# THE OUTBREAK OF MALARIA AT FUYONG ESTATE IN SINGAPORE

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## INTRODUCTION

During the months from August to October 1964, there was reported a minor outbreak of Malaria at the Fuyong Estate in Singapore Island. At about the same time there was also an increase in the incidence of Malaria cases from Pulau Tekong, a smaller island off the north-east coast of Singapore which is under the administration of the Singapore Government. This spate of Malaria cases was unusual, because it was the general impression among the medical circles and the public at large that Singapore[1] has been free from indigenous Malaria for a number of years.

Various claims all conveying the impression that Singapore has no indigenous Malaria ranging from 7 to 10 years have been made by different medical authorities at different times. However, when a closer examination is made on the bases of such claims, this general impression may not be very accurate. The primary reason for this is that there are no proper records kept on Malaria cases. Notification to the Public Health authorities has only recently been made compulsory, as Malaria is now included in the list of notifiable diseases under the Quarantine and Prevention of Disease Ordinance (1955).[2] Such notification as there was at the time of the outbreak was purely voluntary and came largely from the Government Hospitals, with a few from other sources like the Military and private Hospitals and fewer still from private practitioners.

The first official record of the above general impression is to be found in the Annual Report of the Government Health Department for the year 1956 where it was stated that "for the fifth consecutive year there was no morbidity from indigenous Malaria on the main Singapore Island, although there were 3 reported cases from St. John's Island".[3] It is against this background of Singapore Island being relatively free from indigenous Malaria, that the outbreak at Fuyong Estate must be seen. Although it had been officially described as "minor", the outbreak caused a considerable stir in the public health field and had certainly been an event of some epidemiological significance.

## PURPOSE

As this outbreak was of some importance, it would be useful to have a recorded account of it. The purpose of this article is three-fold namely:

1) To describe the epidemiologic features of the outbreak;
2) To trace the likely factors leading to the outbreak; and
3) To describe the measures taken to interrupt the transmission and to eradicate this focus of infection.

## BRIEF HISTORY OF MALARIA IN SINGAPORE

When did Malaria first come to Singapore? Was it rampant and claiming its victims in the pre-British era? Were the fevers one of the contributing forces that led to the crumble of the kingdoms of Sri Vijaya and Majapahit? The answers to these questions though fascinating for speculation, are not really known.

There is a paucity of the records of its presence in the early British colonial era. Galloway quoting a colleague whose experiences went back to the early 1850's says that Malaria became very prevalent in Singapore town about 1880.[4] Brooke writing in the *One hundred years of Singapore* states that, "in 1911 the subject of Malaria came very much to the fore. For the week ending 10th June, deaths from Malaria alone amounted to 127. An anti-malarial committee was then appointed and $10,000 was

[1]Singapore used throughout this article refers to Singapore Island only, although administratively it includes numerous small surrounding islands.

[2]Since February, 1966.

[3]Annual Report, Singapore Government Health Department (1956), p. 49.

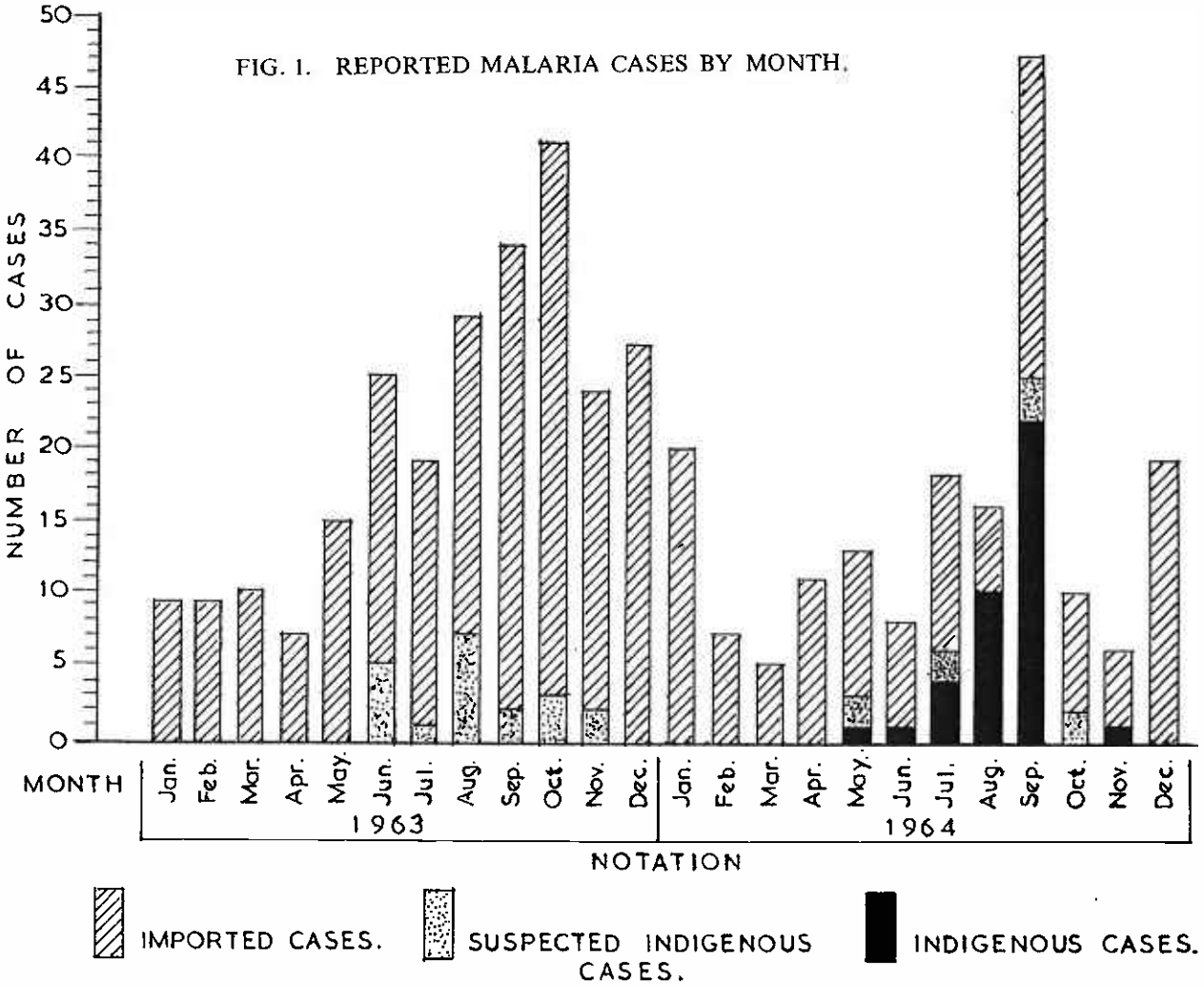
[4]Sandosham, A.A. (1965): Malariology University of Malaya Press p. 12.

