks, is very soft; the chlorination figure averages from three to five parts per million. These cisterns are difficult to discover, as their mouths are closed with stones.

Nearly all these native cisterns in May, 1918, if untreated, were breeding culicine mosquitoes, and ten per cent of them also were breeding anopheline mosquitoes. When these cisterns were disturbed, the mosquitoes would buzz out in swarms. On March 21, 1918, at Mezeirah, out of 60 native cisterns, 3 were breeding anopheline larvae, and 2 of these cisterns were in the centre of the village; but by April 11, 1918, after oiling, the larvae were stamped out.

Another interesting fact was that, although as a rule anopheles preferred to breed in clear water, at Mezeirah the worst breeding place was a well in the centre of the village where the water was most offensive, and contained, in addition to the body of a dead Turk, the larvae of anopheles, of *Culex pipiens* and of *Theobaldia longiareolata*, identified by Major Austen.

Anopheline larvae were more sensitive than culicine larvae. We were never able to get them to live in the cow urine from the pits in Wilhelma, although culicine larvae thrived in it. Nor could we get anopheline larvae to live in the effluent of soapy water, containing a little cresol from the Wilhelma baths, although we constantly found culicine egg rafts in this effluent.

(4) **Pools left in the Wadis.**—These were some of the worst breeding spots, when protected by high vegetation and rushes, and were therefore filled in. Fortunately many of them, especially in the vicinity of Kafrana, dried up by May, 16, 1918. In July, 1918, a small wood on the Wadi Ischar was a favourite shelter for adult *maculipennis* mosquitoes, which had hatched out of the pools.

(5) **Auja River.**—Anopheles were found to be breeding here in the middle of March, both in sheltered spots out of the current and under tree-stumps, or where there was a spring. Anopheline larvae were most frequent in the clear springs and back waters at Ras el Ain under the papyrus roots.

(6) **Swamps.**—These were very common breeding places. Most of the swamps were infected by May, especially at Abuzeitun and in the vicinity of El Mirr, though no anopheles were breeding on January 27, 1918. The Jews had made successful attempts to drain swamps by planting eucalyptus trees in some places. This plan should be extended. They also believed that eucalyptus leaves were a protection against malaria, and in their public steam bath at Mulebbis placed boughs of eucalyptus trees.

(7) **Shell holes** and ablution holes, made to contain a waterproof sheet as an extempore bath, often bred both culicine and anopheline mosquitoes. Larvae were also found in the front-line trenches, which on February 28, 1918, contained nearly a foot of water. Several cases of malaria among a company of the 1/5th Norfolks at the end of February were due to an infected swamp within ten yards of the company headquarters.
Isolated cases occurred in March and May in the vicinity of mosquito breeding areas, among the troops holding Medjel Yaba, in the vicinity of Mezeirah and at Ras el Ain. There were also a number of cases in June, 1918, among the Essex Regiment, who were billeted in a wood within half a mile of some infected pools in the Wadi Lejja, near a spot called Lemon Post. No primary cases occurred in Wilhelmia, and, thanks to anti-mosquito work, no anopheline larvae were found from February to July, 1918, in Wilhelmia, El Yehudie, Kafrana or Rantie. There were consequently few primary cases among the troops here, though breeding was at its height in June in unprotected areas.

(8) In water tubs and butts and cattle troughs at Wilhelmia and Mulebbis, on April 29, 1918, culicine larvae were breeding freely. These tubs had to be emptied. Anopheline larvae were found in a water-butt at Mulebbis on April 29, 1918. We also found adult maculipennis in the houses there, and an affected deep well. There were several primary cases of malaria in Mulebbis during May and June. We found that in abandoned houses breeding took place in water receptacles left behind in locked-up rooms.

(9) Mosquitoes bred occasionally in irrigated ground in the orange and lemon groves, but breeding was not usual except in the puddles. The water dried up too soon in the hot weather.

Adult Mosquitoes:

Both culicine and anopheline mosquitoes were very common in this area in 1918. Most commonly found in the mouths of the native cisterns. On July 7, 1918, the walls of the cisterns at a village called Haditheh, Map Ref. Sheet XIV, Y. 13, A. 20, were literally black with adults. Haditheh was a small native village on a hill south of Kule.

Out of 13 native cisterns at Haditheh 4 were dry, 3 were sealed. Of the remainder two contained anopheline and culicine larvae. There were millions of mosquitoes blackening the sides of these cisterns; two contained culicine larvae only, with culicine adults on the sides; two contained a few anopheline larvae only.

The anopheline mosquitoes found in this village were all of the maculipennis variety. These mosquitoes often lived in European houses as well as in native houses, and though none were seen in Wilhelmia, we found them in several houses in Mulebbis after June, 1918, and hatched them out from larvae found in a water tub. *A. maculipennis* was also found in the tops of the bell-tents occupied by troops in the vicinity of breeding places; but the adult mosquitoes were also very plentiful in the Ischar Wood.

