ANTIMALARIA REPORT UPON THE PROPOSED CANTONMENT SITE AT KAU LUNG TSAL

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A.—INTRODUCTION.

A malaria survey of the area was commenced in March, 1935, and has since been carried out in detail.

The black line in the map indicates a distance of half a mile from the boundaries of the new cantonment site, as originally proposed, and encloses the area which the Government Malariologist had considered necessary to be dealt with in order to obtain efficient malaria control.

The dotted line indicates a distance of half a mile from the boundaries, marked in black, of the new cantonment site, as now proposed.

The malaria survey has been extended to include fresh ground, lying between the black and dotted lines and outside the limits of the survey as originally proposed. In addition, other territory thought desirable of investigation has also been covered.

The work carried out during the course of the survey included:

1 A study of the topographical features of the area.
2 Larval survey of the area within half a mile of the limits of the

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proposed new cantonment site, and outside such boundaries when considered necessary.

(3) Collection, identification and dissection for the presence of malaria parasites in adult anophelines from the area half a mile outside the boundaries and additional areas when desirable.

(4) Preparation of spot maps, records and the taking of photographs.

(5) Investigation of the situation with regard to the existing Chinese population living in the area.

(6) Investigation of special factors influencing mosquito breeding.

(7) Investigation of resting and feeding habits of adult mosquitoes.

(8) Liaison with the Government Malarialogist.

(9) Miscellaneous investigations.

B.—TOPOGRAPHY OF THE AREA.

The area under survey has been fairly thoroughly traversed on foot and a careful study made of the nature of the ground, the extent and character of cultivated tracts and the location and type of human habitations and animal shelters present.

The topographical features of the area are broadly speaking as follows:—

To the north of the area a massive chain of hills runs from east to west, the highest point being Lion Rock with an altitude of 1,618 feet.

A series of spurs runs down, north and south respectively, from the main chain, which forms the principal watershed of the area.

The hill streams rise on either side of the main watershed and flow down to the sea, first through the valleys between the spurs and then through the plains below.

The streams flowing through the area fall into a series of groups, according to their natural drainage areas.

A very important natural feature is the subsidiary watershed which, commencing south of △ 1,152, runs roughly in a south-easterly direction towards the old walled city of Kowloon—a track, outlined on the map by a line of long wide dots, follows approximately the line of the ridge.

The streams rising to the east of this ridge flow into the sea in the vicinity of Kai Tak on the eastern side of the Kowloon peninsula, whilst those rising to the west of this ridge flow into the sea in the vicinity of Shamshuipo and Tai Tok Tsui on the western side of the Kowloon peninsula.

Area under Survey West of the Subsidiary Watershed.

This area is characterized by a series of long spurs, with narrow valleys between them, running roughly in a southerly direction from the main chain of hills.

The spurs are on the whole fairly close together, the valleys between them are deep, whilst the gradients of the hill streams are on the whole steeper than those of the hill streams rising to the east of the subsidiary watershed.
LARVAL SURVEY (ANOPHELINES) OF KAU LUNG TSAI & ENVIRONS

REFERENCE:
WIDE STREAM,
WATER DRAINAGE,
PATH,
BUMPY AREA,
RESERVOIR,
WET CULTIVATION,
DITCH,
FACTORY,
VILLAGE HOUSE,
ROADS.
M. R. Burke

The northern half of this area is heavily afforested, mainly with pine trees, and there are several forest nurseries and experimental gardens maintained by the Colonial Government in this locality.

With the exception of the district west of the Kowloon Tong Estate there are few native habitations and cultivated tracts in this area.

**Area under Survey East of the Subsidiary Watershed.**

The country here is much more open in character—the ridges running south from the main chain are much shorter and are situated further apart—the valleys between them are in consequence shallow and wide, whilst the gradients of the hill streams, after their initial steep descent, are much flatter and several swamps have been located. The valleys run into an open, low-lying, plain of considerable extent. The area is on the whole sparsely wooded, but on the other hand there are large tracts of land under cultivation, wet and dry, particularly on the eastern flank. This flank has a dense native population mainly engaged in agriculture and many of whom live in primitive and insanitary habitations.