voted for preliminary work in the campaign."[5] At the invitation of this anti-malarial committee, Sir Malcolm Watson renowned for his recent successes in controlling the diseases in Klang and Port Swettenham at that time, visited Singapore to make recommendations for dealing with the most malarious district.[6] Some years later in 1934 while giving a historical account of Malaria at the Finlayson Memorial Lecture, Glasgow, Malcolm Watson commented that, "Singapore is now a city of nearly half a million people. Malaria has long ceased to be a scourge it was up till 1911, when the Health Officer reported that malaria was the most prevalent of all diseases in Singapore and increasing in prevalence and severity."[7]

Since the formation of the 1911 anti-malarial committee, control measures within the Municipality were carried out successfully by Hunter and then extended to the rural areas by Scharff.[8] In 1935, there was a small outbreak due to the vector *Anopheles sundaicus*, Rodenwaldt 1925, in the Kallang Basin Fish ponds. During the Japanese Occupation period (1942-1945), the high standard of permanent malarial drains laid before the war was neglected and became ineffective after the British reoccupation.[9]

The post-war period was marked by an improvement of the situation. Control measures were intensified to such a high degree that from the mid-1950's, indigenous malaria apparently disappeared from the Island. However, if the available records for the years 1963 and 1964 were examined it would be observed that there was a suggestion of a resurgence. Below is a histogram showing the monthly reported cases for 1963 and 1964. This would give a background of the outbreak at Fuyong Estate.

FIG. 1. REPORTED MALARIA CASES BY MONTH.




5Brooke, G.E., Makepeace, W.D. & Braddel, R.J. (1921): One Hundred Years of Singapore. Vol. 1, p. 515 London John Murray, Albemarle.

6Watson, M. (1911): Notes on Malarial Conditions in Telok Blanga District, Singapore, Government Publication.

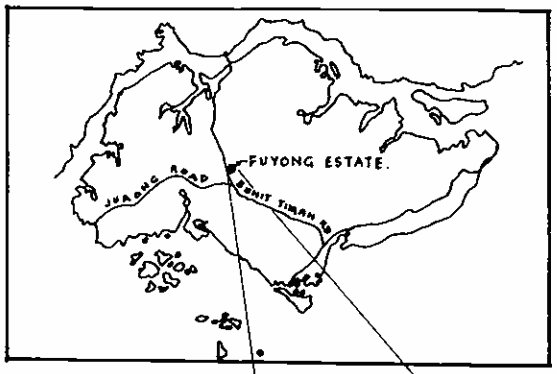
7Watson, M. (1935): Some Pages from the History of the Prevention of Malaria, p. 19. Alex MacDougall, Glasgow.

