

# **FEDERATED MALAY STATES**

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## **MALARIA BUREAU REPORTS.**

**VOLUME I.**

**November, 1919.**

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**BY**

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## PREFACE.

The malariology of this country is very incomplete and it is necessary to exercise extreme caution in accepting generalised conclusions without considering the amount of data on which these are based. Conclusions based upon a certain number of observations in any one locality may have to be given up or modified by the collection of more data, and much more likely is this to be the case when observations from other localities are added.

The variety of opinions on the subject of malaria is evidence of a lack of caution in arriving at conclusions, and action based on incomplete data is likely to be wasteful and possibly harmful. The main object, therefore, of the work at the Bureau is to collect full and accurate data on malaria rather than to add another opinion on the subject, and it is submitted that work along these lines will bring about greater uniformity in conclusions and opinions.

For these reasons no general conclusions on the subject of malaria will be issued from the Bureau until they can be based upon an incontrovertible mass of facts. It is proposed, however, to publish from time to time volumes containing reports on various subjects in practically the form they were originally issued to Government, showing the time, place and number of observations, and the conclusions that could be arrived at on the given data in the light of the knowledge available at the time the report was written. These volumes will be copiously indexed so as to render the data readily available for immediate use as a basis for practice. They will also act as reference books of data from which, in the future, a more uniform theory and practice of malaria prevention and treatment may be developed.

This volume consists of a selection of the reports issued since May 1917, and contains all the work done in connection with the Railway; some data on the change of anopheline fauna caused by the felling of jungle, and some data bearing on the relation of *A. maculatus* and *A. karwari* to malaria. During this time the Entomologist has been working single handed, and is therefore responsible for the whole of the present volume. In the near future, however, others will be appointed, and then each report will bear the name of the member of the staff responsible for collecting the data.

In no aspect is the incompleteness of our knowledge of malaria more marked than on the subject of the relative malaria carrying properties of the various species of anophelines, and the conditions that control these properties. The pathogenicity of jungle species in particular is practically an untouched subject. This peculiarly intricate field of investigation calls especially for co-ordinated research, and no attempt has been made to deal with it; but the lines along which work might be begun have been laid down and will be followed as soon as help is available. In the light of the work of Stanton, Watson and others, these reports should be read with the idea that *A. maculatus* is the most important carrier in hilly country; *A. aconitus* and *A. fuliginosus* in open swampy country, and *A. umbrosus* in low-lying jungle. The recent work of Barber, however, suggests that in certain circumstances most of the species may become infected and therefore may carry malaria.

Throughout this volume, for the sake of brevity, the type of *A. rossi* most common in Malaya will be referred to as *A. rossi*, instead of by its proper name *A. rossi* var. *indefinitus*. Wherever the true *A. rossi*, which is rare in this country, is mentioned it will be referred to as *A. rossi* (Giles). Moreover, it has been found extremely difficult to differentiate between the larvae of *A. maculatus* and *A. karwari*, and it is much wiser in identifying these species to allow the larvae to develop into adults when there is no difficulty in distinguishing between the two species. In view of the possibility of a marked difference in the pathogenicity of the two species, for which some slight evidence is adduced in this volume, wherever the identification depends solely on examination of larvae the letter L. is placed after the name of the species; wherever the identification has been confirmed by the hatching of adults this mark does not appear.

In publishing these reports I wish to express my indebtedness to Mr. T. R. Black for the time and trouble he took over the very excellent reproductions of my rough photographs and plans.

H. P. HACKER.

Kuala Lumpur,

November, 1919.

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## **REPORT I.**

### **On the conditions affecting the incidence of malaria on a site at Sungei Besi, February, 1919.**

1. Reason for the investigation.
  2. Amount of malaria at present on the site.
  3. Species of anophelines found and their general distribution.
  4. Malaria carrying properties of the species found.
  5. Conclusions.
- 

#### **Ia. Some evidence on the relative importance of A. MACULATUS and A. KARWARI as carriers of malaria, September, 1919.**

1. Evidence from estates.
2. Evidence from Kuala Lumpur.
3. Summary.

## REPORT I.

### ON THE CONDITIONS AFFECTING THE INCIDENCE OF MALARIA ON A SITE AT SUNGEI BESI, FEBRUARY, 1919.

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#### 1. Reason for the investigation.

A request for a determination of the likelihood of men contracting malaria on a site chosen for a camp for the Malay States Volunteer Rifles was received from Lieut.-Col. A. J. Fox.

#### 2. Amount of malaria at present on the site.

The locality has a very good reputation for health and Mr. Talalla, who has been stationed at the Sungei Besi Hospital for 7 years, affirms that he has had no cases from that neighbourhood, although from the 7th mile on the Kuala Lumpur-Sungei Besi Road he has had a few cases. Twenty-five persons living near the site were examined for evidences of malaria. The spleen was found to be enlarged in only two of them and no malarial parasites were found in their blood.

The population is a very stationary one, and consists mainly of vegetable gardeners. All the 9 children examined had been born near the site, and the average length of residence of the 16 adults was five years, and this includes 4 new arrivals who had lived there less than a year.

#### 3. Species of anophelines found and their general distribution.

Sungei Besi lies 7 miles south of Kuala Lumpur and about 24 miles from the sea. The site is on undulating ground near the Chinese cemetery. It is about 200 feet above sea level, and on either side of the site is a series of wide ravines. The ravines were mainly open, but contained patches of rather dense secondary jungle especially towards their heads, and one ravine head was under primary jungle preserved as a water collecting area.

The lack of a good topographical map made it impossible to plot out with any accuracy the distribution of the anophelines mentioned in the following table A which shows the species found in 184 breeding places examined, and their relative frequency. In general however, the umbrosus-like larvae, the *A. aitkeni* and *A. leucosphyrus* were found in the jungle and secondary growth, while the other species were found in the open floors of the ravines.

The following Table A shows the species found and their relative frequency.



TABLE A.

Species.	Times found.	Larvae.	Adults.
Larvae of <i>A. maculatus</i> or <i>A. karwari</i> .. .. .	38	1158	141*
<i>A. rossi</i> .. .. .	30	431	68
<i>A. kochi</i> .. .. .	14	57	45
<i>A. tessellatus</i> .. .. .	4	6	—
<i>A. aconitus</i> .. .. .	12	168	13
<i>A. fuliginosus</i> .. .. .	23	308	55
<i>A. barbirostris</i> .. .. .	25	193	20
<i>A. sinensis</i> .. .. .	83	660	87
<i>A. leucosphyrus</i> .. .. .	7	21	—
<i>A. aitkeni</i> .. .. .	9	98	3
Umbrosus-like larvae†			
<i>A. umbrosus</i> .. .. .	7	13	1
<i>A. hunteri</i> .. .. .	13	50	8
<i>A. novumbrosus</i> .. .. .	1	4	2
<i>A. alboataeniatus</i> var. <i>montanus</i> .. .. .	2	11	1
	268	3178	444

\* All the 141 adults hatching from this type of larva were *A. karwari*, rendering it likely that the rest of the larvae were of that species and not *A. maculatus*.

† The presence of *A. umbrosus* so far inland is of interest in showing that this species is by no means limited to the coastal area. (See also page 37).

#### 4. Malaria carrying properties of the species found.

*A. maculatus*, probably the most dangerous species of anopheline, was not found in the neighbourhood of the site, its place being taken by the very similar form *A. karwari*. Other records at the Bureau suggest that *A. karwari* is by no means as dangerous as *A. maculatus*. In this connection it is interesting to note that at the 7th mile Kuala Lumpur-Sungei Besi Road, from which district cases of malaria are reported, *A. maculatus* was readily found.

The other species which may be regarded as dangerous are *A. aconitus*, *A. fuliginosus* and *A. umbrosus*, although it is possible that any species of anopheline may become infected and therefore dangerous.

#### 5. Conclusions.

The absence of any marked malaria on the site, and the absence of *A. maculatus* are points in favour of the site; but it must be allowed that sufficient anopheline breeding exists to cause malaria if other conditions become suitable. The fact that the population is stationary, and not subject to an influx of newcomers, must be

borne in mind; and if a large labour force containing carriers of malarial infection were brought in, an outbreak of malaria might well occur in this neighbourhood. If, however, the incoming population were free from the carriers of infection, the site could be used probably with impunity.

**Ia. SOME EVIDENCE ON THE RELATIVE IMPORTANCE OF *A. MACULATUS* AND *A. KARWARI* AS CARRIERS OF MALARIA.**

The main interest in the above report is that all the adults from larvae of the maculatus-karwari type obtained from the healthy site were *A. karwari*, whereas at a place a mile and a half away, from which cases of malaria are reported, the adults hatched out to be *A. maculatus*. This is suggestive of a difference in the relative malaria carrying properties of these two species, and the other records referred to in the report as supporting this idea may be summarised as follows:—

1. **On estates.** A rubber estate, visited in January and February, 1919, on which a bungalow had to be abandoned on account of malaria, showed all of the 13 adults obtained from this type of larva to be *A. maculatus*; another estate, visited in July, 1917, on which the cooly lines had to be abandoned on account of malaria showed 22 out of 30 adults to be *A. maculatus*; whereas an estate visited in December, 1917, because it was healthy in spite of the presence of "maculatus," based on the identification of larvae by the Medical Officer of the estate, showed only *A. karwari* and no *A. maculatus*.
2. **In Kuala Lumpur.** The adults hatching from maculatus-karwari larvae obtained from different districts of Kuala Lumpur varied considerably with the locality from which they were obtained. This variation is shown in Table B in which the names used for denoting districts of Kuala Lumpur are those shown on the Survey Department's map No. 81/16 and do not refer to the villages of the same name just outside Kuala Lumpur.

TABLE B.

District.	Adults hatched out from maculatus-karwari larvae.	Percentage of <i>A. maculatus</i> .
North-east—Ampang and Batu .. ..	398	6%
South-east—Pudu, Lama and Bukit Petaling	400	60%
West—Kolam Ayer .. .. .	155	91%

Although no definite figures are to be obtained, a general impression is produced by conversation with medical practitioners that the incidence of malaria in these districts varies in much the same way as the percentage of *A. maculatus* in the table.

The districts also show a regular progression in their natural conformation, thus the North-east may be called flat, the South-east undulating, and the West hilly; but the actual breeding places in which the larvae were found were very similar in each district.

**3. Summary.** The evidence obtained so far is purely epidemiological, and is based on a correlation between distribution of species and distribution of malaria. It is dangerous to rely on this type of evidence, but as there are no data pointing in the opposite direction it is strongly suggestive that *A. maculatus* is more dangerous than *A. karwari*, although the larvae and breeding places of these two species are so similar.

Work should be directed to determine whether the results of experimental infection support this conclusion; and if so the reason for this difference in closely related species is a promising field of work. Moreover, should this difference be demonstrated it becomes of importance to determine what natural conditions control the majority of these two species being *A. maculatus* in one district, and *A. karwari* in a neighbouring district in very similar breeding places.

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## REPORT II.

### **On the breeding places of anophelines found along the railways in Kuala Lumpur, August, 1917.**

1. Reason for the investigation.
2. Methods of survey.
3. List of breeding places.
4. Photographs illustrating types of breeding places found.
5. Remarks (*a—d*).
6. Suggestions (*a* and *b*).

## REPORT II.

# ON THE BREEDING PLACES OF ANOPHELINES FOUND ALONG THE RAILWAYS IN KUALA LUMPUR.

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### 1. Reason for the investigation.

During the investigation of a small outbreak of malaria at the European Hospital, Kuala Lumpur, the breeding places of several species of anophelines were discovered. Among these the only one in which *A. maculatus* L. (probably the most potent carrier of malaria in this country) was found, consisted of certain springs in a railway drain almost opposite the road to the hospital. This was reported as the most likely source of the outbreak. Further, a prolific source of *A. maculatus* (photograph No. 1, page 20) was found in the railway cutting near the Gaol. On account of these two findings, it was thought that a complete survey of the railways in Kuala Lumpur would be advisable as the conformation of cuttings, embankments, and drains might afford suitable sites for the permanent breeding places of *A. maculatus*.

### 2. Methods of survey.

The consent and very valuable assistance of the Railway Authorities was obtained before commencing the work. At their suggestion, the sites of the breeding places have been identified by noting the number of the nearest telegraph post, and the terms right and left are used as in facing the direction of increase in mileage.

The survey has been limited to the railway fence on either side of the track, with the exception of the breeding places 34-37 which are outside the right fence but on the Railway Reserve extending to Brickfields Road.

### 3. List of breeding places found.

The breeding places found have been arranged in tabular lists which show the position of the breeding place, the nature of the place and the species found therein.

Table C shows the places found on the Main Line in going from the Maxwell Road Bridge to the junction of the Port Swettenham line.