The topographical features of the country north of the high ridges running from Beacon Hill on the west to Grasscutters' Pass on the east have also been studied.

The northerly slopes of the main chain are on the whole more gradual and the valleys between the spurs fairly open. With the exception of a few dwellings and cultivated tracts in the vicinity of Shatin Pass the northerly slopes are uninhabited and form part of a natural catchment area. There is a considerable native population in the plains below, which are heavily cultivated.

A typical stream, after its initial steep descent, flows with a varying gradient through a valley between the spurs running out from the main chain; more or less level stretches, interrupted at intervals by abrupt falls, occur until the stream reaches the plain below where the flat gradient continues until it reaches the sea.

These streams are usually strewn with boulders for the greater part of their courses, and their beds, until they reach the plains, are usually composed of rocks and sand, but not infrequently the water flows over solid rock for some distance.

To the west of the subsidiary watershed, referred to above, the sides of the valleys are well covered with shrubs and trees but the shade afforded is often insufficient to prevent the sun's rays reaching the water, except in some places, where the valleys are narrow and have high steep sides.

To the east of the subsidiary watershed the valleys are much more open, their sides are on the whole sparsely wooded, and shaded streams are uncommon.

The boulders in the streams vary considerably in number, size and shape; some of the larger boulders are fifteen to twenty feet in height and about the same in width.
Antimalaria Report upon Proposed Site at Kau Lung Tsai

C.—The Anopheline Mosquitoes of Kau Lung Tsai and Its Environs.

A survey of known and potential breeding places has been carried out to determine the species of anophelines present in the area, their breeding habits and the nature of their breeding places.

Special attention has been paid to the location and to the type of breeding places of those species of anophelines which are known to be the most important carriers of malaria in the Colony.

Whilst it has been found impossible to repeat in detail surveys of all breeding places detected, nevertheless the more important localities have been searched monthly, so far as was practicable, as the species of anopheline larvae present in any one area vary widely from time to time.

A total of 77,411 anopheline larvae was collected and identified microscopically, and a total of 3,536 anopheline adults was hatched out from large larvae and pupae, and their species determined during the period March 26, 1935, to June 30, 1936.

Larvae and pupae of the following species of anophelines have been encountered: A. aitkenii var. bengalensis, Puri; A. hyrcanus var. sinensis, Wied; A. tessellatus Theo; A. funiaticus James; A. minimus Theo; A. jeyporiensis var. candidiensis, Koidzumi; A. maculatus Theo; A. karwari James; A. splendidus Koidzumi.

The collection of adult mosquitoes during the course of the survey has been mainly confined to selected "key points," situated in or near that portion of the area on which building is most likely to take place.

Routine catching of adults, morning and evening, has only been carried out since August, 1935, although some collecting was done in May and July, 1935.

During the period May, 1935, to June 30, 1936, inclusive, 580 adult anophelines were collected and identified; of these 444 adult females were dissected for presence of malaria parasites, but none was found to be infected. The factors which have contributed to the total absence of infection amongst adults dissected are considered to be as follows:

1. Catching has been mainly confined to the area referred to above; this area, with the exception of "D" valleys, contains few native huts, mat-sheds, etc.

2. Dangerous breeding places, which formerly accounted for a high incidence of malaria in the Kowloon Tong estate, have been eliminated, and streams trained, whilst a good deal of reclamation has been carried out, both east and west, of the residential area.

3. There are many native huts in the "D" valleys, but the Chinese living in this locality also keep a large number of pigs and water buffaloes which possibly afford some protection, due to the mosquitoes feeding on them.

4. Chinese living in the Lion Head Farm area (situated north of Kowloon Tong), which has been considerably developed as regards cultivation since the commencement of the survey, state that they have not
had any attacks of malaria and that they use nets. Extension of cultivated tracts is still proceeding in this area, which has developed into a potentially dangerous one from the malaria point of view for reasons stated later on in this report, and it is considered that it is only a question of time, when a carrier will be introduced to render this area malarial, if it remains as it is at present.

The species of adult anophelines caught include those found in the larval survey, with the exception of A. aitkenii and the addition of A. vagus Dönitz.