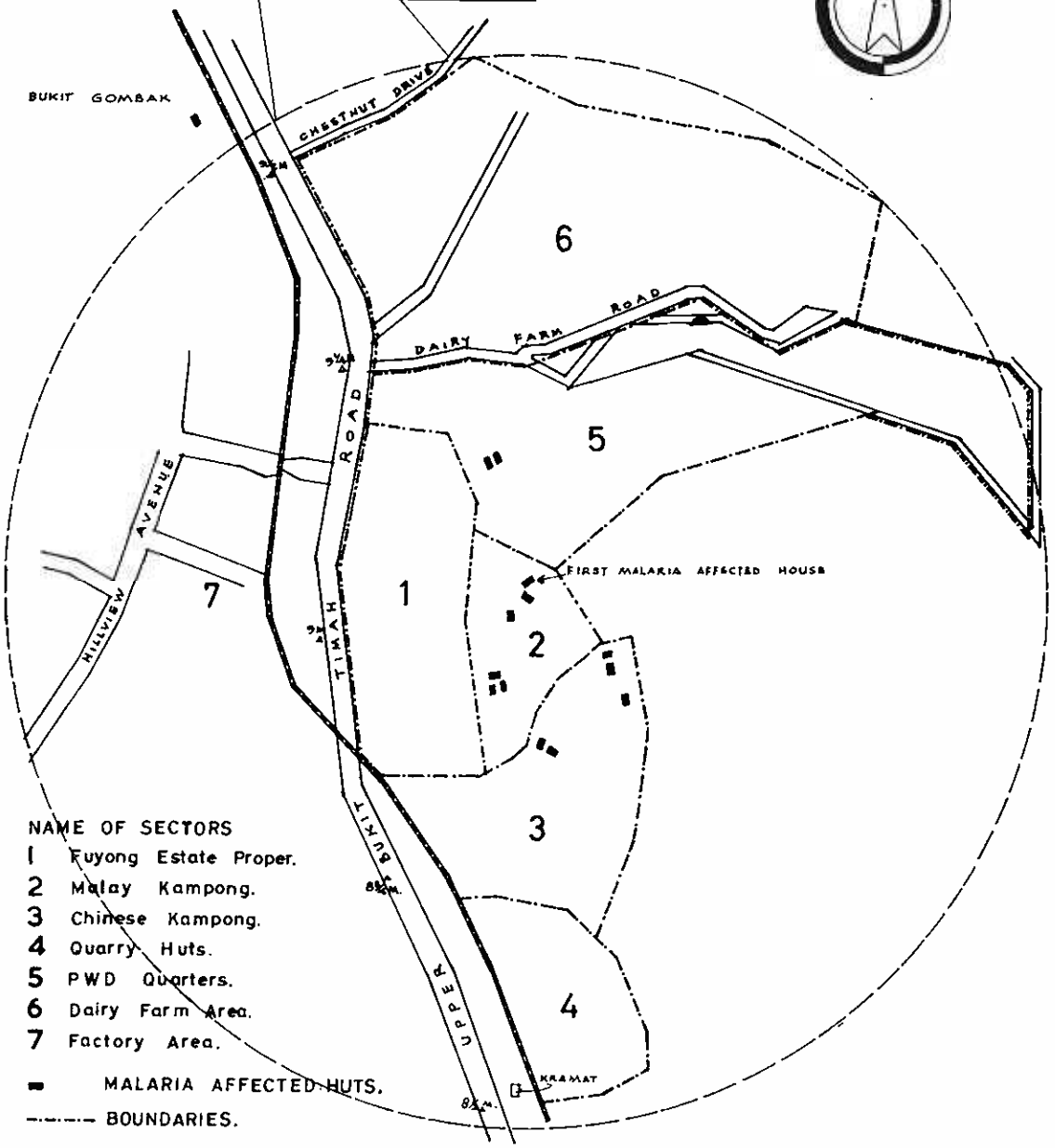
8Sandosham, A.A. (1965): Malariology p. 22 University of Malaya Press.

9Vickers, W.J. (1946): Annual Report of Medical Department, Colony of Singapore p. 14.

FIG. 2

**MAP SHOWING GEOGRAPHICAL DISTRIBUTION OF MALARIA AFFECTED HOUSES, FUYONG ESTATE, SINGAPORE.**



## GEOGRAPHICAL DESCRIPTION OF FUYONG ESTATE

A look at the physical features map of Singapore will show that Fuyong Estate is situated just beside the central portion of the island in the hilly area known as Bukit Timah Hill Forest Reserves. It is at about 8½ milestone, off the main Bukit Timah Road. There are five large quarries and as many ravines.

### Boundaries

As soon as it was established with certainty that there was an outbreak of Malaria, it became necessary for organisational purposes to give boundaries to the area of outbreak. It must be noted that the boundaries were fixed arbitrarily and to some extent artificial. Generally, the area was taken to be enclosed by a rough circle with a half mile radius from the house of the first reported case (see Fig. 2). It was approximately 0·8 of a square mile.

The northern boundary was Chestnut Drive at about the 9¼ milestone, Bukit Timah Road. Towards the southern limit was the Kramat Habib Ismail at about the 8¼ milestone, Bukit Timah Road. Bukit Timah Hill Forest Reserve formed the natural eastern boundary and the Hillview Avenue in the Princess Elizabeth Estate, the western boundary.

This area of the outbreak termed the "operation area" was conveniently further sub-divided into 7 sectors for purposes of the anti-malarial measures taken. They were:

### Sector 1—Fuyong Estate Proper

This was a built up area and a Housing Estate consisting mainly of families of British Military personnel and a few civilians.

### Sector 2—Malay Kampong

This was adjacent to Sector 1 and on a hillslope consisting mainly of Malay huts where the first few cases were discovered.

### Sector 3—Chinese Kampong

Towards the south of the Malay Kampong were small groups of huts scattered here and there and occupied by Chinese.

### Sector 4—Quarry Huts

Between the Singapore Granite Quarry and the Kramat Habib Ismail was another group of Chinese Huts belonging to the quarry workers.

### Sector 5—P.W.D. Quarters

North of Fuyong Estate proper were rows of quarters for the Indian Labourers of the P.W.D. Quarry.