Table D shows those found on the Pudu Line in going from Pudu Station to Sultan Street Station.

TABLE C.

MAIN LINE FROM MAXWELL ROAD BRIDGE TO JUNCTION OF  
PORT SWETTENHAM LINE.

Reference No.	Telegraph Post.	Side of rail.	Description of breeding places.	Species found.
1	240/12-13	R	Pools in side drain in the cutting .. ..	<i>A. maculatus</i> L. <i>A. karwari</i> L.
2	240/13	L	Spring in side drain .. ..	<i>A. maculatus</i> .
3	240/13	L	Side drain .. ..	<i>A. sinensis</i> , <i>A. kochi</i> .
4	240/14	R	Spring in side drain with grass .. ..	<i>A. maculatus</i> , <i>A. karwari</i> .
5	240/14	R	Pools in side drain .. ..	<i>A. karwari</i> .
6	240/15-16	R	Pools in side drain .. ..	<i>A. maculatus</i> L.
7	240/16-17	R	Cross drain carrying water from jungle, Culvert 970 .. ..	Species not identified.
8	ditto.	L	ditto.	<i>A. sinensis</i> .
9	241/ 1- 2	L	Cross drain, Culvert 972 .. ..	<i>A. kochi</i> , <i>A. rossi</i> , <i>A. sinensis</i> .
10	241/ 4- 5	R	Cross drain with algae and fine grass Culvert 973 (see photograph No. 3) .. ..	<i>A. maculatus</i> L. <i>A. maculatus</i> L.
11	ditto.	L	ditto.	<i>A. rossi</i> .
12	241/ 8- 9	R	Spring in side drain .. ..	<i>A. rossi</i> .
13	241/10-11	R	Cross drain, round muddy pool in square cutting, spring in wet weather, Culvert 974	<i>A. maculatus</i> L. <i>A. rossi</i> .
14	ditto.	L	Same cross drain .. ..	<i>A. maculatus</i> L.
15	241/13 near	L	Pool in side drain .. ..	<i>A. kochi</i> .
16	241/19-20	R	Muddy pool in cross drain, Culvert 977 ..	<i>A. rossi</i> .
17	241/19-20	L	Muddy pool, no grass, same cross drain ..	<i>A. maculatus</i> L.
18	241/20-21	R	Muddy pools in side drain at bottom of bank ..	<i>A. rossi</i> , <i>A. kochi</i> .
19	241/21-22	R	Spring in side drain at bottom of bank ..	<i>A. maculatus</i> L.
20	In yard	L	Pools behind Mr. Shaw's house .. ..	<i>A. rossi</i> .
21-33	Swamp from	L	Five places .. ..	<i>A. kochi</i> .
			Three places .. ..	<i>A. rossi</i> .
	242/27 to		One place .. ..	<i>A. maculatus</i> L.
	243/3		One place .. ..	<i>A. tessellatus</i> ,
			One place .. ..	<i>A. barbirostris</i> ,
			One place .. ..	<i>A. sinensis</i> .
			One place .. ..	{ <i>A. barbirostris</i> , <i>A. sinensis</i> , <i>A. fuliginosus</i> .
34-37	Swamp from	R	Four places .. ..	<i>A. maculatus</i> L. <i>A. kochi</i> , <i>A. barbirostris</i> , <i>A. sinensis</i> .
	242/27 to			<i>A. maculatus</i> L.
	242/29.			<i>A. rossi</i> , <i>A. kochi</i> .
38	243/ 4- 5	R	Springs in side drain .. ..	<i>A. maculatus</i> L. <i>A. rossi</i> , <i>A. kochi</i> .
39	243/ 5	R	Stagnant pools in drain .. ..	<i>A. rossi</i> .
40	243/ 5	L	Earth drain near bridge .. ..	<i>A. maculatus</i> L.
41	243/ 9	L	Stagnant water in side drain .. ..	<i>A. rossi</i> .
42	243/10	L	Stagnant water in side drain .. ..	<i>A. rossi</i> .
43	243/12	L	Side drain overgrown with coarse grass ..	<i>A. barbirostris</i> .
44	243/15	R	Muddy pool in side drain .. ..	<i>A. rossi</i> .
45	243/19	R	Hoof marks in silted stream near junction of Port Swettenham line .. ..	<i>A. kochi</i> .

TABLE D.

## PUDU LINE FROM PUDU STATION TO SULTAN STREET.

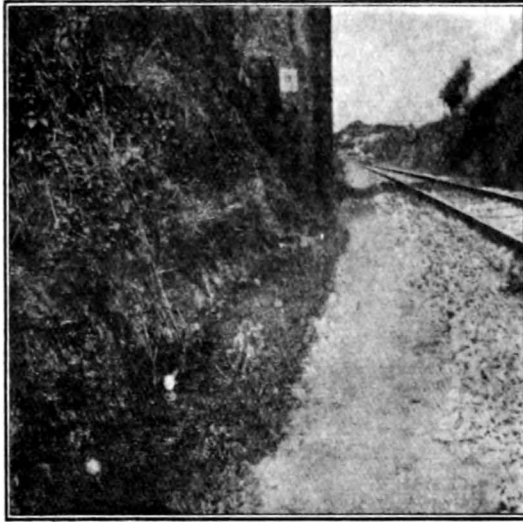
Reference No.	Telegraph Post.	Side of rail.	Description of breeding places.	Species found.
46	3/ 3	L	Grassy pools below bank .. .. .	<i>A. karwari</i> , <i>A. kochi</i> .
47	3/ 4	R	Grassy pools below bank .. .. .	<i>A. aconitus</i> , <i>A. barbirostris</i> , <i>A. kochi</i> .
48	ditto.	L	Small grassy pools .. .. .	<i>A. tessellatus</i> , <i>A. kochi</i> .
49	3/ 5	R	Grassy pool below bank .. .. .	<i>A. aconitus</i> , <i>A. rossi</i> .
50	3/ 6	L	Pond in swamp .. .. .	<i>A. fuliginosus</i> , <i>A. rossi</i> , <i>A. sinensis</i> .
51	3/ 8	R	Pool near turn-stile .. .. .	<i>A. sinensis</i> .
52	3/11	L	Grassy drain, flowing water .. .. .	<i>A. rossi</i> , <i>A. sinensis</i> .
53	3/12-13	L	Drain from Gaol, Culvert 18 .. .. .	<i>A. kochi</i> , <i>A. rossi</i> , <i>A. sinensis</i> .
54	3/16	R	Pool beside drain .. .. .	<i>A. rossi</i> .
55	3/16-17	L	Side drain 10 yards from bridge 19 .. .. .	<i>A. rossi</i> .
56	3/17-20	R	Side drain at base of cutting, film of water running over sand and algae, many small springs (see photograph No. 1) .. .. .	<i>A. maculatus</i> , <i>A. karwari</i> , <i>A. rossi</i> .
57	ditto.	L	Stagnant drain with a few springs (see photograph No. 2) .. .. .	<i>A. rossi</i> , <i>A. maculatus</i> .
58	3/23	R	Pool beside drain. .. .. .	<i>A. rossi</i> .
59	3/25	R	Spring water in damp place near fence .. .. .	<i>A. maculatus</i> L.
60	4/ 1- 2	L	Seepage from bank flowing over concrete side of drain (see photograph No. 4) .. .. .	<i>A. maculatus</i> , <i>A. karwari</i> .
61	4/ 2	L	Spring in side drain .. .. .	<i>A. rossi</i> , <i>A. maculatus</i> .
62	4/ 3	R	Grassy pool beside drain .. .. .	<i>A. sinensis</i> .

## 4. Photographs illustrating types of breeding places found.

Photographs 1-4 on the following pages show the features of certain typical breeding places encountered. In all of them *A. maculatus* (3L) larvae were obtained and they illustrate the danger of the small inconspicuous patches of fresh seepage water so common along the course of a railway.

PHOTOGRAPH 1. Breeding place 56.

Numerous small springs with a thin film of water flowing over sand.  
Much green algae and fine grass.

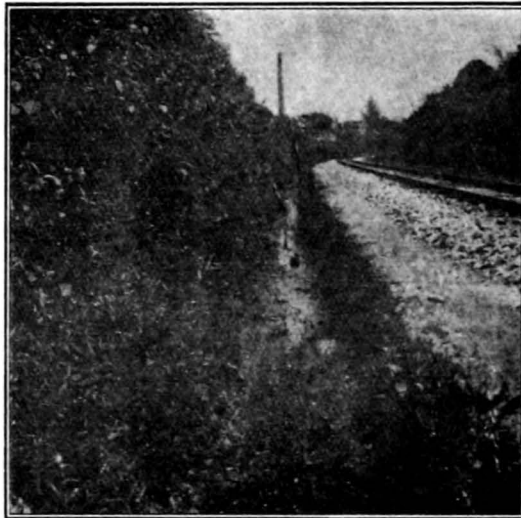


A very large number of larvae were obtained from here  
and 113 adults were hatched out. Of these there were:—

<i>A. maculatus</i>	..	..	..	99 = 87.6%
<i>A. karwari</i>	..	..	..	8 = 7.1%
<i>A. rossi</i>	..	..	..	6 = 5.3%

PHOTOGRAPH 2. Breeding place 57.

A more stagnant drain on the opposite side of the railway. There were a  
few springs, but the water was polluted by the side drain marked D.



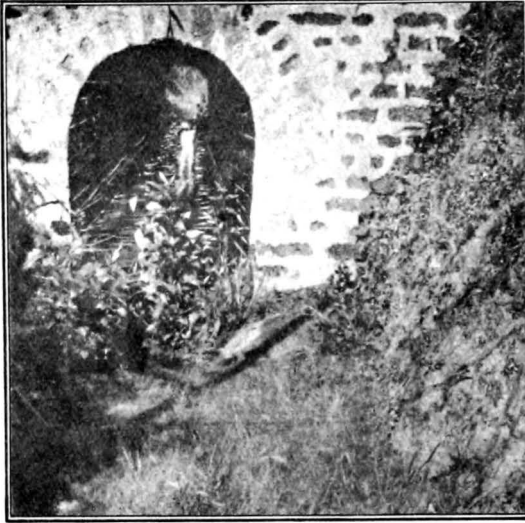
Of 25 adults bred out from this site only 2 or 8%  
were *A. maculatus* the rest being *A. rossi*.

This site is not so dangerous as that shown in  
Photograph 1, but it is advisable to destroy it if possible.



## PHOTOGRAPH 3. Breeding place 10.

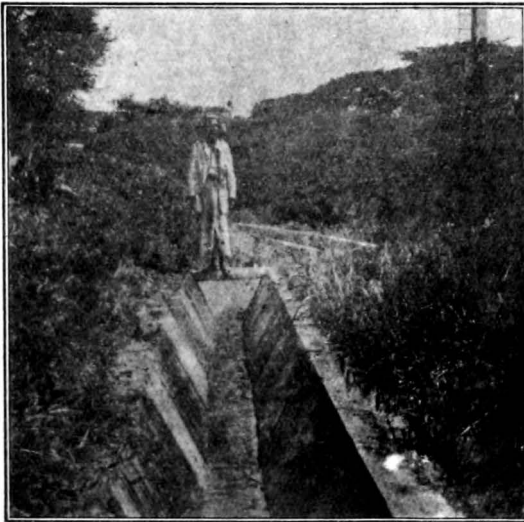
A culvert through which the cross drains are led. At the bottom of the bank there is fresh spring water, abundance of algae and fine grass.



*A. maculatus* L. larvae were readily obtained here among the fine grass at the edge of the drain.

## PHOTOGRAPH 4. Breeding place 60.

A concrete drain over the edge of which there is a flow of seepage water from the banks.



In the thin film of water and algae on the side of the drain *A. maculatus* larvae were readily obtained.

**5. Remarks.**

- (a). A large proportion of the places reported are breeding *A. maculatus*, a most dangerous species of anopheline.
- (b). This is because *A. maculatus* prefers fresh spring or seepage water such as is supplied for it in the cuttings, embankments and cross drains of the railway.
- (c). Many of the places reported (for example photographs 1, 3 and 4) are in the nature of permanent spring water.
- (d). It is possible therefore that the railway is the permanent source of *A. maculatus* in Kuala Lumpur from which other sources of fresh water (*e.g.* a newly-dug foundation or a subsoil pipe that is blocked) become infected.