All known species of anophelines encountered so far in the Colony have been met with in the area under survey.

The following species of anophelines have been found infected with malaria in the Colony: A. minimus, A. jeyporiensis, A. maculatus, A. hyrcanus, A. splendidus, A. tessellatus. The chief carriers of malaria in the Colony are A. minimus and A. jeyporiensis.

A. maculatus and A. hyrcanus do not appear to be carriers as a general rule, but under certain circumstances they do become infected in fairly appreciable numbers and must, in consequence, be taken into account.

A. maculatus has only been found infected in the Colony at Shing Mun (in the New Territories) and at Wo Li Hop, a village about half a mile distant.

There have been on an average some 2,000 coolies, employed in the construction of a new dam, residing in the lines at Shing Mun, and some of them have lived from time to time at Wo Li Hop.

A. hyrcanus has only been found infected in the Colony at Shing Mun and at Little Hong Kong (a Chinese village on the island).

A. splendidus has only been found infected twice—on both occasions at Shing Mun.

A. tessellatus, a species which is normally but rarely encountered in the Colony, has only been found infected at Little Hong Kong.

A. minimus and A. jeyporiensis are the primary carriers at Shing Mun, Wo Li Hop, and Little Hong Kong and it is considered that A. maculatus and A. hyrcanus have become secondary carriers, due to the incidence of malaria in these districts. A. splendidus and A. tessellatus have probably become infected for the same reason, but the adults are only occasionally caught, and the numbers found infected are so small, that it is not considered that these two species are of any importance as carriers of malaria.

The percentage infection rates of anophelines caught at Shing Mun, Wo Li Hop, and Little Hong Kong for the years 1933, 1934 and 1935 are quoted here by courtesy of the Government Malariologist as an illustration of the relative importance of the various species of anophelines encountered in the Colony.

[N.B.—It should be noted that the antimalaria measures carried out at Shing Mun and vicinity are mainly of a temporary nature.]
RESULT OF DISSECTIONS FOR MALARIA INFECTION OF ANOPHELINES CAUGHT IN

(a) Wong Chuk Hang.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of dissections</th>
<th>Number with infected glands only</th>
<th>Number with infected midgut only</th>
<th>Number with infected glands and midgut</th>
<th>Per cent infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. minimus</td>
<td>3,259</td>
<td>1,980</td>
<td>3,507</td>
<td>118</td>
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<tr>
<td>A. jeyporiensis</td>
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<td>2</td>
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<tr>
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<td>139</td>
<td>91</td>
<td>16</td>
<td></td>
<td></td>
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<tr>
<td>A. hyrcanus</td>
<td>58</td>
<td>30</td>
<td>20</td>
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<tr>
<td>A. tessellatus</td>
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(b) Shing Mun.

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<th>Number with infected glands only</th>
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<th>Number with infected glands and midgut</th>
<th>Per cent infected</th>
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</thead>
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<tr>
<td>A. minimus</td>
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<td>775</td>
<td>1,159</td>
<td>64</td>
<td>7</td>
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<td>A. jeyporiensis</td>
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<td>4,166</td>
<td>2,016</td>
<td>218</td>
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<tr>
<td>A. maculatus</td>
<td>230</td>
<td>900</td>
<td>819</td>
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<tr>
<td>A. hyrcanus</td>
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<td>5,245</td>
<td>4,012</td>
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<tr>
<td>A. splendidus</td>
<td>25</td>
<td>48</td>
<td>35</td>
<td></td>
<td></td>
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<tr>
<td>A. karwari</td>
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(c) Wo Li Hop.

<table>
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<th>Species</th>
<th>Number of dissections</th>
<th>Number with infected glands only</th>
<th>Number with infected midgut only</th>
<th>Number with infected glands and midgut</th>
<th>Per cent infected</th>
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<td>86</td>
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<td>A. splendidus</td>
<td>4</td>
<td>5</td>
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</table>
A. minimus.—Larvae of this species have been collected chiefly from pools in those portions of boulder-strewn hill streams where the gradient flattens out; such pools are usually either rocky with a sandy bottom, or else pockets in the sandy bed of the same stream courses. These pools are often fringed with grass, normally contain vegetation, and are almost invariably open to the sunlight.