### Sector 6—Dairy Farm Area

Between the Dairy Farm Road and Chestnut Drive were another group of huts occupied by Chinese and some Malays.

### Sector 7—Factory Area

Across Bukit Timah towards the west was the Factory Area of Princess Elizabeth Estate.

### Population

There were about 690 houses within the "operation area" and approximately 4,000 residents including men, women and children. All the 4 major ethnic groups lived here namely, Malays, Chinese, Indians and Europeans. It is estimated that about 50% or more of the population here are below the age of 20 years.

### Seepages and Springs

Seepages and spring water abounded in this "operation area" especially in the surfaces and foothills scarred by the 5 granite quarries. There had been some clearing of the forests in the Housing and Development Board Quarry and the cutting of hillslopes in the Princess Elizabeth Estate making way for new developments since the early part of 1964. These might have exposed the slow flowing, clear and sparkling water to sunlight and thus provided the ideal breeding grounds for the dangerous vector *Anopheles maculatus*, Theobald 1901.

## DESCRIPTION OF THE OUTBREAK

The first reported case was a Malay lad of 18 years who was a part-time labourer at Hume Industries. His family migrated from Johore in 1956 and he had since remained in Singapore. He had no history of having suffered from Malaria and the last time when he went to Malaya was in April, 1964. He left for Pontian in Johore at 9.00 a.m. in the morning and returned to Singapore at 4.00 p.m. on the same day. He did not get any fever. He was first seen at Thomson Road Hospital on 30.7.64 and diagnosed as a case of Malaria on a positive blood film. His house was in the Malay Kampong shown in Sector 2 (Photo A).

The Public Health Inspector investigating this case found that there were 17 other people who had bouts of fever, chills and rigors living in the same kampong during the month prior to this first reported case. He also went to various General Practitioners in the vicinity who saw

Photo A. The first reported case in a Malay lad. (Outside his house).

some of these cases. One doctor did suspect Malaria in one of his fever cases. This patient was given Nivaquine* tablets. Some of these tablets were taken by a few of the "fever cases" in the neighbourhood. These "fever cases" recovered! This story was the first suggestion of a possible outbreak here.

About 3 weeks after this first case, a Lady General Practitioner in the area sent a Chinese girl aged 6 years, whom she suspected of having Malaria, to the Health Officer at Bukit Panjang District Health Office. She wanted to have the case confirmed by a blood film examination. When a slide was taken, it was found to be full of *Plasmodium vivax*, Grassi and Feletti, 1890, parasites.

A house to house search for "fever cases" was immediately embarked upon and these cases had blood films taken for Malaria Parasites. 10 positive cases were picked up. 2 of the more severe cases were sent to hospital and the diagnosis of Malaria was affirmed.

A few days later the Bukit Panjang Outdoor Dispensary and Tan Tock Seng Hospital reported 2 more cases.

A Medical Student following up a social case of Malaria in an infant of 3 months old from the Malay Kampong, took blood films of all the 4 members of this family and found them positive for Malaria, although they appeared well. 2 neighbours whose blood films were taken, were also positive. With this number of cases confirmed, the outbreak of Malaria was established.

Subsequently at various intervals from August to October 1964, cases were reported by the General Hospital, and others were picked up from a Focal Blood Survey (described later). Until the outbreak tailed off 3 months after the first reported case, a total of 33 positive cases were reported. 4 had definite histories of being imported but have been included in the total of 33 cases. No further cases were discovered, though 3 surveillances were done at different intervals of time, 3 months after the last reported case.

## ANALYSIS OF CASES

The following tables give an analysis of the 33 Malaria cases reported during the whole period of the outbreak. It should be noted that 4 of these 33 cases have definite histories of being imported from Johore. But as they occurred in close proximity to the "operation area", they have been included in the analysis.

### Distribution of Malaria Cases by Age

It will be readily observed from Table I that the majority of cases were in the younger age groups *i.e.*, from infancy to the 12 year age groups. There were only few cases in the older age groups. 25 cases were below the age of 20 years, and 8 cases above the age of 20 years. The proportions appear to be in conformity with the general population distribution of Singapore where more than 50% of the people are below the age of 20 years.

The important point about the cases was that there were 3 of them below the age of one year. The youngest patient was a baby girl of only 3 months old. As the total number of

### Distribution by Age

TABLE I

DISTRIBUTION OF MALARIA CASES BY AGE

| Age in Years | 0- | 2- | 4- | 6- | 8- | 10- | 12- | 14- | 16- | 18- | 20- | 22- | 24- | 26- | 28- | 30- | 32- | 34- | 36- | 38- | 40- | 42 | 60 | 72 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Cases | 4 | 3 | 6 | 4 | 2 | 1 | 4 | - | - | 1 | - | - | - | - | 1 | 1 | 1 | - | - | - | 2 | 1 | 1 | 1 |

*Trade name for Chloroquine.

infants living in the "operation area" was not known, the Infant Parasite Rate could not be calculated. However, it would be safe to assert that the occurrence of infant cases without any history of their being imported, was strong epidemiological evidence in the favour of local transmission of Malaria.

**Distribution by Sex**

TABLE II

DISTRIBUTION OF MALARIA CASES BY SEX

| Sex | No. of Cases |
|---|---|
| Male | 23 |
| Female | 10 |
| Total | 33 |

From Table II, it will be noticed that there were twice as many male cases as there were female cases. As the distribution of the population by sex of those living here was not known, it would be difficult to make any generalisation on the unequal proportions of male and female cases.