**6. Suggestions.**

- (a). That efforts should be made to destroy the breeding places as thoroughly as possible.
  - (b). That, say, six months later, a further survey be made to test the success of these efforts.
-

## REPORT III.

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### **On the examination of a ravine covered by secondary jungle, April, 1919.**

1. Reason for the investigation.
2. Date of examination.
3. Results.
4. Conclusions (*a—e*).

### **IIIa. Notes on a comparison of anopheline larvae found in an estate ravine kept under jungle with those found in the open cultivated ravines, June, 1917.**

1. Observation.
2. Conclusions (*a and b*).

### **IIIb. Notes on the anopheline breeding found in a newly-opened ravine, February, 1919.**

1. Observation.
2. Conclusions (*a and b*).

## REPORT III.

### ON THE EXAMINATION OF A RAVINE COVERED BY SECONDARY JUNGLE.

#### 1. Reason for the investigation.

During the work at Perhentian Tinggi, a ravine at the 4th mile Seremban-Tampin Road was noticed to be under very heavy secondary jungle, except for a narrow path running across it. The opportunity was taken of determining the species of anophelines found in the jungle and comparing them with those found in the open parts of the ravine, namely, on the path and at the lower edge of the jungle.

#### 2. Date of examination.

The first examination was made on March 19th, 1919, and photographs were taken and a further examination made on March 24th, 1919.

#### 3. Results.

In the jungle only 9 breeding places were found during a thorough search, and the species present were *A. aitkeni* (7 times), *A. leucosphyrus* (twice).

Along the path, see photograph No. 5, *A. maculatus* L. was found in two places.

PHOTOGRAPH No. 5.



Narrow path crossing a jungle covered ravine. Note the dense growth on either side of the path. Larvae of *A. maculatus* L. were not found in the shade of this jungle but were present on the path.

The part of the ravine at which the secondary growth ended is shown in photograph No. 6. Where the assistant is working, on the bank of the stream just as it comes into the open, *A. maculatus* L. was found.

PHOTOGRAPH No. 6.



Note the dense vegetation in the back-ground under which only *A. aitkeni* and *A. leucosphyrus* were found. *A. maculatus* L. was found on the very edge of this jungle as soon as the shade of the vegetation ceased.

#### 4. Conclusions.

- (a). These observations confirm other records in showing that *A. maculatus* does not breed under the shade of secondary growth or jungle. (See page 28).
- (b). They show how slight the opening may be in order to allow *A. maculatus* to breed.
- (c). Therefore, in adopting vegetation as a preventive measure against this dangerous species, great care must be taken to produce a uniform shade.
- (d). The main points to be guarded against are:—
  - i. Paths across the ravine as in photograph No. 5.
  - ii. The point of emergence of the stream from the jungle, as in photograph No. 6, needs attention.
  - iii. Openings made for bathing pools. (cf. photograph No. 13, page 46).
  - iv. Patches of vegetation killed by water or silt. (cf. photograph No. 12, page 45).

- v. The over-growth of certain trees should be watched for and prevented as this may cause a killing out of the surrounding vegetation and so form a relatively open patch.
- (e). In fact, if vegetation is to be used as a method of excluding *A. maculatus*, it should be carefully cultivated and treated as a strict reserve, and, preferably, fenced off to prevent the access of labourers and cattle.
- 

### IIIa. NOTES ON A COMPARISON OF ANOPHELINE LARVAE FOUND IN AN ESTATE RAVINE KEPT UNDER JUNGLE WITH THOSE FOUND IN THE OPEN CULTIVATED RAVINES, JUNE, 1917.

#### 1. Observation.

An estate was visited in June, 1917, in order to compare the breeding found in a jungle covered ravine with that found in the open ravines. The jungle covered ravine was flat and swampy with a stream flowing through it. A slight opening had been made to provide a bathing place which was surrounded by reeds. On the path to the bathing place *A. sinensis* was breeding. In and around the bathing place *A. sinensis* and *A. tessellatus* were found, while in the jungle, breeding was scarce and *A. tessellatus* was found twice, and *A. sinensis* once.

In the opened ravines, *A. maculatus* was found 10 times (8L), *A. kochi* 4 times, *A. barbirostris* (once) and *A. sinensis* (once).

#### 2. Conclusions.

- (a). The entire absence of *A. maculatus* from the jungle covered ravine and its frequency in the open ravines is a characteristic finding.
- (b). The jungle species found, *A. tessellatus*, differs from those found in the ravine which is the subject of the main report.
- 

### IIIb. NOTE ON THE ANOPHELINE BREEDING FOUND IN A NEWLY OPENED RAVINE, FEBRUARY, 1919.

#### 1. Observation.

In October, 1918, an opportunity arose for studying the anopheline breeding in a ravine in which rather heavy secondary jungle had been felled recently. The clearing had commenced on September 1st, and at the time of examination felling had just been completed and the debris had not been completely cleared. Photograph No. 14, page 47, shows the condition present. The number of cut stumps and amount of fallen vegetation showed that the whole area had been under quite dense shade previous to the felling.

The following table E shows the species and the relative frequency with which they were found in the examination of 38 breeding places.

TABLE E.

Species Found.	Frequency.
Open small pool breeders .. .. .	<i>A. maculatus</i> 23 times (17L). <i>A. rossi</i> 2 " <i>A. kochi</i> 1 "
Open swamp breeders .. .. .	<i>A. sinensis</i> 31 " <i>A. barbirostris</i> 3 " <i>A. aconitus</i> 2 "
Shade breeder .. .. .	<i>A. tessellatus</i> 2 "

*A. tessellatus*, the only shade breeder found, is probably a remnant of the original fauna. The other species present are all species which prefer open breeding places and in particular *A. maculatus* has never been found in jungle or secondary growth on the basis of the description of origin of over 30,000 larvae, (see also page 34).

On the hillside of the ravine there was a small vegetable garden in the furrows of which *A. maculatus* L. was readily found, and it is probable that this is the source from which *A. maculatus* spread widely over the newly opened area.

Support is given to the idea that *A. maculatus* and *A. sinensis* were new arrivals by the following observations in a small branch of the ravine which was the last to be opened and in which the invasion was observed to occur. *A. tessellatus* was also found in this branch.

October 7th. One breeding place of *A. sinensis* was found.

October 16th. *A. maculatus* L. was found in this breeding place together with *A. sinensis*, and two other breeding places of *A. maculatus* L. were found.

October 22nd. Six breeding places were found, five of which contained *A. maculatus* L., and four *A. sinensis*.

## 2. Conclusions.

- (a). That the felling of vegetation allows the entry of light-loving species, and that the commonest species found in a newly opened ravine are *A. sinensis* and *A. maculatus*. These results are closely similar to those observed at Gemas (see page 52).
- (b). If a ravine is to be opened, steps should be taken to prevent the access of the dangerous species *A. maculatus*.

## REPORT IV.

### On the Malaria Problem at Gemas, October, 1918.

1. Reason for undertaking the work.
2. Date of investigation.
3. Weather during investigation.
4. Amount of malaria.
  - (a). Incidence in relation to various sites.
  - (b). Incidence in relation to percentage of haemoglobin.
  - (c). Incidence in relation to length of residence.
5. Species of anophelines found.
6. Distribution of anophelines.
  - (a). Open hilly country (i-v).
  - (b). Open swampy country.
  - (c). Jungle (i) Low-lying jungle.
    - (ii) Hilly jungle.
7. Conclusions.
8. Suggestions for malaria prevention.
  - (a). Education of engineers.
  - (b). Swamp filling.
  - (c). "Jungle treatment" of ravines.
  - (d). Drainage of ravines.
  - (e). Methods against *A. umbrosus*.
  - (f). Detection of breeding places.
9. Photographs illustrating breeding places.
10. Plan of district for reference.



## REPORT IV.

### ON THE MALARIA PROBLEM AT GEMAS.

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#### 1. Reason for undertaking the work.

A demand for information on this subject was received from the Principal Medical Officer, Federated Malay States, on account of the difficulty experienced in maintaining a staff at Gemas. The work was watched with interest and was assisted greatly by all the authorities concerned in keeping a staff there, particularly the District Officer, Tampin, and the officials of the Railway.

#### 2. Date of investigation.

The work was done from August 7th to September 4th, 1918.

#### 3. Weather during the investigation.

No rainfall statistics were available; but, preceding and during the first half of the work, there had been very little rain. Many of the small pools and seepage areas were dry therefore, and this affects the results of the field work by minimising the frequency of species which breed in these situations.

#### 4. Amount of malaria.

Spleen and blood examinations were carried out to determine the amount of malaria present. In 132 cases examined the spleen rate was 52.3, the parasite rate was 44.7, and the total incidence rate was 60.6%. These results show that the bad reputation of the district is justified; but the incidence of malaria could be very much higher.

##### (a). RELATION OF INCIDENCE OF MALARIA TO THE SITE OF RESIDENCE.

The results have been analysed according to site of residence in order that some information can be obtained on the relative incidence of malaria in different sites, thus:—

Site I. Rest House hill and Railway quarters by examining the Railway staff.

Site II. Opposite hill and head of valley by examining the Customs, Police, Post and Forest staff.

Site III. Base of valley by examining persons from the new Town site.

The results are shown in the following Table F.

The sites referred to are shown on the accompanying plan, page 48.

TABLE F.  
(1). ADULTS.

Site.	Evidence of malaria				Total cases examined.	Cases with evidence of Malaria.	
	Nil.	Spleen positive.	Spleen and blood positive.	Blood positive.		Total.	Percentage.
I. Railway Quarters ..	20	8	14	7	49	29	59.2
II. Opposite hill and head of valley .. ..	7	6	4	1	18	11	61.1
III. Base of valley, new Town site .. ..	14	7	16	2	39	25	64.1
(2). CHILDREN.							
I. Railway Quarters ..	10	—	8	1	19	9	47.4
III. Base of valley, new Town site .. ..	1	—	6	—	7	6	85.7
Total ..	52	21	48	11	132	80	60.6

The analysis, although the groups are small, shows that the Railway Quarters are freer from malaria than the town, and the quarters on the opposite side of the valley are intermediate between these two sites. In the case of the children, the evidence in favour of the Railway Quarters site is more marked. This, probably, is due to the children being a more delicate test of the amount of malaria, and to the fact that they are more localised to their site of residence and do not visit the other sites at night as much as the adults do.

(b). RELATION OF INCIDENCE OF MALARIA TO PERCENTAGE OF HAEMOGLOBIN.

The haemoglobin percentage, which is a good index of the capacity for work of a population, is closely related to the incidence of malaria. The 41 adults without evidence of malaria had an average haemoglobin of 89.3%, while the 56 cases with evidence of malaria had an average of 79.5%.

The same figures for the children were 86.8% and 65.7% respectively.

## (c). RELATION OF INCIDENCE OF MALARIA TO LENGTH OF RESIDENCE.

When the correlation of incidence of malaria and the length of residence is studied, no relationship can be detected if small groups or small periods are taken. The figures are very discordant and suggest that no connection exists between these factors. It is possible, however, by taking all the cases and arranging them in rather long time-periods to show some kind of orderly progression of the incidence rate. This has been done in Table G.

TABLE G.

Period of residence.	Cases examined.	Cases with evidence of malaria.	Incidence rate.
Up to 3 months .. ..	24	12	50%
From 3 to 6 months .. ..	29	17	58%
From 6 months to 1 year .. ..	18	12	66.7%
From 1 to 2 years .. ..	20	14	70%
From 2 to 4 years .. ..	22	14	63.6%
From 4 to 7 years .. ..	10	6	60%
From 7 to 13 years .. ..	9	5	55.5%
Total ..	132	80	60.6%

This arrangement of the results may be merely juggling with figures; but the fact that such groups can be arranged seems to indicate that the incidence of malaria tends to increase up to the second year of residence and then to diminish.

## 5. Species of anophelines found.

The following Table H shows the frequency with which the various species were found. The species have been grouped according to their characteristic breeding places, and in each group the species usually recognised as dangerous carriers are shown first and marked thus: †. It is wise, however, to regard all the anophelines as possible carriers of malaria.

TABLE H.

Characteristic breeding place.	Species.	Times found.	Specimens.
Small open pools and seepage areas in open hilly country.	<i>A. maculatus</i> † .. .. .	31 (19L)	177*
	<i>A. rossi</i> .. .. .	46	252
	<i>A. kochi</i> .. .. .	24	53
Large grassy pools and streams in open swampy country.	<i>A. aconitus</i> † .. .. .	4	7
	<i>A. fuliginosus</i> † .. .. .	21	170
	<i>A. sinensis</i> .. .. .	69	216
	<i>A. barbirostris</i> .. .. .	90	536
Jungle. In swampy patches of low-lying jungle and along the course of streams in jungle covered ravines.	<i>A. umbrosus</i> † .. .. .	76	542
	<i>A. albotaeiniatus</i> var. <i>montanus</i> .. .. .	37	189
	<i>A. brevipalpis</i> .. .. .	10	23
	<i>A. tessellatus</i> .. .. .	17	25
	<i>A. leucosphyrus</i> .. .. .	20	49
	<i>A. aitkeni</i> .. .. .	42	198
	Total .. .. .	487	2437

\* 18 larvae hatched, all were *A. maculatus*.