This species also occurs fairly commonly in irrigation ditches, especially those arising from and close to hill streams.

A. minimus breeds most abundantly in the flat stretches of hill streams nearest to the foothills, and has been but very rarely encountered, and then only in exceedingly small numbers in any part where the gradient is steep.

These larvae have also been met with in foothill seepages, pools left at the sides of streams after heavy rains, a disused concrete washing place, amongst grass and weeds fringing streams, which were not boulder strewn but which were open to sunlight, and occasionally in swampy areas and flooded abandoned paddy fields. Larvae were rarely obtained from pools, etc., devoid of vegetation of some kind or other.

Larvae of this species were also encountered in large numbers in November, 1935, in isolated pools in the sandy bed of a flat stretch of a hill stream. This portion of the stream passes through a highly populous area, and by a large dairy farm. It was used extensively as an open-air latrine and as a rubbish dump, and was quite dry except for the isolated pools, mentioned above, fed by seepage.

The degree of pollution in these practically stagnant pools must have been very considerable, and the presence of A. minimus larvae in such large numbers was, under the circumstances, quite unexpected, as this species usually favours clear, unpolluted water for breeding.

Larvae of this species were met with throughout the period of the survey except in the month of August, 1935. They breed most abundantly in the boulder-strewn streams after the cessation of the rains, when the flow of water eases up and the volume diminishes. They are scarce during the rainy season, when the streams are in spate, and do not appear to be able to stand up to swift currents like A. maculatus.

They have been found to be most plentiful in the “A.” and “B” series of streams. All these streams flow towards, and the main streams through, areas heavily populated by Chinese, many of whom live in most primitive dwellings.

The Lion Head Farm area (situated north of Kowloon Tong) became, after October, 1935, an abundant source of A. minimus larvae. This was due to certain developments in this locality which will be referred to in detail later in the report.

A. minimus has been the commonest species of anophelines encountered in carrying out adult catching in human habitations in the area under survey.
Adults have been fairly readily captured from certain types of native dwellings such as mat-sheds. These structures usually consist of a bamboo framework with sides and top composed of palm leaves, old sheets of corrugated iron or sheeting derived from petrol tins, biscuit tins, etc. Occasionally they are roofed with tiles.

These habitations are of a primitive type and are usually dark and badly ventilated. It has been found difficult to capture *A. minimus* from Chinese dwellings built of stone or brick and roofed with tiles, as these buildings are lighter and better ventilated, although of a poor hygienic standard.

This species has only been occasionally obtained from animal shelters in the area under survey. All adults caught have been collected from human habitations and animal shelters close to *A. minimus* breeding places, whilst the bulk of the captures made were after the cessation of the rains—(cf. larval findings).

Evidence collected by the Government Malariologist, elsewhere in the Colony, shows that adults of this species are difficult to obtain from houses inhabited by Europeans and better class Chinese, although they can be readily captured in native dwellings of the mat-shed type, and that dwellings situated closest to the breeding places receive most attention from them.

This species is a most dangerous carrier of malaria in the Colony and has also been found naturally infected with filaria. It has been experimentally infected with subtertian malaria and microfilaria (*W. bancrofti*) by the Malaria Bureau.

Experience in the Colony has shown that the nearer human habitations are to the foothills the greater the danger of contracting malaria. The malaria incidence in these localities has been shown to be due in the main to their proximity to dangerous anopheline breeding places, such as the flat portions of boulder strewn hill streams, swamps and paddy fields.

The history of the Kowloon Tong Estate (Kau Lung Tong) is cited here as a typical example of the association between the presence of important *A. minimus* breeding places and a high malarial incidence.

This estate was developed as a "garden city," and the houses built were all of the European type. The area on which building took place was largely reclaimed land, but, apart from the drainage of the estate itself, little else was done in the way of training hill streams in the vicinity until some years had elapsed.

Occupation of the northern half of the estate was commenced in 1925, and of the southern half in 1926. The residential population was made up of Europeans, Portuguese and Chinese—the Chinese being in the majority in the southern half.

By 1931 the malaria situation had become so intense that a report was submitted, on behalf of the residents of the estate, to the Hon. Director of Medical and Sanitary Services of the Colony.