It might be postulated however, that since it was known that A. maculatus preferred to attack in the open* *i.e.*, out of doors, and since generally speaking males are more often outside than inside houses, it would be expected that there would be more male than female cases in a Malaria outbreak transmitted by the vector A. maculatus.

**Distribution by Ethnic Groups**

TABLE III

DISTRIBUTION OF MALARIA CASES BY ETHNIC GROUP

| Ethnic Group | Total of Cases |
|---|---|
| Chinese | 16 |
| Malay | 13 |
| Indian | 4 |
| Others | 0 |
| Total: | 33 |

Table III shows that there were slightly more cases in the Chinese than in the Malays and only a few in Indians. This appeared to be in line with the population distribution by these 3 major ethnic groups living here. It was estimated that there were only slightly fewer Malays than Chinese here in the Kampongs and a much smaller number of Indians concentrated in the P.W.D. labour lines.

However, it might be useful to note that although there were a good number of Europeans, largely British Military personnel living in Fuyong Estate proper shown in Sector 1 (which was just adjacent to the Malay and Chinese kampongs where most cases were found), there were no reported cases in Europeans.

**Geographical Distribution** (see Fig. 2)

It could readily been seen that a large number of cases was concentrated in an area bordering Sectors 2 and 3 *i.e.*, the Malay and the Chinese kampongs. The houses here were situated on the hillslopes just at the verge of the Forest Reserves and intersected by a few ravines. A few sporadic cases were located in the P.W.D. Indian labourers' lines in Sector 5 and one case in a Gurkha soldier in Bukit Batok just outside the "operation area".

These pockets of infection around cluster of houses fitted into the pattern of a disease transmitted by an insect vector. It is known that after having a blood meal the infected mosquitoes do not fly very far away. Except for Sectors 2, 3 and 5 the other Sectors were free from cases.

## ENTOMOLOGY

In any outbreak of Malaria the incrimination and identification of the vector or vectors responsible for the transmission forms an important part of the total exercise to eradicate the disease. Conditions and circumstances leading to the proliferation of the particular vector/s have to be carefully examined and studied so that control measures could be scientifically and accurately applied.

**Vector/s**

As the "operation area" was situated in forested hillocks, and intersected by many ravines, the well-known and dangerous vector A. maculatus was suspected from the very beginning of the outbreak.

Vector surveys took the form of a search for larvae in the seepages and ravines and the trapping of adult mosquitoes in the house of the first reported case and its neighbourhood. These were done by two teams, one from the Central

*Sandosham, A.A. (1965): Malariaology, University of Malaya Press p. 145, 307.

Surveillance Squad of the Quarantine and Epidemiology Section and the other from the Bukit Panjang District Health Office.

When the first case of Malaria was discovered in early August, a larval survey was carried out on 14.8.64 and 15.8.64 within the area of ½ mile radius from the first infected house. The results below showed that collections of the 4th instar larvae of the dangerous vector A. maculatus were made in a seepage pool around a broken sub-soil pipe line in the Dairy Farm area:

1) A. maculatus — in seepage pool from broken sub-soil line within Dairy Farm area (4th instar larval collected)
2) A. vagus — in seepage pool
3) A. kochi — in an earth well
4) A. aitkeni — in shaded seepage pool
5) A. leucosphyrus — in shaded seepage pool.

Adult trapping by the human bait method was also done for 3 nights on 24th, 25th and 26th August, 1964. Only 2 adult A. maculatus were caught. They were not engorged with blood meal. Dissections revealed that they were free from infection. No other vectors were found.

Subsequent to this, further larval collections of A. maculatus were found in a ravine in the Nature Reserve by the side of the Housing and Development Board's Quarry, off the Singapore Dairy Farm Road and in the seepages at the face of the Singapore Granite Quarry Ltd., and at another jungle ravine near the Kramat Habib Ismail off 8½ milestone Bukit Timah Road.

It was therefore confirmed from these vector surveys that A. maculatus was responsible for the present outbreak at Fuyong Estate.

**Bionomics**

Fuyong Estate is situated in the area of Singapore typically described as a "Maculatus Area". Bukit Timah Hill, with an altitude of 581 feet is the highest peak in the central range of the island, is nearby. The base of the low hills in the range is scarred by about 5 granite quarries (Photo B). These granite out-crops are closely

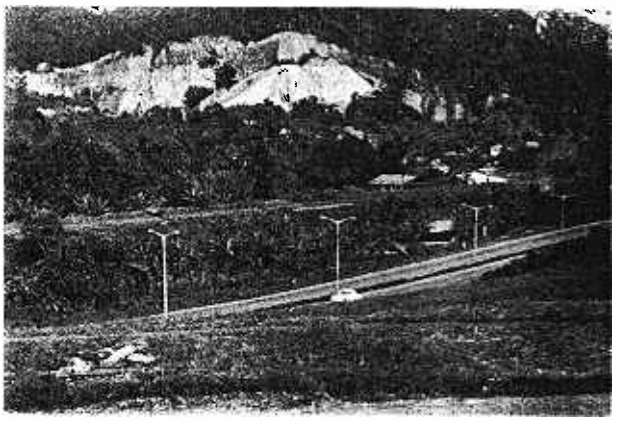


Photo B. Maculatus area—Foothills scarred by granite quarries in Bukit Timah Range.

associated with the abundance of hill foot springs and seepages wherein this dangerous vector A. maculatus may breed. The clearings of jungle foliage for the granite quarries and housing estates in the neighbouring hills have let in the sunlight on these springs and seepages producing the ideal slow flowing, clear, sparkling and sunlight waters which are the haven for A. maculatus to multiply. It has been pointed out that A. maculatus is such an important vector that just a few adults may start transmitting Malaria.*

No other known vectors breed in this region.