† Species usually recognised as carriers of malaria.

## 6. Distribution of anophelines.

The sites referred to by letters are shown on the accompanying plan by the corresponding letters in red.

### (a). OPEN HILLY COUNTRY.

These areas are on either side of the valley; thus the Railway Quarters hill Q, and the Post Office hill P. They are bounded on one side by jungle (marked green in the plan), and on the other by the large swampy areas (marked yellow). The characteristic species of anophelines are the small open pool breeders *A. kochi*, *A. rossi* and *A. maculatus*. The relative infrequency with which these species were found is due to the very dry conditions under which most of the work was done. *A. maculatus* L., probably the most dangerous species, was found only 31 times; but there are many sites in the opened area where it would breed freely in wet weather. That the weather was unsuitable for this species is shown by the fact that 23 larvae of *A. maculatus* were found in a disused kerosine tin, a rather unusual place for it to breed in. It was never found, however, in jungle or secondary growth even when the conditions in the open were so unfavourable for its breeding. The following are the different types of places in which it was found:—

- (i). Seepage areas in the open country especially round the Railway Quarters, Q, and on the Post Office hill, P.
- (ii). Springs at the foot of the railway embankment marked J.
- (iii). Railway cuttings. A good example exists at H, near the new Town site and is shown in Photograph 7.

This kind of breeding place is frequently found along railways at the base of cuttings and embankments†. There is often, as in this case, a mere film of water flowing over sand and algae. The species commonly found is *A. maculatus* because the fresh spring water is a most favourable condition for that species. That this kind of place is dangerous is shown by the fact that cooly lines No. 118 were pointed out by the District Engineer of the Railway as being the most unhealthy of all lines between Gemas and Tampin. Adjacent to these lines was a cutting, shown in photograph 9, from which *A. maculatus* was readily obtained. Here again, as will be seen from the photograph, there is only a slight amount of water.

- (iv). Cuttings on Roads. Breeding places suitable for *A. maculatus* are produced by roads as well as by railways. Roads, however, having a greater choice of gradient, tend to pass above the ground water level in crossing a ridge and not to cut into it to the same extent that a railway has to do. They are therefore not so liable to open seepage areas and thereby tend to be less dangerous to health than railways.

Photograph 8 shows the cutting G on the road near the Town. It is a cutting through the same ridge as the railway cutting H but it is at least 15 feet above its level. It was dry at the time of examination; but there was, however, a green film of dried algae which shows that it would be suitable, probably, for *A. maculatus* in wet weather.

Photograph 10 shows a breeding place of *A. maculatus* in a road cutting L at the mouth of Ravine M.

- (v). Open parts of ravines. Photograph 11 shows a very typical breeding place of *A. maculatus* in a recently opened part of ravine E. This photograph, as also Nos. 7, 9 and 10, is of importance in showing the inconspicuous patches of wet ground which are sufficient for *A. maculatus* to breed in. This point cannot be emphasised too strongly. The assistant is not standing in water, but in rather boggy ground in which a foot mark readily fills with water. Such a place would be passed by most engineers as insignificant and they would pay attention to larger swampy areas which may not be so dangerous. The methods for collecting *A. maculatus* may be described in order to emphasise the point still further.

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† See also pages 20 and 22.

One method is to scoop up wet earth and algae into the examining dish, add water from another source and pick up the larvae as they rise to the surface. Another method is to scoop out a hole in the wet earth, wait till it fills with water and then collect the larvae.

(b). OPEN SWAMPY AREAS.

These areas are indicated in yellow on the plan. The chief ones are along the side of the railway, C and T; the site of the new recreation ground, K; near the new Town site, F; and, in fact, the whole of the floor of the main valley. They are characterised by large open pools and streams with grassy edges, and are not so much affected, therefore, by the dry weather as the small open pools. The predominant species are *A. barbirostris* and *A. sinensis* with which are associated *A. fuliginosus* and *A. aconitus*, the latter probably being active carriers of malaria.

At F, near the new Town site, *A. fuliginosus* was found 4 times in 11 breeding places of *A. barbirostris* and *A. sinensis*.

When the swampy areas adjoined jungle, some intermixing of the characteristic faunae was observed. In these circumstances, *A. umbrosus* and *A. aitkeni* were occasionally found in open swamps, and *A. barbirostris* and *A. sinensis* in swampy jungle; but *A. aconitus* and *A. fuliginosus* were never found in jungle. These swamps will be reclaimed to a large extent in order to make use of the land; but filling will not rank in the same degree, as an anti-malarial measure, as the obliteration of the small inconspicuous places in which, it has been shown, *A. maculatus* breeds.

(c). JUNGLE.

The fauna of flat swampy jungle differs considerably from that of the hilly ravines. This can be shown best by comparing the percentage composition of the 409 specimens obtained from the low-lying jungle of areas A, B and D, with the percentage composition of 295 specimens obtained from the jungle-covered parts of ravines M, O and R. This has been done in the following Table J.

TABLE J.

Species.	Hilly jungle-covered ravines M, O & R.	Low-lying swampy jungle A, B & D.
<i>A. aitkeni</i> .. .. .	41.3%	2.0%
<i>A. albotaeniatus</i> var. <i>montanus</i> ..	39.7%	2.2%
<i>A. leucosphyrus</i> .. .. .	11.5%	.5%
<i>A. tessellatus</i> .. .. .	4.1%	1.7%
<i>A. umbrosus</i> .. .. .	3.4%	93.6%

- (i). Low-lying jungle. The predominant species is seen from Table J to be *A. umbrosus*. The frequency with which it was encountered can be seen from Table H. This is the first time that this species, to which Dr. Watson attaches so much importance on the coast, has been found in bulk so far inland. Previous observers† have regarded this species as limited to the coastal plain and this observation is important in showing that it does exist in its appropriate breeding places as far inland as Gemas which is over 30 miles from the sea. Moreover the observation is not an isolated one, (see page 12), it has been found also in the Gardens area of Kuala Lumpur in ravines still under jungle.

*A. tessellatus* is found in about the same percentage in both kinds of jungle; but *A. aitkeni*, *A. albotaeniatus* var. *montanus* and *A. leucosphyrus* are relatively rarely found in low-lying jungle as compared with hilly jungle.

Apart from artificial clearings, such as wood cutters huts and bathing pools, patches of jungle are killed occasionally by water or silt and this lets in the open swamp breeders. An extremely good example of this is shown in photograph 12. This place is on the right side of the railway near telegraph post No. 342/16. The photograph is taken with the railway behind the camera, and the large open swamp is due to the virgin jungle being killed by water; which has accumulated, probably, because natural drainage from the jungle has been blocked by the railway. The intact low-lying jungle is seen in the back-ground and on both sides of the picture. In the central swamp *A. fuliginosus* and *A. aconitus* were obtained. In the intact jungle these species were not found, but *A. umbrosus*, *A. tessellatus* and *A. brevipalpis* were present. *A. sinensis* and *A. barbirostris* were found in both places, but were more common in the open swamp.

- (ii). Jungle covered ravines. In hilly jungle, as is shown in Table D, the characteristic species are *A. aitkeni*, *A. albotaeniatus* var. *montanus* and *A. leucosphyrus*; but *A. tessellatus* and *A. umbrosus* are found occasionally.

In ravine R, *A. umbrosus* was not found; but all the other species just mentioned were obtained.

In ravines M and O, *A. maculatus* was obtained from opened areas at their bases, and will probably spread in to them if the clearing is not done according to the principles laid down by the Executive Engineer, Malaria Advisory Board.

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† C. W. Daniels. Studies Inst. Med. Research, Vol. III, Part 3, p. 265. C. Strickland, Federal Council paper, No. 15 of 1915, p. 3.

Ravine E is interesting as being an epitome of the distribution of anophelines throughout the district. At its head, E1, *A. aitkeni*, *A. albotaeniatus* var. *montanus* and *A. leucosphyrus* were found. At E2 it broadens out, but is still under jungle, and here *A. umbrosus* was found. At E3 the ravine has been opened, and the small open pool breeders *A. maculatus* (see photograph 11) and *A. kochi* were obtained. The swamp F may be regarded as the base of the ravine and here *A. fuliginosus* was found in association with the large open pool breeders, *A. barbirostris* and *A. sinensis*.

## 7. Conclusions.

- (a). It is of little use, from the anti-malarial point of view, to do extensive filling of swamps if the relatively inconspicuous breeding places of *A. maculatus* are not destroyed at the same time, as *A. maculatus* is probably the most virulent species present.
- (b). The natural conditions were so unfavourable to *A. maculatus* that it was found breeding in an old kerosine tin. In spite of this, however, it was never found in jungle or secondary growth.
- (c). *A. umbrosus* is not necessarily limited to the coastal area, as commonly stated, but may be found plentifully as far inland as Gemas.
- (d). If the opinion of Dr. Watson on the pathogenicity of *A. umbrosus* is justified, the jungle in this neighbourhood cannot be regarded as harmless.
- (e). If, however, the low-lying jungle were to be cut down, *A. aconitus* and *A. fuliginosus* would appear in the open swamps left behind; if jungle covered ravines were to be opened, *A. maculatus* would appear; and the results would almost certainly be worse than the present condition.
- (f). The present site of the Town is not so good as the old site, because:—
  - (i). The incidence of malaria is higher than in either of the other two sites investigated on this point.
  - (ii). It is near extensive breeding places of *A. maculatus* (E 3, G, H and J), of *A. fuliginosus* (F) and of *A. umbrosus* (A, B, D and E 2).
  - (iii). Its low-lying character may make it difficult to treat from an engineering point of view.

## 8. Suggestions for malaria prevention.

- (a). Education of engineers. The engineers in charge of the betterment of the present condition or the further development of the Town should bear in mind the fact that the most dangerous mosquito breeds in most inconspicuous places. The two Railway Engineers who attended the field demonstration were duly surprised at the places shown in photographs 7 and 11, but if this fact is not constantly borne in mind undue attention will be paid to filling and draining swamps.



- (b). Swamp filling. If the above point is kept in view, as much swamp filling as possible is advisable. The filling should be begun at the upper end of the swamp. When it is begun at the lower end, as in two cases noted recently, the filling is saturated with water and breeding is found on its surface; and, moreover, the water is dammed back in the head of the ravine forming suitable breeding places for the large pool breeders.

Care must be taken, also, that in obtaining the material necessary for filling, breeding places suitable for *A. maculatus* are not made. It is quite possible to dig away enough of a hill to expose the ground water level, and thus produce an area of seepage eminently suitable for *A. maculatus*.

- (c). "Jungle Treatment" of ravines as an anti-malarial measure. In further opening of the hill jungle, which is necessary for the development of the place, an attempt might be made to keep the ravines, which contain practically all the water, and therefore all the breeding places, under the original jungle and so prevent the access of *A. maculatus*.

If this measure is adopted, the ravines should be watched very carefully as there is a likelihood of silt from the opened hill-side killing patches of jungle.

The population must be watched, also, lest they make a way down to a bathing place in the ravine. Photograph 13 illustrates this danger very clearly. It shows an open bathing place in a ravine covered by secondary growth and long grass. Throughout the rest of the ravine breeding places were rare, and the only species obtained were *A. barbirostris* and *A. sinensis*; but at the bathing pool, *A. maculatus* L. was found.

- (d). Ravine drainage. If it be decided to drain the ravines, this should be done, as recommended by the Executive Engineer, Malaria Advisory Board, before the jungle is cut down. Photograph 14 shows the wrong method of commencing to drain a ravine; for in the pool by which the assistant is standing, *A. maculatus* was obtained; and it is highly improbable that it existed in such a situation before the vegetation was cut down. (See page 28).
- (e). Methods against *A. umbrosus*. These consist of draining and felling the low-lying jungle, and might well be undertaken since *A. umbrosus* is a proved carrier of malaria. Here again it is advisable to drain the jungle before felling it, as it would be unwise to replace *A. umbrosus* by *A. aconitus* or *A. fuliginosus*.
- (f). Detection of breeding places. In undertaking any work for the improvement of a site or for opening new country, it would pay to have a competent staff for the detection of breeding places. Breeding places detected should be oiled until they can be permanently

eradicated by the engineer. The staff for detection and the staff for treatment of breeding places should be distinct from each other. At the first sign of collusion between the two, one or other should be transferred to a different district. It means hard work and the expenditure of money; but any place, even Gemas, could be opened up without causing malaria; but, if Gemas is opened up in a haphazard manner, the usual out-break of malaria is to be expected.