In the Abuzeitun Marsh *A. sinensis* and *A. algeriensis* were freely hatching out in May, 1918, and were identified by Major Austen.

We hatched out a number of pupae from the wadi pools and also from the River Auja near Ras el Ain, and found an unsotted anopheline identified by Colonel Fowler as *A. bifurcatus*, but Major Austen did not
meet with this species. There was also a small speckle-winged anopheline with two white terminal tarsals of its hind legs, which was not identified. Colonel Fowler identified from hatched out specimens: A. mauritianus, A. pharoensis, A. palestinensis, A. fragilis. These were also identified by Major Austen, but were not common here.

In the Wadi Ghuzze the two varieties of anopheline mosquitoes were: A. turkhudi, A. palestinensis. The introduction of small fish in the Wadi Ghuzze was a most successful anti-mosquito measure. Of the culicine mosquitoes Culex pipiens and Theobaldia longiareolata, with its large black-headed wriggling larvae, were most common.

Dixa larvae were very common in the Auja in clear water under papyrus roots or old tree stumps, and were easily distinguished from anopheline larvae by their lateral wriggling motions and their ability to climb up the side of a glass jar.

Simulium flies were often found with the anopheline mosquitoes; and there were plenty of sand flies in the vicinity of Wilhelma by the middle of July, 1918.

A systematic search was made for adult mosquitoes, and much good resulted from explaining to all ranks the dangers of the mosquito, and the methods of distinguishing it throughout its life history. Many adults were killed and breeding areas reported.

Protection of the Men.

(1) Anti-mosquito ointment was indented for, but the small quantity used was not a success and it was discontinued.

(2) "Salonica" shorts were issued to some units, and these protected the knees of the men on duty at night. Ordinary "shorts" were not allowed to be worn after sundown.

(3) Prophylactic doses of quinine were not given to healthy men, but all cases of malaria returned from hospital were put on a three months, course of quinine treatment—sixty grains per week in solution if possible. This was supervised by the regimental medical officer.

(4) Mosquito bivouacs were issued, one for every two men. They were weighted at the sides with pockets filled with earth, and when used properly were an effective protection for the men at night. They were also cooler than a bivouac of waterproof sheets, but were not available until the first week in June. At first they were improperly used. We found that one battalion had placed wire beds under them, and so prevented the net reaching the ground; the wire was also apt to tear the meshes. Company officers were made responsible, and rigid supervision prevented a repetition of the error.

Mosquito Huts.

On June 14, 1918, we inspected five of these huts on the Auja in use by the 1/5 Essex. They were not mosquito proof, and were badly warped by
the sun. Two of the huts had the gauze windows missing. The sliding roofs were very unsatisfactory and were left open by the men who slept there. These huts were quite useless, and were discontinued.

The most important protection was to billet men as far as possible from the mosquito breeding places—at least a mile from any native village which was highly infected. Many of the villagers suffered from malaria, and a high percentage of the children had enlarged spleens. The villages placed on rocky high ground were more infected than those on the plains, and had a higher death rate; which was not surprising in view of the greater number of breeding places for anopheline mosquitoes, and the curious custom of disposing of the dead by placing them in rocky caves with a stone rolled over the entrance. This method of burial was practised at Mezeirah within 100 yards of the village; but on the plains the dead were buried in the Mohammedan cemeteries.

In conclusion, it is not in the scope of this paper to discuss the number and location of cases of malaria primary and secondary occurring among troops in this area, as it has been impossible for me to obtain the malaria returns. But I think it is clear that the anti-mosquito work done on the Auja definitely proved its value. There were, it is true, cases of benign tertian and malignant tertian malaria in isolated groups in the vicinity of anopheline breeding areas. But as long as our men remained in this protected zone we were able by constant supervision to keep malaria in check. When the troops moved forward in the September advance the epidemic attained alarming proportions and decimated General Allenby's victorious troops during the final advance into Syria. Before the advance we had been able to hold the Auja line, a highly infected area, with a comparatively low hospital admission rate for malaria. General Allenby, himself, in July, 1918, inspected the anti-mosquito work done on the Auja, and took a keen interest in it. It was a privilege to take even a small share in this anti-mosquito campaign under Colonel Fowler, and we were well repaid by the knowledge that our work was effective both from a military and a civilian standpoint.

Two conclusions in particular seem to be justified from these experiences during three years’ service with the same battalion:

1. The necessity of all ranks receiving some training in the prevention of tropical diseases before proceeding on a campaign. This especially applies to the regimental medical officer.

2. The desirability of a strenuous after-war campaign against malaria and bilharziasis in Palestine if this fertile country, after its happy release from Turkish misrule, is ever again to become "a land flowing with milk and honey," or even a fit place for white colonists to live in.