**Weather Conditions**

It has been suggested that certain weather conditions *c.g.*, rainfall, have a profound influence on the output of mosquitoes and therefore have an indirect relationship to malaria incidence.** Wet seasons are sometimes recognised to be malarial. It will be noticed from the Meteorological Data tabulated below, that July was the wettest month during this period and it was significant that the first case was admitted to Thomson Road Hospital at the end of July and the subsequent cases appeared in the months of August and September.

A look at the temperature and relative humidity data in Table IV also shows that July had the lowest recorded temperature and the highest recorded average relative humidity. These are known factors conducive to the propagation of mosquitoes and their progeny.†

* Sandosham, A.A. (1963): Personal communication.

** Scharff, J.W., Faris, D.W.G. and Nicholas, W.A. (1937): Malaria-Mosquito control in Singapore, Singapore Government Publication p. 2.

† MacDonald, G. (1957): The Epidemiology and control of Malaria, London Oxford University Press, p. 91.

TABLE IV

METEOROLOGICAL DATA FROM TENGAH AIRFIELD

(Nearest Weather Station to Fuyong Estate)

| Particulars | Year | Months | | | | | |
|---|---|---|---|---|---|---|---|
| | | May | June | July | Aug. | Sept. | Oct. |
| Monthly Rainfall in inches | 1962 | 4·78 | 9·09 | 5·17 | 6·81 | 4·71 | 11·41 |
| | 1963 | 4·00 | 7·00 | 4·55 | 2·53 | 4·35 | 6·00 |
| | 1964 | 9·48 | 6·55 | **17·03** | 5·15 | 7·74 | 14·69 |
| Mean daily Temperature in Degree F | 1962 | 82·3 | 81·3 | 80·4 | 79·7 | 80·7 | 81·5 |
| | 1963 | 83·0 | 81·1 | 81·3 | 81·1 | 81·2 | 81·1 |
| | 1964 | 82·6 | 81·1 | **79·3** | 80·8 | 80·8 | 79·5 |
| Mean daily Relative Humidity (%) | 1962 | 84 | 84 | 83 | 85 | 83 | 84 |
| | 1963 | 83 | 83 | 80 | 81 | 83 | 84 |
| | 1964 | 83 | 83 | **88** | 81 | 84 | 85 |
| Mean Relative Humidity at 9.30 a.m. (%) | 1962 | 79 | 81 | 81 | 82 | 80 | 77 |
| | 1963 | 78 | 78 | 75 | 79 | 79 | 79 |
| | 1964 | 79 | 81 | **85** | 78 | 81 | 81 |

*Source:* Malayan Meteorological Service, Fullerton Building, Singapore.

**Labour conditions**

The "operation area" was strictly under malarial control in the sense that anti-larval measures like oiling and drainage were present even before the 2nd World War as early as in 1936.++

The normal oiling operations carried out prior to the labour trouble were as follows:

Before actual spraying of the oil was done, the water-bearing area was clearly defined and "prepared" *i.e.*, the drains and ditches were rapidly cleared of vegetation and other impediments like pieces of wood, twigs, leaves and bushes, and if necessary, regraded by a category of labourers termed "oiler". If seepages were spread over a vast surface, new ditches were made to collect them so that proper spraying without wastage of oil could be done. When these water-bearing areas are "cleaned", then the sprayers would proceed to spray the oil so that it formed a fine thin film. Particular attention is paid to the head of ravines, to the sides of streams, as well as to the side pockets and permanent obstructions. It would be noticed that both clearing work *i.e.*, including grass cutting and spraying work was done by one category of workers namely "oilers", in the rural areas.

In the city area the "oilers" only performed spraying work with removal of minor impediments but no grass cutting. The clearing work was done by another group of workers called "drainage labourers".

When Integration of Government and City Council took place, the "oilers" in Bukit Panjang district refused to cut grass in May, 1963 and as a result, this became a Union issue. No settlement was reached since then and without the water-bearing areas properly "prepared" the spraying of oil became ineffective. Consequently the breeding of vector A. maculatus must have been profuse and with the density increased, and with the introduction of a single case of malaria from the Federation, the stage was set for transmission to occur.

## MEASURES TAKEN TO INTERRUPT TRANSMISSION

Before embarking on the different measures employed to interrupt the transmission of Malaria, it was necessary to outline the theoretical basis for their implementation.

**Theoretical Basis**

When it was established from the epidemiological evidence collected, that there was a Malaria Focus in this locality, planning of the measures to be taken had to be done immediately. This focus of infection was NEW because it occurred in an area where Malaria had apparently disappeared and also ACTIVE because, besides the possibility of a few imported cases, most of them were indigenous; the vector was

++ Scharff, J.W. (1937): Malaria—Mosquito Control in Singapore, Singapore Government Printer, p. 4.

present and environmental conditions were favourable to transmission.