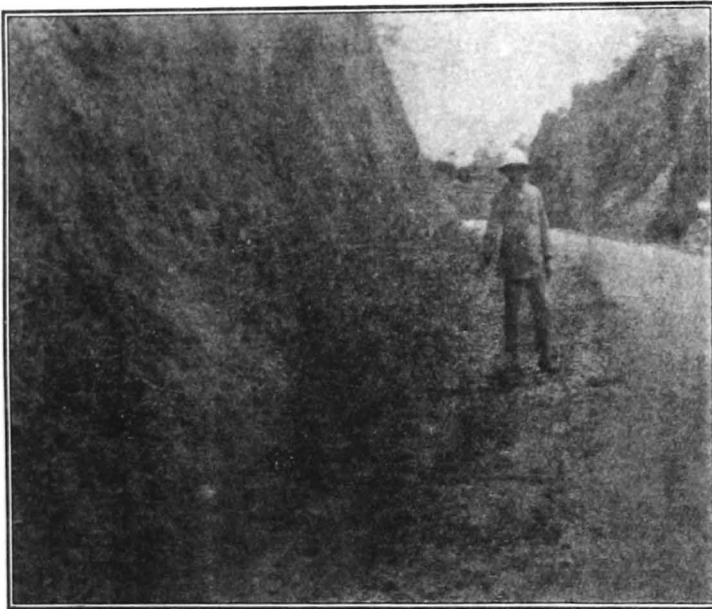
### 9. Photographs illustrating breeding places.

PHOTOGRAPH 7. Railway cutting marked H.



*A. maculatus* L. was found, where the assistant is working, in a thin film of water seeping out of the bank. The fresh clean character of the water renders it suitable for this dangerous species; no actual pool of water is necessary. This type of breeding place is frequently found along the course of railways. (See also pages 20 and 22).

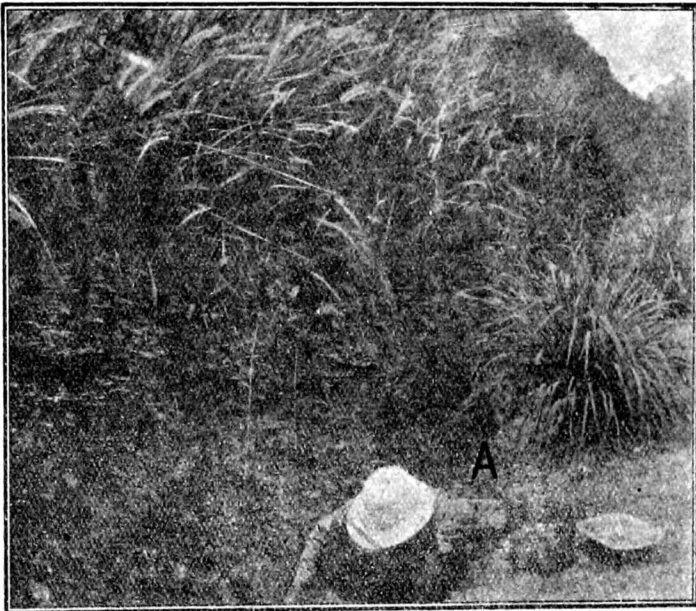
PHOTOGRAPH 8. Cutting on road, marked G.



This cutting is through the same ridge as the railway cutting shown in photograph No. 7. It is over 15 feet higher than the latter cutting and was dry during the investigation. The fact that there were green algae in the side drain shows, probably, that this also would be a favourable site for *A. maculatus* in wet weather.

Photographs 7 and 8 illustrate the fact that roads are less liable than railways to produce breeding-places for *A. maculatus* although both tend to do so.

PHOTOGRAPH 9. Railway cutting near cooly lines No. 118, about 4 miles from Gemas.



Cooly lines 118 were pointed out as being the most unhealthy of all between Gemas and Tampin. The cutting shown in the photograph is adjacent to these lines, and *A. maculatus* was obtained readily in the trickle of water shown at A, in the photograph. This illustrates the danger of cuttings in which the slightest amount of seepage is allowed to remain open.

PHOTOGRAPH 10. Roadside cutting marked L.



*A. maculatus* was obtained here, which shows that roads are not free from the responsibility of opening seepage areas.

This breeding place is situated at the mouth of the jungle covered ravine M in which nothing but jungle species of anophelines were found. It would form a source from which *A. maculatus* could spread into the ravine, if the ravine is opened without proper precautions.

PHOTOGRAPH 11. Opened part of Ravine E marked E 3.



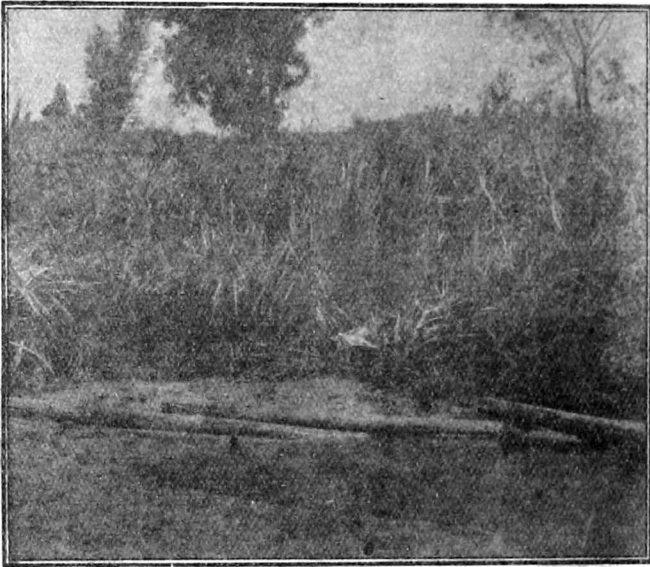
The assistant is standing in a boggy patch of ground from which many larvae of *A. maculatus* were obtained at the time the photograph was taken. This photograph illustrates the inconspicuous nature of the wet ground which is sufficient for *A. maculatus* to breed in.

PHOTOGRAPH 12. Patch of jungle killed by water, about 8 miles from Gemas.



This is an example, on a large scale, of what is often seen in jungle; that is, an open patch which is too wet for the growth of jungle. In the open swamp, the malaria carriers *A. aconitus* and *A. fuliginosus* were found. In the surrounding jungle these species were not present; but *A. umbrosus*, *A. tessellatus* and *A. brevipalpis* were found. In both places *A. barbirostris* and *A. sinensis* were obtained but these species were more common in the open. If jungle is kept as a precautionary measure against malaria, care must be taken that no open patches like this are formed by stagnation of water or by deposition of silt.

PHOTOGRAPH 13. Bukit Kiara Estate, Kuala Lumpur, bathing place in a ravine.



This photograph indicates another precaution that must be taken if the anti-malarial measure consists in preserving the natural shade over water in a ravine. *A. maculatus* L. was found in this open bathing place. The rest of the ravine was covered by secondary growth and long grass, the only other species found being *A. sinensis* and *A. barbirostris*, and these but rarely.



PHOTOGRAPH 14. Newly felled ravine.

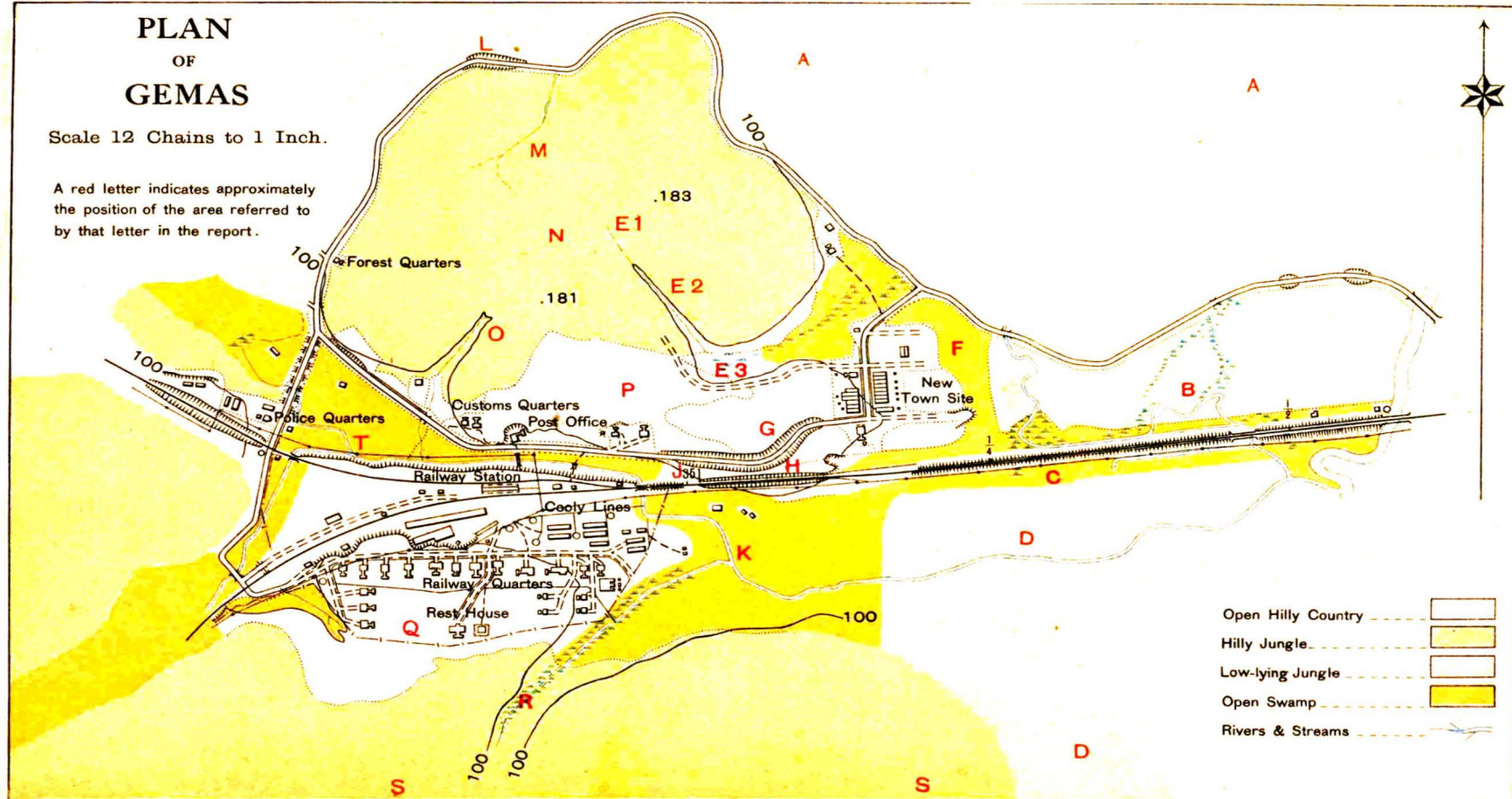


This photograph shows the wrong way to commence draining a ravine. *A. maculatus* was found in the pool by which the assistant is standing, a place in which it is most improbable that it existed before the vegetation had been cut down. If the ravine had been drained before the general cutting down of the vegetation, as is so strongly advocated by the Executive Engineer, Malaria Advisory Board, it is possible that *A. maculatus* might never have been found in the ravine.

# PLAN OF GEMAS

Scale 12 Chains to 1 Inch.

A red letter indicates approximately the position of the area referred to by that letter in the report.



## REPORT V.

### On the Malaria Problem at Gemas, March, 1919.

1. Reason for the investigation.
2. Date of investigation.
3. Effect of felling jungle.
  - (a) In ravines.
  - (b) Low-lying jungle.
4. Effect of oiling in ravines and streams.
5. Effect of oiling in open areas.
6. Miscellaneous observations (*a* and *b*).
7. Mode of action of oil.
8. Conclusions and suggestions for malaria prevention (*a—h*).

NOTE—The letters used in this report to denote areas are the same as those used on the plan accompanying Report IV.

## REPORT V.

### ON THE MALARIA PROBLEM AT GEMAS.

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#### 1. Reason for the investigation.

Since the first report, dated October, 1918, containing observations made from August 7th to September 14th, much jungle clearing and earth work had been done. It was to determine the effect of this work upon the mosquito breeding, and to test the efficiency of the oiling that had been undertaken to counteract the breeding places unavoidably made during the clearing, cutting and filling, that the observations now reported were made.

#### 2. Date of investigation.

The field work was done from February 4th to 8th, 1919, in rather dry weather; but no rainfall records are available.

#### 3. Effect of felling jungle.

##### (a). IN RAVINES.

Most of the jungle in the ravines had been felled; but the timber had not been cleared away and a very remarkable change in the anophe-line fauna had occurred, which will be seen from the following table K in which the results obtained from the ravines when under jungle are compared with the results obtained from the same areas after the jungle had been felled.

TABLE K.