The report stated that at this time there were 242 houses on the estate of which 232 were occupied, and the total population was estimated to be
Householders had been asked to send in returns of all cases of malaria occurring in their homes in the previous year (1930). Replies received covered 52 houses and from 29 of these 108 cases of malaria were reported; the incidence being highest in the upper section of the estate where practically every household had been affected. It was also stated that there had been a large number of cases in the households from which returns had not been received and amongst servants who had left for the country.

Later on a private practitioner reported that in November and December, 1932, he had treated eleven cases of malaria in Kent Road (see the map) ten of which were diagnosed microscopically. He stated that he believed the whole of Kent Road to be highly infected and that almost everyone was taking quinine and plasmoquine.

In 1931 and 1932 the Government Malariaologist carried out a malaria survey of Kowloon Tong and its vicinity and found that important A. minimus breeding places existed in flat portions of hill streams, and certain irrigation ditches, in close proximity to the estate—especially in the neighbourhood of the northern half. The chief breeding places were located in the streams: E (now obliterated by reclamation), F, F1, G2 and its tributaries, and the irrigation ditches of an experimental garden. The worst breeding places were found to be stream G2 and its tributaries.

He found that malaria infections were common in that part of Kowloon Tong nearest to the foothills (from Cornwall Street to York Road, especially in Kent Road) whilst there was no strong evidence of the occurrence of malaria in the remaining part of the estate.

He based his opinion on the malaria incidence from the evidence furnished by blood and spleen examinations, hospital admissions and inquiries.

The Government Malariaologist made exhaustive recommendations, and considerable antimalaria drainage work (of a permanent nature) and reclamations have now been carried out by the Colonial Government chiefly to the west, north-west and east of Kowloon Tong.

As a result of this permanent work malaria has to-day been practically wiped out in Kowloon Tong.

Malaria is not a notifiable disease in the Colony, consequently it is difficult to estimate its incidence from statistics available, but the following information gives a relative indication of the progress made in abolishing the scourge at Kowloon Tong.

Admissions for Malaria to Kowloon Hospital (a Government civil hospital) from Kowloon Tong.

- **1932**: 12 admissions from Kent and Somerset Roads (this total does not include 11 cases from Kent Road referred to above and treated by a private practitioner).
- **1933**: 19 admissions from Kent, Devon, Norfolk, Suffolk and York Roads and Essex Crescent. Bulk of cases came from Kent Road.
- **1934**: 2 admissions from Kent Road and Boundary Street.
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1935 4 admissions from Waterloo Road. All these cases came from that portion of Waterloo Road which lies opposite to the mouth of "D" valley. (It is considered that these cases were probably the result of reclamation partially carried out during the year, which interfered with the natural drainage of the "D" valley, and resulted in the formation of important *A. jeyporiensis* breeding places).

1 admission from Kent Road.

*A. jeyporiensis*—Larvae of this species have been found chiefly in localities where water is flowing slowly through grass, especially in flooded abandoned paddy fields and swamps.

They have also been met with in the flat portions of hill streams, but only in small numbers, except under certain circumstances. After a prolonged period of dry weather the flow in the streams is considerably diminished and the Chinese construct temporary dams to conserve the supply of water for agricultural purposes—as a result of these measures the flow of water becomes extremely sluggish, the edges of the stream become heavily fringed with grass, etc., whilst in some instances the stream bed itself becomes overgrown with grass and weeds. Thus, conditions extremely suitable for *A. jeyporiensis* breeding arise—marked increase in breeding of this species does in fact take place in these situations, and was especially observed to occur in the first quarter of 1936.

Larvae of *A. jeyporiensis* are usually only found in small numbers in tracts of wet cultivation, apart from paddy, but in the last quarter of 1935 large numbers were obtained from the following types of wet cultivation: *Pistia stratiotes* (water lettuce), *Eichornia speciosa* (water hyacinth), *Convolvulus septans* (water spinach).

These plants are frequently grown together in the same plot of wet cultivation.

Watercress beds have also been diligently searched throughout the survey but no larvae of *A. jeyporiensis* have ever been collected from them. Species of watercress grown in the Colony is *Nasturtium officinale*.