The main objectives of the measures taken were two-fold:

i) To estimate the size of the reservoir of infection (epidemiological),

ii) To interrupt transmission and eradicate the new and active focus of infection as soon as was practicable (remedial).

The table below gives a schematic idea of the components of the measures taken.

| | | |
|---|---|---|
| Measures Taken | Epidemiological | Passive Detection |
| | | Active Detection |
| | | Focal Blood Survey |
| | Remedial | Mass Drug Administration (Anti-parasite) |
| | | Residual Spraying & Swing Fogging (Anti-adult) |
| | | Oiling and ditching (Anti-larva) |

**Table V—The Components of the Measures Taken**

i) *Estimation of the size of the reservoir of infection*

With an estimated population of about 4,000 residents within the "operation area", it was important that the number of people with parasites in their blood should be ascertained. Once the infected persons were picked out from the mass of non-infected persons, the eradication of the reservoir of infection could be more thorough and complete.

The ways in which this estimation was carried out were as follows:

a) passive detection—People with fever or chills and other suspicious symptoms were asked to report to the Bukit Panjang District Health Office. Private Practitioners and Government Outdoor Clinics in the vicinity were also requested to report suspected cases to the Health Office for blood examinations.

b) active detection—This was a systematic house-to-house search by public health inspectors for fever cases within the "operation area". Blood slides were taken from these cases.

c) focal blood survey—This was a blood survey of about 50 people staying in and around confirmed Malaria cases, notwithstanding whether they had symptoms or not.

All positive cases picked up through these 3 ways, were given a full course of anti-malarial therapy (Chloroquin and Camoprima used).

ii) *Interruption of Transmission and Eradication of the Focus of Infection*

In order to break the chain of transmission, a systematic and concerted attack was made on three fronts namely:

a) The attack on the reservoir of parasites by mass drug administration.

While in the circumstances the most effective and quick way to interrupt the transmission was to eradicate the reservoir of infection by mass drug administration, this took time to organise properly, so that every person as far as possible, living within the "operation area" was covered. As the mass drug administration was organised, the other measures were effected immediately. Ideally, both a suppressive and prophilactic drug should be used. In this instance, Camoprima* was employed.

b) The attack on the Adult Vector by residual spraying and swing-fogging.

Since the transmission was being effected by infected adult vectors, which were at that time still flying around, the spearhead of the attack was more on the adults, although the attack on larvae was also carried out concurrently.

The main methods used were:

1) residual spraying of all houses in the Malarious area using 5% DDT emulsion;

2) swing fogging of the bushes harbouring the vectors using Dieldrex 15.

c) The attack on the Larval Vector by heavy oiling and ditching.

As the vector here was A. maculatus, all the well-known breeding places like seepages around the foothills and the quarries were sprayed with extra anti-malarial oil. Ravines overgrown with grass and thick vegetation were gradully

*Camoprima—a Parke Davis product, consisting of a combination of amodiaquin (camoquin) and primaquin.

cleared. Ditches were made to collect sprawling seepages and enable more effective oiling to be done.

Systematic larval surveys were made to check on the breedings and efficiency of oiling.

**Actual Measures Taken**

Having set forth the theoretical basis or rationale of the measures employed to interrupt the transmission of Malaria and to eradicate this new and active focus of infection, we may now describe the actual measures taken.

**Epidemiological data to estimate size of reservoir of infection**

i) *Passive Detection*

When the possibility of many unconfirmed Malaria cases occurring in the district was known, public health inspectors informed the various private clinics and government dispensaries in the area to report to the District Health Office any case the doctor in attendance suspected to be Malaria, so that a follow-up with blood examination could be made. The response was not very good. Only 2 cases, one each from private and government clinics were confirmed by blood examination. This, however, led the public health team to call up the families and neighbours of positive cases for further blood examinations.

ii) *Active Detection*

A blood survey team of one doctor and 5 public health inspectors went from house-to-house to enquire for "fever cases". Thick and thin films were taken from them for staining and examination for the plasmodium parasite.

Table VI summarises the results of this blood survey of "fever cases". The team took a total of 6 days to cover about 700 houses with an estimated total population of over 4,000 residents in the "operation area".

TABLE VI

RESULTS OF BLOOD SURVEY OF FEVER CASES AT FUYONG ESTATE

| Date | No. of Slides Taken | No. found Positive | % Positive |
|---|---|---|---|
| 28.8.64 | 21 | 3 | 14·29 |
| 29.8.64 | 23 | 6 | 26·09 |
| 1.9.64 | 4 | 0 | 0 |
| 2.9.64 | 12 | 1 | 8·3 |
| 3.9.64 | 5 | 0 | 0 |
| 9.9.64 | 1 | 0 | 0 |
| Total | 66 | 10 | 15·1% |

iii) *Focal Blood Survey*

While the active detection through a blood survey of only "fever cases" was done, it was realized that there could be a possibility of missing some people who had parasites in their blood but were symptomless. This fear was confirmed by the survey of one family done by a medical student who had followed up one of the Malaria cases admitted to the Paediatric Unit in General Hospital. He took blood slides of the whole family of 4 other persons and 2 neighbours. Of these 6 persons only 2 of them had symptoms. But all 6 had positive blood films for plasmodium vivax.