(1) Unopened jungle Aug: 7th to Sep: 4th, 1918.	Breeding places found.								
	Jungle species.					Open species.			
Ravine.	<i>A. umbrosus.</i>	<i>A. alboataeniatatus</i> var. <i>montanus.</i>	<i>A. leucosphyrus.</i>	<i>A. tessellatus.</i>	<i>A. aitkeni.</i>	<i>A. barbirostris.</i>	<i>A. sinensis.</i>	<i>A. kochi.</i>	<i>A. maculatus</i> L.
Ravine M .. ..	1	5	2	1	5	—	—	—	—
Ravine O .. ..	1	1	3	3	3	—	—	—	—
Small ravine below Railway Quarters .. ..	—	—	—	—	—	—	—	—	—
Ravines drained by culvert No. 1450 K. L. line ..	13	1	2	2	6	1	—	—	—
Total ..	15	7	7	6	14	1	—	—	—
(2) Opened Jungle Feb. 4th to 8th, 1919.									
Ravine.									
Ravine M .. ..	—	—	—	—	—	—	4	—	2
Ravine O .. ..	—	—	—	—	3	—	12	—	6
Small ravine below Railway Quarters .. ..	—	—	—	—	—	—	—	1	3
Ravines drained by culvert No. 1450 K. L. line ..	—	—	—	—	—	—	6	—	1
Total ..	—	—	—	—	3	—	22	1	12

The almost complete disappearance of the jungle species and the universal entry of *A. maculatus* L. is typical of what has been observed elsewhere (see page 28) and shows the danger of opening ravines, since *A. maculatus* is a most dangerous species of anopheline.

That this change of fauna is due to the felling of jungle is shown by certain control observations on ravines which had not been opened.

Thus, in ravine E, of which only a small part containing no breeding places had been opened, the following species were found:

## PRECEDING VISIT.

*A. albotaeniatus* var. *montanus*.  
*A. aitkeni*.  
*A. umbrosus*.  
*A. leucosphyrus*.

## PRESENT VISIT.

*A. albotaeniatus* var. *montanus*.  
*A. aitkeni*.  
*A. umbrosus*.  
*A. sinensis*

And in ravine R, *A. aitkeni* and *A. albotaeniatus* var. *montanus* were still found in its unopened head, while there were 4 breeding places of *A. sinensis* at its opened base.

## (b). LOW-LYING JUNGLE.

A portion of the swampy jungle of area D had been felled, with a result that *A. umbrosus* was not found this time in that area, its place being taken by *A. barbirostris*. Later, as grass grows in the swamp, the swamp carriers *A. aconitus* and *A. fuliginosus* may be expected here.

An area at the head of the valley, formerly under somewhat sparse secondary growth, has been opened as a Chinese vegetable garden and pig farm. The area opened consists mainly of flat swamp but it extends on to the neighbouring hillside. This area was not examined on the previous visit; but on the present occasion the following species were found:—

<i>A. maculatus</i> L.	..	..	..	in 5 places.
<i>A. rossi</i>	..	..	..	in 3 "
<i>A. kochi</i>	..	..	..	in 5 "
<i>A. sinensis</i>	..	..	..	in 8 "
<i>A. barbirostris</i>	..	..	..	in 1 place.

The frequent presence of *A. maculatus* on this newly opened area makes the area dangerous especially to the new Customs Quarters which are adjacent.

## 4. Effect of oiling in ravines and streams.

Oiling in ravines was done by placing on the course of the stream a can of oil from which a continuous drip was obtained by means of a wick. The apparatus was devised by Mr. G. S. Helps and was extremely efficient. The cans were examined at every opportunity and were never found to have stopped dripping. This method of oiling, however, was not effective as will be seen from the results shown in table K.

The chief causes of its failure were as follows:—

## (a). THE OIL NOT BEING PLACED AT THE VERY HEAD OF THE RAVINE.

The importance of this defect in the method lies in the fact that the spring at the head of an open ravine is a favourite site for *A. maculatus* to breed in. The defect was most marked in Ravine O where 3 breeding places of *A. maculatus* were found above the origin of the oil.

## (b). RETENTION OF OIL BY VEGETATION AND FLOATING DEBRIS.

Larvae were never found in the pool into which the oil actually fell although there might be vegetation and debris in it. In the debris-strewn ravines, larvae were obtained within a few yards below the origin of the oil, whereas in the more open streams the best results of the continuous dripping were seen; and photograph 15 shows a place about 50 yards from the source of oil which was the first place at which larvae were obtained. The larvae are present because the oil is held back by floating debris, allowing the under flow of water, and not spreading satisfactorily into all the pools. The fact that the investigation was done in dry weather probably leads to an under-estimation of the efficiency of the method as the flushing due to rain would tend to spread the oil more evenly.

A good example on a large scale of this holding back of the oil is shown in photograph No. 15 which was taken from the Kuala Lumpur line looking towards the extensive cutting and filling at the foot of the hospital site which is seen in the back-ground.

PHOTOGRAPH No. 15.



In the main stream in the foreground no larvae were obtained despite the heavy vegetation on the banks, although in the next pool about 10 yards to the right of the photograph, larvae of *A. sinensis* were found. In the centre of the photograph, where the assistants are standing, a small side pool, the colour of which was quite different from that of the oiled area, was protected from the oil by the floating log. In this pool, *A. sinensis* and *A. kochi* were found.

- (c). INABILITY OF THE OIL TO REACH SEEPAGE AREAS ON THE BANK OF A STREAM. The seepage areas on the bank above a stream are especially dangerous as a source of *A. maculatus* and are out of reach of oil applied by this method. This factor is well shown in photograph No. 16 taken in the small ravine below the Railway Quarters.

PHOTOGRAPH No. 16.



In the foreground a stream is seen heavily oiled by the waste oil from an open seepage drain; but on the bank are springs from which the assistant is collecting *A. maculatus*.

##### 5. Effect of oiling in open areas.

The method of oiling used here was the constant drip-feed in drains from seepage, and also individual oiling of seepage areas and pools.

###### (a). SEEPAGE FROM HILLSIDES.

This was extremely efficiently dealt with, and no larvae were obtained in the oiled area. The seepage among the Railway Quarters was caught in a contour drain which was oiled by two constant drip feeds, the waste being conducted into the ravine on either side of the hill.

As a control observation, the seepage from the hillside in the newly opened vegetable garden, which is just outside the oiled area, gave 5 places breeding *A. maculatus* L.



## (b). PERMANENT RAILWAY CUTTINGS.

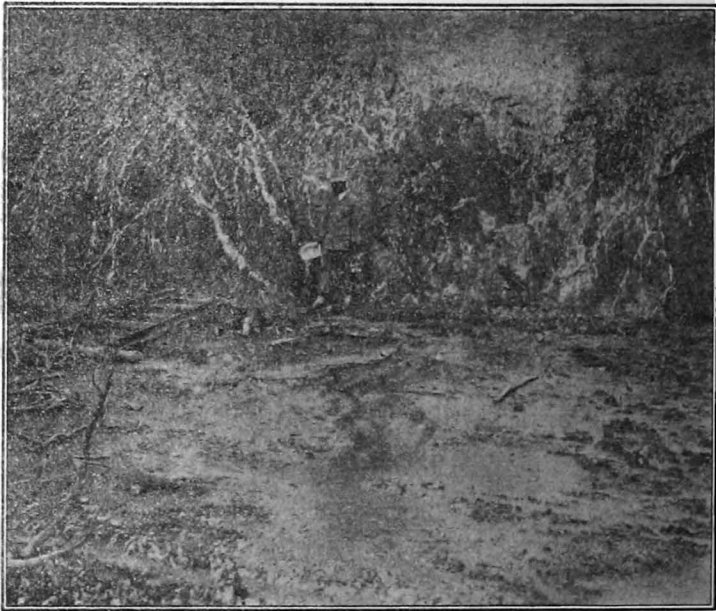
The danger of these cuttings breeding *A. maculatus* was pointed out in the first report, and the two main cuttings, the one on the Singapore line and the first on the Bahau line, had been well oiled and no larvae were obtained.

As a control observation, the two smaller cuttings on the Bahau line (T. P. O/13—O/19) were breeding *A. maculatus* L. profusely, and the road cutting L was breeding *A. maculatus* L. much more extensively than on the last visit; these places being outside the oiled area.

## (c). CUTTING AND FILLING.

A very great deal of earthwork had been done, and the Railway Authorities deserve credit for having accomplished this without causing a severe outbreak of malaria. Photograph No. 17 is taken at the foot of the new hospital site, and shows an area of seepage from this new earthwork.

PHOTOGRAPH No. 17.

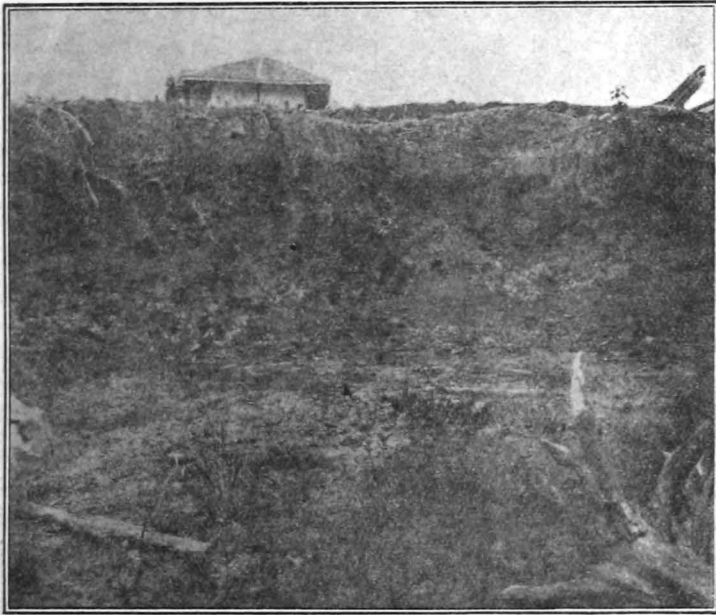


Seepage from newly cut bank. No larvae were obtained here although the fresh spring water makes the place most suitable for *A. maculatus*. Oil was applied daily to the freshly exposed surfaces.

There were a large number of such places which are most favourable for *A. maculatus*; but they had been oiled and no larvae were obtained in the oiled area. The fact that the examination was made in dry weather probably leads to an over-estimation of the efficiency of the methods of oiling used, as in wet weather there would be many more areas of seepage and the oil would be washed away more

quickly than in dry weather; but this furnishes a most satisfactory result of oiling. As a control observation photograph No. 18 shows a similar area in the cutting and filling done by the Public Works Department near the town.

PHOTOGRAPH NO. 18.



No oiling was done here, and *A. maculatus* L. and *A. rossi* were found.

#### 6. Miscellaneous observations.

- (a). An empty tin in the Chinese-owned vegetable garden was found to be breeding *A. maculatus* L. The presence of anopheline larvae in disused tins is unusual, and in this instance may be due to the natural breeding places being reduced in number by the oiling and dry weather; but the tin was found outside the oiled area.
- (b). *A. maculatus* L. was found twice in shallow earth wells or bathing pools, once in the Chinese vegetable garden and once by the first railway cutting on the Bahau line. The latter well was closed by the Railway Authorities within 12 hours of the discovery of the breeding.

#### 7. Mode of action of oil.

The absence of larvae from pools which had by no means a complete film of oil raises the doubt whether the oil acts merely mechanically by preventing the larvae having access to air. Photograph No. 19 shows a good example of an incomplete film.



The assistant is examining the part of this rather deep seepage pool which is free from oil, but no larvae were found.

In a deep pool like this the oil is usually found near the bank owing to the undercurrent of water impinging first on the further side; but in a shallow pool the oil is usually found on the further side, being carried by the flow of water from the side nearer the bank. In either case, the tendency of the water current is to carry the larvae into the oil. Certain preliminary experiments on this subject seem to indicate that oil acts chiefly by blocking the breathing tubes of individual larvae and depends on the larvae merely coming in contact with the oil, so that it is more important to have some oil in every pool than to attempt to get a uniform film. When the necessary apparatus is available, it is hoped to work out this problem in detail and to issue a report on the mode of action of oil and the best methods of applying it.

#### 8. Conclusions and suggestions for malaria prevention.

- (a). The oiling in open areas is extremely efficient and the Railway Authorities deserve credit for having done so much earthwork without causing any breeding in the area of operations. Dangerous breeding was found, however, in the cuttings and seepage areas outside the region protected by the Railway Authorities, particularly was this so in the cuttings on the Railway and on the Circular Road, the newly opened vegetable gardens and the cutting and filling operations near the Town. The area of oiling should be extended,

therefore, to include these areas, the present position of the Railway Administration being similar to that of an estate in the neighbourhood of a newly-opened area, village, or other estate in which no anti-malarial measures are being taken. Where this occurs it pays, as in several cases known to the Bureau, for the person undertaking anti-malarial measures to extend them, if possible, on to his neighbour's ground at his own expense.