It is interesting to note that the Government Malariologist has found that although *A. jeyporiensis* larvae can be collected throughout the year in flooded abandoned or fallow paddy fields, in the last quarter of the year they can be obtained from rice cultivation itself and in pools amongst rice stubble. Those found in the rice stubble were probably there before the rice was cut, as few were found in surveys carried out some weeks afterwards.

Larvae of this species have also been found occasionally in irrigation ditches fringed with grass, grassy seepages and fallow plots of wet cultivation.

This species has been found to breed most abundantly in the area under survey from August to December.

There are a number of abandoned paddy fields in the area surveyed, but no tracts of actual rice cultivation have been observed.

The chief breeding places met with were: Flooded abandoned paddy
fields, tracts of wet cultivation and swamps fed by streams B3a, B3al, B5; swampy area through which stream B7 flows; swampy area through which stream B3b flows.

It should be noted that in November, 1928, two hundred troops were in camp at Chuk-UN which is fairly close to the breeding places referred to above. There were seventy-three cases of malaria within a month and the camp was closed down.

This species next to A. minimus has been the one most frequently met with in carrying out catching of adults in human habitations in the area under survey.

With one exception all the adults captured from human habitations have been collected from the mat-shed type of dwelling, whilst none has been obtained from animal shelters.

Unlike A. minimus a fair proportion of the A. jeyporiensis adults captured have been obtained from human habitations remote from known breeding places of this species. It is interesting to note that at Shing Mun the range of flight of the adult female has been suspected to be a mile and a half. The bulk of the adults captured were collected in the last quarter of the year when the breeding of this species was found to be at its height.

Evidence collected by the Government Malariologist shows that A. jeyporiensis adults can be obtained without difficulty from the mat-shed type of human habitations within flying distances of the breeding places of this species.

A. jeyporiensis is a dangerous carrier of malaria in the Colony and has been found naturally infected with filaria. It has been experimentally infected with subtertian malaria by the Malaria Bureau.

A. maculatus.—Larvae of this species were the commonest met with in the area under survey, and have been encountered over the greater part of the area.

A. maculatus breeds abundantly throughout the year, mainly in the hill streams, and has been found to breed as high up as 750 feet.

After heavy rains, when the hill streams are swollen and the flow of water is fairly fast, larvae of this species can be collected without much difficulty from the flat portions of such streams, although larvae of other species are only occasionally met with and then in exceedingly small numbers under these circumstances. This is due to the fact that larvae of A. maculatus possess well-defined caudal hooks which enable them to hang on to projecting vegetation or marginal irregularities of pools, etc., whilst larvae of other species are washed away.

A. maculatus is ubiquitous and has been obtained from every type of breeding place encountered in the area under survey. It has been found chiefly in rocky or sandy pools, usually open but sometimes shaded, and normally with vegetation in the hill streams. Although commonest in the flat stretches it has also been met with in those portions of hill streams where the gradient is steep. It is also commonly encountered along the
grassy edges of streams and in irrigation ditches and seepages, with or without vegetation. Other breeding places met with include swamps, flooded abandoned paddy fields, pools left at the sides of streams after heavy rains, pools of rain water not connected with any streams, polluted streams flowing through market garden areas, tracts of wet cultivation, a disused concrete washing place and in isolated pools in an otherwise dry stream bed heavily polluted with rubbish and human excreta.

There are a number of Chinese open-air laundries in the area under survey, operated at certain times of the year when weather conditions are suitable. These laundries usually consist of a concrete dam across the stream below which is a concreted washing place, constructed in the stream bed. The overflow from these laundries, containing a good deal of soap, has been noted to exercise a definite deterrent action on anopheline breeding. It has been observed that whereas larvae of *A. minimus* are rarely met with for some distance below such laundries, nevertheless larvae of *A. maculatus* and sometimes *A. hyrcanus* can be collected without much difficulty, although in smaller numbers than usual.

Although *A. maculatus* is an abundant and ubiquitous breeder the total adult catches of this species have been extremely small. The total number of adults captured bears but an insignificant relation to the enormous number of larvae of this species collected in the vicinity of both human habitations and animal shelters. Comparative catches made on the same days from human habitations and animal shelters show that this species prefers the latter.