- (b). The oiling acts, not so much by preventing the larvae reaching the air, as by blocking the breathing tubes of individual larvae, and therefore a perfectly continuous film is not so essential as the presence of some oil in every pool. As extensive a film as possible is advisable, however, as the chances of the larvae coming into contact with the oil are greatly favoured by increasing the extent of the film of oil.
- (c). The effect of felling jungle in the ravines is to allow *A. maculatus* and *A. sinensis* to enter into places where purely jungle species existed previously. The present condition of the ravines is, therefore, more dangerous than the original condition.
- (d). The method of oiling used in the ravines is inefficient because the oil is held up by vegetation and debris and moreover cannot reach the dangerous areas of seepage on the banks of the stream. The encumbering timber should be removed, therefore, from the ravines as quickly as possible. The courses of the streams should be defined and oiled by a constant drip feed placed at their very source, and the pools and seepage areas, rendered evident by the removal of timber, should be oiled by hand in the same way as similar places in the open area have been dealt with. The oiling should be commenced at once but it cannot be done efficiently until the ravines have been cleared of timber.
- (e). The newly opened Chinese vegetable garden and pig farm is a source of *A. maculatus* L. and is therefore a danger to the adjacent Custom Quarters. Licences issued in future should be subject to the condition that any measures necessary for malaria prevention may be carried out without entitling the licensees to compensation.
- (f). *A. maculatus* L. was found in a disused tin. Empty tins and artificial collections of water should be cleared up, mainly with a view to reducing mosquito nuisance, but also to preclude the possibility of these receptacles being used as breeding places by dangerous species. Much work of this kind has been accomplished by the Railway Authorities.
- (g). *A. maculatus* L. was found twice in shallow earth wells or bathing pools. These are therefore a source of danger and should be watched, especially those at hillfoots, and closed or oiled if found to be breeding *A. maculatus*.

- (h). If it had been possible to place a working party at Gemas for detection and identification of larvae, as suggested in the first report, (see suggestion (f.), page 39) the dangerous condition of the ravines would have been detected much earlier. This very advisable measure is impossible to carry out when only one man is appointed to undertake the investigation of malaria throughout the Federated Malay States.
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#### **Note on mode of action of oil.**

The experiments on oiling referred to in this report indicate that a complete film is by no means necessary in order to kill larvae but that mere contact with oil is sufficient to destroy them. Momentary contact with fresh oil will doom a larva to death in spite of washing it free from oil and keeping it in fresh water; but the oil loses this activity very markedly when it is left in contact with water. These results may explain the remarkable success of the oiling at Gemas since fresh oil was used either as a continuous drip or daily applications to the new cuttings without any attempt to cover the pools with oil, because it is not rare to find larvae in comparatively well oiled pools in which oiling is done weekly or at longer intervals.

Experiments on the mode of action of oil and on the cause of the loss of activity are being proceeded with and may afford evidence as to the best method of applying oil. These experiments will be described in detail in the next volume.

## REPORT VI.

### On the Malaria Problem at Perhentian Tinggi, July, 1919.

1. Reason for the investigation.
2. Date of examination.
3. Weather during the examination.
4. Amount of malaria.
5. Breeding places of anophelines found.
6. Adult mosquitos caught in houses.
7. Distribution of anophelines.
  - (a). Jungle.
  - (b). Secondary growth.
  - (c). Open areas.
8. Observations on previous anti-malarial work.
  - (a). Subsoil drains.
  - (b). Minor filling on Perhentian Tinggi Estate.
  - (c). Oiling.
  - (d). Screening.
9. Conclusions and suggestions for malaria prevention (a—e).
10. Plan of area for reference.

## REPORT VI.

### ON THE MALARIA PROBLEM AT PERHENTIAN TINGGI.

#### 1. Reason for the investigation.

A request was received from the Railway Authorities for an investigation of the conditions at Perhentian Tinggi on account of the difficulty of maintaining a staff there.

#### 2. Date of examination.

The field work was done from March 13th to March 26th, 1919.

#### 3. Weather during examination.

The weather during and preceding the examination was very wet, the rainfall on Perhentian Tinggi Estate being:—

March 1st—10th	.. ..	11.14 inches.
March 11th—20th	.. ..	6.79 inches.

This leads probably to an under-estimation of the breeding that occurs in ordinary wet weather in the railway drains and cuttings, and a slight over-estimation of the breeding in ravines, because the railway drains would tend to be cleared by the frequent heavy rains.

#### 4. Amount of malaria.

Six members of the Government staff were available for examination, out of the 7 who usually reside there. The length of residence varied from 2 months to 2 years. Five out of the six cases showed enlargement of the spleen, and two showed parasites in the blood, the species being quartan. It is of interest to note that the type of fever contracted by the Medical Entomologist on this excursion was also quartan.

#### 5. Breeding places of anophelines found.

Two hundred breeding places were found and examined in the area round the station from T. P. 295/16, culvert No. 1219 to T. P. 296/13, culvert No. 1227 and the intervening ravines, this area being shown on the plan attached.

The following table L shows the species found and their relative frequency:—

TABLE L.

Species.	Times found.	Specimens.	
		Larvae.	Adults.
Larvae of <i>A. maculatus</i> or <i>A. karwari</i>	147	954	113*
<i>A. kochi</i> .. .. .	39	113	5
<i>A. rossi</i> .. .. .	18	61	7
<i>A. sinensis</i> .. .. .	19	111	5
<i>A. aitkeni</i> .. .. .	6	25	2
<i>A. tessellatus</i> .. .. .	2	3	—

\* Of these 113 adults, 110 were *A. maculatus* and 3 *A. karwari*. The *A. karwari* were obtained from two places on the railway, all the hatchings from the ravines being *A. maculatus*.

It is obvious from this table that the dangerous species *A. maculatus* is by far the most prevalent species in this area.

#### 6. Adult mosquitos caught in houses.

Fifteen adult mosquitos were caught in houses being:

<i>A. maculatus</i>	..	13
<i>A. rossi</i>	.. ..	1
<i>A. aconitus</i>	..	1
		—
		15
		—

The predominance of *A. maculatus* is again manifest. One of this species was found to be infected with parasites. The specimen contained two oöcysts fully differentiated into sporozoites. The breeding place of *A. aconitus* was not found; but it probably breeds in the same places as the *A. sinensis* shown in Table L, because these two species are often found together.

#### 7. Distribution of breeding places.

The station stands at the summit of a pass in country very broken up by ravines, in fact, the Malay words *perhentian tinggi* mean "the high stopping place."

##### (a). JUNGLE.

There is no jungle in the immediate vicinity; but the original anopheline fauna of the neighbourhood may be studied in the jungle at the foot of Gunong† Angsi and along the Seremban Road. In this jungle the following species were found:—*A. aitkeni*, *A. leucosphyrus*, *A. albotaeniatus* var. *montanus* and *A. novumbrosus*.

The first three of these have been shown to be typical of hill land jungle. (See page 36).

##### (b). SECONDARY GROWTH.

A part of the ravines is covered with somewhat sparse secondary growth and it is from these places that the *A. aitkeni* and *A. tessellatus* shown in Table L were obtained. The places in which these species were found are shown by the letters A, B and C on the accompanying map. The secondary growth was not dense and uniform enough to exclude the light-loving species *A. maculatus*, because this species was found in every ravine.

##### (c). OPEN AREAS.

The greater part of the country consists of open ravines with streams and many springs and seepage areas. *A. maculatus* was found in all the ravines shown on the plan; but the greatest concentration of breeding places was found in ravine D almost opposite the station; where, in the shallow earth drains and along the foot of the railway embankment crossing the ravine, 17 breeding places of *A. maculatus* (12 L.) were found. The drains in this ravine receive the factory waste from the Perhentian Tinggi Factory; but the presence

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† The Malay word *gunong* signifies mountain.



of this was not sufficient to eliminate breeding. Along the course of the Railway are various cuttings the dangerous nature of which has been pointed out†. The chief cuttings are shown on the plan as E, F, G and H. Of these cutting F, the one behind the station, is the most dangerous as there is a spring of fresh water in which *A. maculatus* L. was found to be breeding extensively. Cutting E was breeding *A. maculatus* in many places, some in the side drain of the Railway and others up the bank of the cutting. Cutting G was peculiar in that the species found was mainly *A. rossi*, instead of the usual *A. maculatus*, and will be dealt with in detail later in this report. Cutting H was dry at the time of examination. Of the 200 breeding places examined, 55 were found on the Railway and 145 in the ravines. The proportion of those breeding *A. maculatus* was high and about equal in the two situations, being 60% on the Railway and 78.6% in the ravines. This high percentage depends on the configuration of the country, and is probably the cause of the bad reputation of the place.

The small muddy pool breeder *A. rossi* was found in 29% of the places on the Railway and only 1.3% of the places in the ravines, whereas the small grassy pool breeder *A. kochi* was found 12.7% on the Railway and 22% in the ravines.

## 8. Observations on previous anti-malarial work.

### (a). SUBSOIL DRAINAGE.

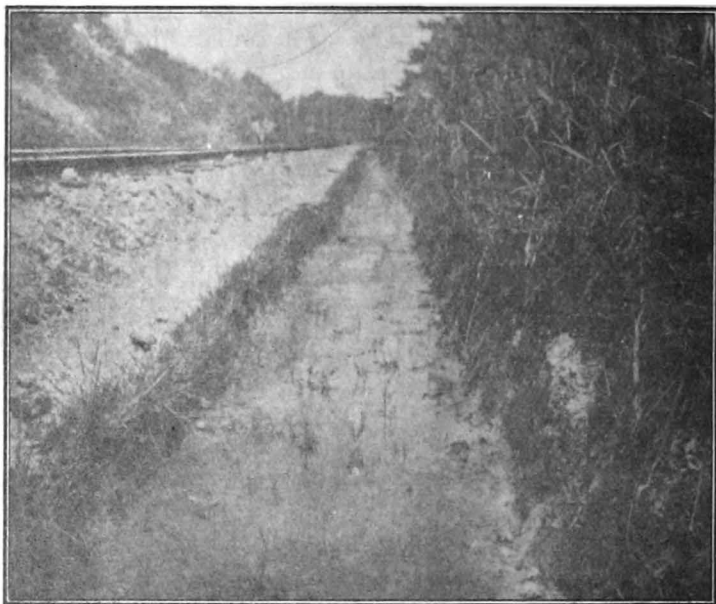
In 1912 some subsoil drainage was carried out, namely, the side drains of the Railway along cutting G and extending into the neighbouring ravines. The banks of this cutting contain in certain parts a kind of fine clay and this caused a most interesting condition. The clay was washed out of the bank and deposited on the surface of the drain sealing the surface and producing stagnant pools of water.

On digging up some of the pipes it was found that the flow of water through them was good and that after 6 years use the only effect in the pipe was a layer of silt 2 inches deep which did not interfere with the flow of water.

The stagnation of water on the surface was due solely to the surface film of clay, because on removing a portion of this film so as to expose the underlying clean sand, the pools drained so rapidly that a little whirlpool was seen at the cleared spot. Photograph No. 20 shows the original condition of a stagnant drain with some of the whitish clay outcropping on the bank of the drain. Photograph No. 20a shows two small holes dug through the layer of clay and the resultant drying up of the drain. Photograph No. 21 shows a small stagnant pool in the drain, and Photograph No. 21a shows the result of digging a hole through the clay.

† See pages 20 and 22, 35 and 42.

PHOTOGRAPH No. 20.



Showing a stagnant condition of drain due to a layer of clay on the surface. The origin of this clay can be seen on the right bank of the drain.

PHOTOGRAPH No. 20a.



Showing the condition of the drain a quarter of an hour after two small holes had been dug through the layer of clay. The subsoil pipe was acting well, therefore, but the water was prevented from reaching it by the impervious surface layer.

PHOTOGRAPH No. 21.



Showing a small stagnant pool in which larvae and pupae of *A. rossi* were found.

PHOTOGRAPH No. 21a.



Showing the effect of digging a hole through the impervious surface layer of clay deposited in the drain from the bank.

Although these pools were breeding places, the water was stagnant and the species present differed very much from the species found in pools in which the water was always being drained away and replaced by a new flow of water. The difference is shown in Table M in which the findings of 17 breeding places in this clay area are compared with those of the remaining 38 places found along the rest of the Railway.

TABLE M.