Evidence collected by the Government Malariologist in the Colony shows that *A. maculatus* adults are difficult to obtain from human dwellings, under normal circumstances, but that fair numbers can be collected from cow byres and pigsties—whilst precipitin tests carried out seem to show that this species prefers animal to human blood. Various observers have reported from time to time that this species leaves human habitations after feeding, and this has been confirmed in the Colony by evidence collected at Shing Mun.

Mosquito proofing of the coolie lines containing some 2,000 persons was commenced in September, 1933. Comparatively few adults of this species had been captured in the lines prior to their being mosquito proofed, but after screening had been carried out the total number of *A. maculatus* caught increased considerably—this increase was due to defects in the mosquito proofing, which arose from time to time, resulting in the huts acting as mosquito traps.

*A. maculatus* is considered to be a dangerous carrier of malaria in Malaya, and yet in this Colony, where it is by far the commonest species met with in larval surveys, it appears to be but of minor importance in this respect.

It has only been found infected in the Colony at Shing Mun and Wo Li Hop. In both these places *A. minimus* and *A. jeyporiensis* are the
primary carriers and it is considered that *A. maculatus* has become a secondary carrier due to the incidence of malaria in these districts.

This species has also been found naturally infected with filaria in the Colony and has been experimentally infected with subtertian malaria and with microfilariae (*W. bancrofti*) by the Malaria Bureau.

*A. hyrcanus*—This species is pre-eminently a market garden and swamp breeder and the larvae were chiefly met with in stagnant water with vegetation.

It breeds abundantly throughout the year and was, next to *A. maculatus*, the commonest species encountered in the larval surveys.

Favourite breeding places noted were tracts of wet cultivation, swamps, flooded abandoned paddy fields, grassy edges of streams, and irrigation ditches where the flow was sluggish. Larvae were also collected from pools with sandy beds in the flat portions of the hill streams (such pools were usually open, but sometimes shaded, and generally contained vegetation), shallow swamps, a disused concrete washing place, pools in grass after heavy rains and an irrigation ditch with a fairly swift flow and with but little vegetation.

It has been found to breed abundantly in both clean and heavily polluted water.

*A. hyrcanus* has been the commonest species encountered in carrying out adult catches in the area under survey. The total adult catch of this species from human habitations was, however, only about one-fifth of that obtained from animal shelters.

Evidence collected by the Government Malarialogist at Shing Mun shows that *A. hyrcanus* like *A. maculatus* leaves human habitations after feeding. He has also found that this species does not figure to any extent in adult catches from human habitations, with the exception of the screened lines at Shing Mun, although considerable numbers have been obtained from suitable village pigsties and cow byres.

Although *A. hyrcanus* is the second commonest species encountered in the larval surveys carried out in the Colony it is but of minor importance as a carrier of malaria.

This species has also been found naturally infected with filaria in the Colony and has been experimentally infected with microfilariae (*W. bancrofti*) by the Malaria Bureau, although attempts to infect it with subtertian malaria were unsuccessful.

*A. karwari*—Larvae of this species have been chiefly met with in swampy areas and flooded abandoned paddy fields, and to a much lesser extent in the flat portions of hill streams, where the flow was sluggish, either in rocky or simple pools (usually open, sometimes shaded), or along the grassy edges of such streams.

They have also been found occasionally in such places as irrigation ditches fringed with grass, tracts of wet cultivation, shallow sumps with grassy fringes, and pools left in grass after heavy rains.

It has been found to breed abundantly from August to December,
chiefly in swampy areas and flooded abandoned paddy fields (cf. *A. jeyporiensis*).

Adults of this species are but rarely encountered—two were caught in human habitations and one in an animal shelter in the area under survey.

*A. karwari* has never been found infected with malaria in the Colony, and, so far as the author of this report is aware, no natural infections have been recorded in other countries.

*A. splendidus*.—Larvae of this species have been chiefly met with in swampy areas and flooded abandoned paddy fields, and occasionally in open or shaded pools, containing algae and vegetation, in the sandy beds of the flat portions of hill streams, along the grassy edges of such streams, in irrigation ditches and plots of wet cultivation.

It breeds most abundantly from August to December (cf. *A. jeyporiensis* and *A. karwari*), chiefly in swampy areas and flooded abandoned paddy fields.

Only one adult has been captured (from a pigsty) in the area under survey—elsewhere in the Colony a few adults are occasionally captured from time to time.

Two adults of this species have been found infected at Shing Mun and as far as the Government Malariaologist is aware the only other record of infection of *A. splendidus* is that reported by Robertson at Saharanpur (1910). It is not therefore considered that this species is of any importance as a carrier of malaria.

It has also been found naturally infected with filaria by the Malaria Bureau.

*A. aitkenii*.—Larvae of this species have been very rarely encountered in the area under survey.

They were all collected from pools in sandy beds of flat portions of hill streams. No adults of *A. aitkenii* have been captured in the area, nor has it figured yet in catches (adult) made elsewhere in the Colony by the Malaria Bureau. Christophers (1933) states that there is no evidence regarding its playing any part in malaria transmission.

*A. tessellatus*.—This species is rarely encountered in the Colony. Only one larva of this species was collected—it came from an open pool in a sandy bed of a flat portion of a hill stream. Pupae of *A. tessellatus* have, however, been very occasionally met with in a plot of wet cultivation, in sandy pools in streams fringed with vegetation and edges of streams overgrown with weeds. Adults were bred out from these pupae in the laboratory.

No adults of *A. tessellatus* have been obtained from the area under survey, although the Malaria Bureau collected a fair number from mat-sheds and pigsties in 1935 elsewhere in the Colony. It has been rarely met with in other years. It has been found infected with malaria on one occasion by the Malaria Bureau—one infection has been recorded in Dutch-East Indies—it is not considered of any importance as regards malaria transmission.
**A. vagus.**—No larvæ of this species have been encountered during the survey—elsewhere in the Colony they have been collected from small muddy, grassy pools and from pools in rice stubble.

Two adults were captured from human habitations in the area—elsewhere in the Colony they have been collected in fair numbers from cow byres.

It has never been found infected with malaria in the Colony, and but rarely elsewhere, and is not considered of any importance as regards malaria transmission.

**A. fluviatilis.**—No larvæ of this species have been identified in the larval stage from area under survey.

The larvæ of *A. fluviatilis* very closely resemble those of *A. minimus*, differing only from them in certain very minor details. Distinction of *A. fluviatilis* from *A. minimus* in larval stages involves the taking of microscopic measurements—this takes up a good deal of time and, for reasons which will be given later, it was not considered worth while to distinguish between these two species in the larval stages.

The sum totals of larvæ of *A. minimus* identified as such probably include a small proportion which should have been classified as *A. fluviatilis*.

Adults of *A. fluviatilis* have, however, been bred out and identified from large larvæ and pupæ collected from open pools (usually with, but sometimes without, vegetation present), in sandy beds of flat portions of hill streams, a pool overgrown with weeds and fed by seepage, and the edges of an irrigation ditch.

Adults of this species were occasionally captured from human habitations, and to a lesser extent from animal shelters.

Some adults have been captured, or bred out from large larvæ and pupæ, which have proved to be exceedingly difficult to identify definitely as either *A. minimus* or *A. fluviatilis*, as characteristics distinctive of both of these species have been present in the specimens. The attention of the Government Malarialogist, Dr. R. B. Jackson, M.D., D.P.H., was drawn to variations in the palpal markings of certain adults captured whose wing markings resembled either *A. minimus* or *A. fluviatilis*. Dr. Jackson, who had noted other distinct differences in palpal and wing markings of similar adults, has made a close study of this subject and has taken the matter up with Dr. Edwards at the British Museum whilst home on leave.

Although natural infection of this species with malaria in the Colony has not so far been recorded by the Malaria Bureau it should be regarded with caution, as it is considered in India to be an important carrier of malaria.

Its adult habits resemble those of *A. minimus*, whilst its breeding places are also somewhat similar.

Measures taken against *A. minimus* should therefore prove equally efficacious against *A. fluviatilis*.

(To be continued.)