Species.	Percentage of times found in clay area.	Percentage of times found in the rest of the railway.
<i>A. rossi</i> .. .. .	50.0	7.3
<i>A. kochi</i> .. .. .	19.2	4.9
<i>A. sinensis</i> .. .. .	15.4	14.6
<i>A. maculatus</i> .. .. .	15.4 (L 7.5)	65.9 (L 51.3)
<i>A. karwari</i> .. .. .	—	7.3

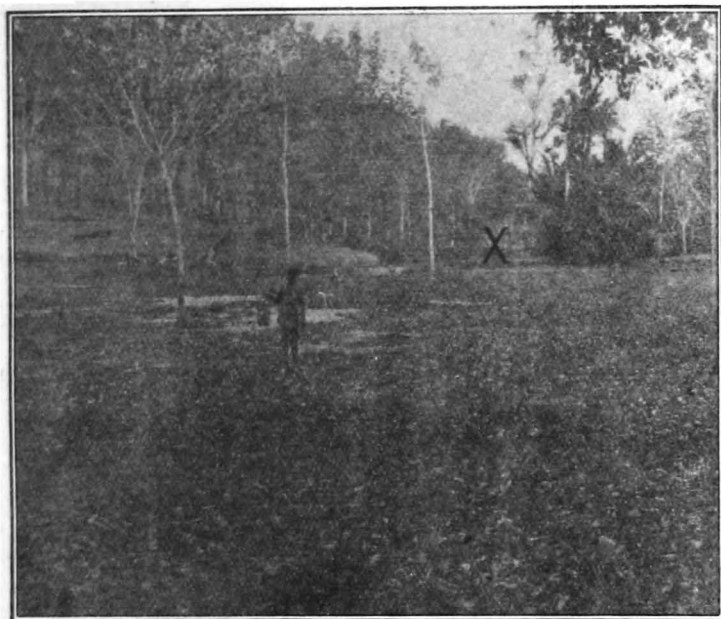
It is at once seen that the characteristic species of the stagnant pools is *A. rossi*, whereas the characteristic species of the rest of the railway is the much more dangerous *A. maculatus*.

(b). MINOR FILLING ON PERHENTIAN TINGGI ESTATE.

The lower end of ravine J is close to the cooly lines and hospital of Perhentian Tinggi Estate and the Manager, Mr. J. D. McCulloch, kindly demonstrated what had been done in 1918 to this ravine.

Photograph No. 22 shows a view of the ravine looking from the cooly lines.

PHOTOGRAPH No. 22.



Originally the foreground was swamp fed by a stream which entered on the right of the photograph. A channel for this stream was cut along the hillfoot in the background and the stream diverted into this channel by the small bund marked X.

The swamp was then levelled and filled in with the spoil from the new stream bed. This work was still unfinished and being continued, as will be seen from the newly laid patches of sand and gravel in the photograph. It is intended to go on filling in this way wherever a patch of wet ground is detected.

A survey of this recently filled area gave 14 places with *A. kochi*, 1 place with *A. rossi* and 1 place with *A. maculatus*. This fauna is a very characteristic one as *A. kochi* is a species which likes small open, grassy pools, indeed the photograph may be taken as illustrating the typical habitat of this species.

In the stream, only one place breeding *A. maculatus* L. was found; but owing to the rainy weather the stream was fairly full with an even flow of water. In dry weather more breeding of *A. maculatus* is to be expected, as was found in the stream at Tarentang<sup>1</sup>, owing to the formation of bays, islands, and pools along its course. The main interest of this survey was the finding of three artificial breeding places, namely, empty tins scattered from the cooly lines. In two cases the species present was *A. kochi*, and in one *A. maculatus*. The rarity with which anophelines are found in artificial breeding places has been emphasised<sup>2</sup>, and this being an example of rapid

<sup>1</sup> See Tarentang Estate, Malaria Bureau Annual Report 1918, page 6.

<sup>2</sup> See Artificial Breeding places, Malaria Bureau Annual Report 1918, page 4.

recent obliteration of natural breeding places suggests that the anophelines are being driven into less congenial domestic breeding places; but there may be another explanation of the phenomenon.

(c). OILING.

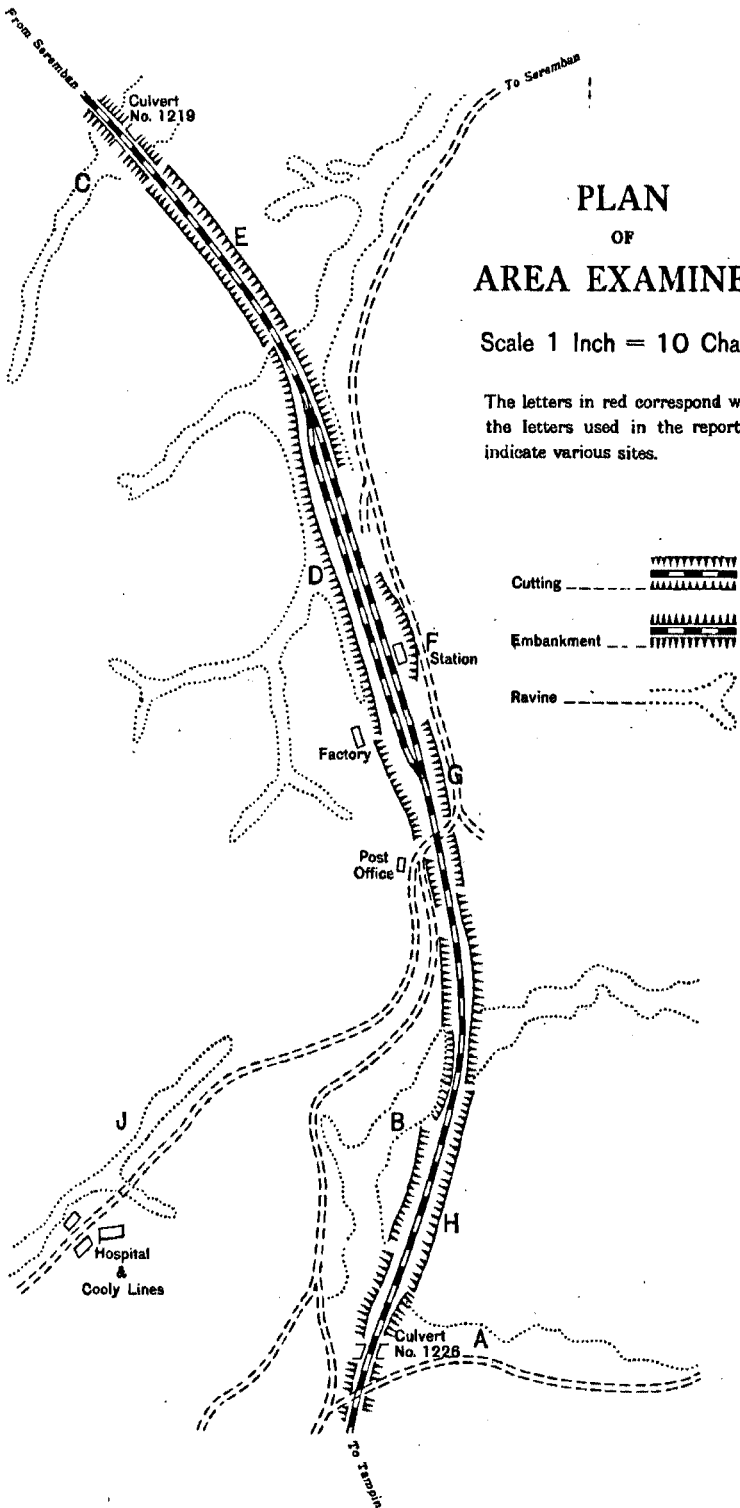
No oil was encountered during the field work; but in ravine D two dis-used drip cans were found.

(d). SCREENING.

One room at the Post Office Quarters had wire gauze over the door and window. This was effective as far as it went, but was not extensive enough as the occupant only used the room for actually sleeping in, and the verandahs and living room were unprotected.

9. Conclusions and suggestions for malaria prevention.




- (a). *A. maculatus* has been shown to be widely prevalent over the area in the streams, springs and seepage areas which abound in country so broken up by ravines. The eradication of this species from an area so abounding in breeding places suitable for it would be extremely difficult, and it is doubtful whether the expenditure would be justified in order to protect a labour force of 6 persons.
- (b). The most dangerous places have been shown to be ravine D, and the cutting behind the station F. These areas are close to the station and the destruction of breeding places here might be advisable.
- (c). It has been shown that the surface of the side drains of the Railway in cutting G tends to become sealed by a layer of clay with the production of stagnant pools. The remedy is easy, since directly the surface film is broken up the water is rapidly removed by the sub-soil drain.
- (d). In the recently filled ravine J, anophelines were found in no less than three empty tins. The rarity with which anophelines are found in artificial containers of water suggests that here it is due to the recent destruction of the many natural breeding places and raises the question whether anophelines may not become domesticated by this means. There may be, however, quite a different explanation of this occurrence for in well drained areas it is extremely rare to find the breeding in artificial receptacles, which would occur if the first hypothesis were true.
- (e). The protection of a small population, in an area where anopheline eradication is considered to be too costly, depends on the provision of efficient screening and whitewashing of the quarters and medical supervision of the inhabitants. The screening, to be effective, should include the whole house, both verandah and living rooms. When this is done, the onus of maintaining health by keeping regular hours and taking good food can be placed upon the individual.

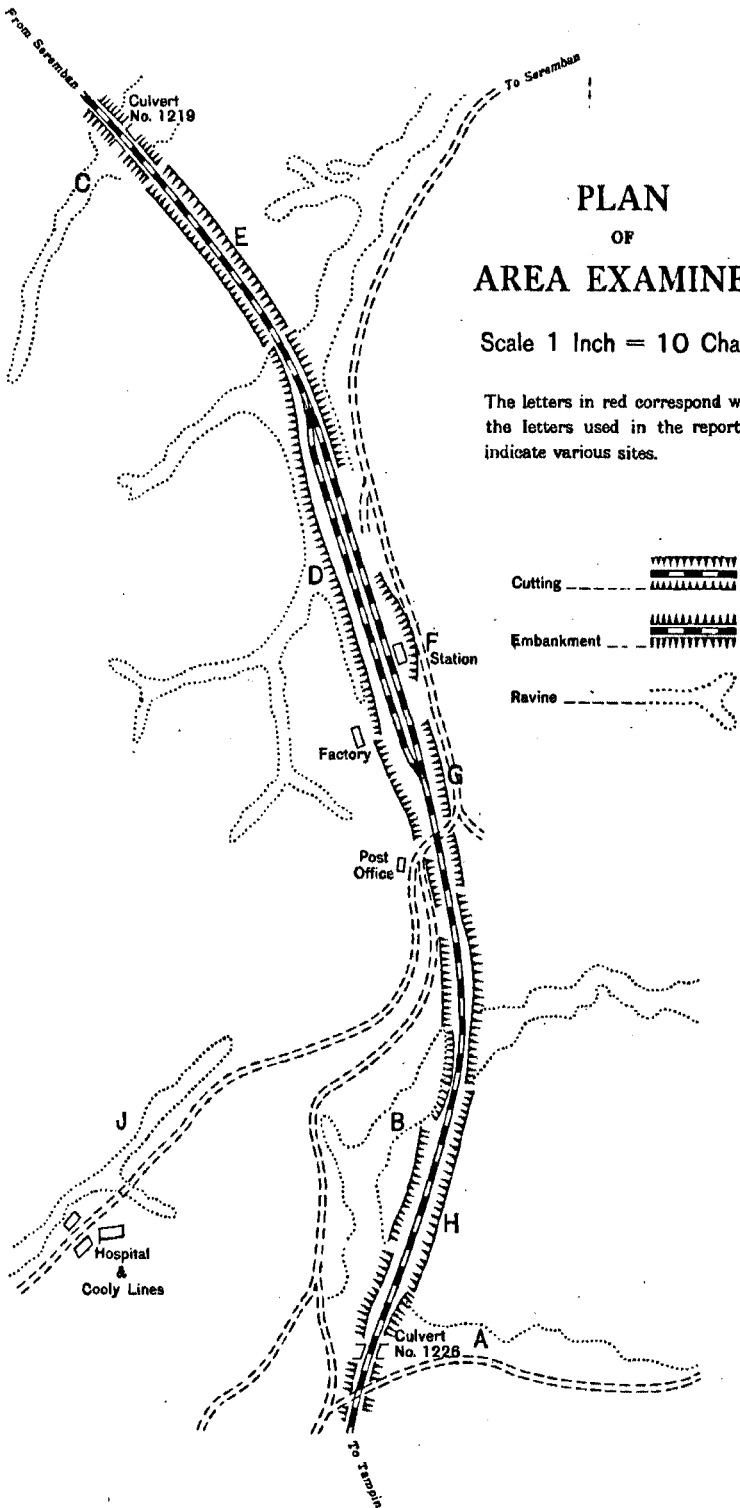


# PLAN OF AREA EXAMINED

Scale 1 Inch = 10 Chains.

The letters in red correspond with the letters used in the report to indicate various sites.

- Cutting  
- Embankment  
- Ravine  



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