It was because of this, that a focal survey was undertaken. The ideal was to do a blood survey of every person living in the "operation area". But this was a vast project and not likely to be useful nor was it practicable.

The idea of a focal blood survey was to take blood films from about 50 persons living in and around the cluster of positive cases. While in the sectors free from positive cases, a random group of 50 persons would also be surveyed for the parasite. It would reveal to a certain extent, a pattern showing clusters of cases scattered here and there. This was in accordance with diseases transmitted by infected mosquitoes. Mosquitoes do not fly too far away to infect people.

The results of the focal blood survey have been tabulated below.

TABLE VII

RESULTS OF FOCAL BLOOD SURVEY

| Date | No. of Slides Taken | No. found Positive | % Positive |
|---|---|---|---|
| 12.9.64 | 163 | 1 | 0·61 |
| 14.9.64 | 211 | 8 | 3·80 |
| 15.9.64 | 176 | 0 | 0 |
| Total | 550 | 9 | 1·64 |

Only 9 cases were picked up out of a total of 550 people surveyed making a percentage of 1·64.

When the 9 cases were tabulated according to the sectors from which they came as in Table VIII, it could be readily observed that they were located in sectors 2 & 3 *i.e.* the Malay and Chinese kampongs respectively. No cases were discovered in the other sectors.

TABLE VIII

FOCAL BLOOD SURVEY BY SECTOR

| Sector | No. of Slides Taken | No. found positive |
|---|---|---|
| 1 | 54 | 0 |
| 2 | 110 | 1 |
| 3 | 125 | 8 |
| 4 | 75 | 0 |
| 5 | 80 | 0 |
| 6 | 55 | 0 |
| 7 | 51 | 0 |
| Total | 550 | 9 |

iv) *Summary of epidemiological data*

From the three ways described above, passive detection, active detection and focal blood survey, a total of 21 cases was discovered from an estimated population of over 4,000 residents making a parasite rate of approximately 0·52%. The majority of cases were from the Malay and Chinese kampongs (sectors 2 and 3).

**Measures employed to interrupt transmission and eradicate the focus of infection (Remedial)**

This was the phase of attack and as described earlier, the operations were directed on three fronts namely, the reservoir of parasites, the adult vector and the larval vector in the order of importance though not in the order of chronological sequence.

i) *Attack on Parasite by Mass Drug Administration*

In the prevailing circumstances mass drug administration to all the residents in the locality constituted by far the most effective measure to break the transmission speedily. As administrative problems associated with the implementation took time to organise, because of the large number of residents involved and differing posology of the drug Camoprima to be employed, it was not the first measure to be effected in this campaign.

The choice of a suitable drug to be used had to be considered carefully. There was a wide variety of anti-malarial drugs available, with different side effects, prices and ease of administration. These factors had to be weighed and balanced before a suitable one was derived. Ideally, for a mass administration programme the drug of choice should be one which could act as a blood schizonticide and also a tissue schizonticide because vivax infections were known for relapses.

The drug used for this campaign was Camoprima. There were 2 types of tablets. The one for adults contains 15 mg. primaquine and 150 mg. amodiaquine (in terms of base) and the preparation for children termed "infatabs" contains 15 mg. primaquine and only 75 mg. amodiaquine. The different doses for different age groups were prepacked in envelopes ready for distribution.

A handbill explaining the outbreak and the drug to be given was distributed to the residents. The team for the operation consisted of 22 public health inspectors and 2 doctors. The public health inspectors were subdivided into seven groups of 2 or 3 inspectors in each group to cover all the seven sectors. They went systematically from house to house and registered all the persons before giving them the correct packet of drugs.

The drug administration programme was that 3 doses would be given at weekly intervals. A week after the first dose, on the revisit for the second dose, symptoms of side effects were recorded. The same procedure was applied to the revisit for the third dose. Suspicious cases were noted and blood slides taken and investigations were instituted. A week after the third dose another revisit was made to record the side effects of the drug.

Table IX summarises the results of the mass drug administration.

Side effects were classified as severe or moderate. Those with severe symptoms necessitated discontinuing the prophylaxis. The severe side effects were vomitting and diarrhoea, abdominal pain, rash, headache, breathlessness and aggravation of bronchial asthma. The milder symptoms were nausea, giddiness, chills, itch, backache and chills. Table X gives the number of people having the side effects.

It will be noticed that out of over 4,000 persons given for each dose, an average of 45 persons had side effects. This was about 1%.

ii) *Attack on the Adult Vector*

The operations against the adult mosquitoes were carried out early at the wake of the outbreak. They consisted of residual spraying of houses and swing-fogging of the bushes and valleys.

a) *Residual Spraying*

The insecticide used initially was a solution of Gammexane. But as there were complaints of the white powdery residue left on walls and floors, it was

TABLE IX

MASS DRUG ADMINISTRATION NUMBER OF DOSES GIVEN BY AGE GROUPS

| Age Groups \ Dose | First on 16.9.64 & 17.9.64 | Second on 23.9.64 | 30.9.64 on Third | Total |
|---|---|---|---|---|
| 6 months to 23 months | 230 | 231 | 229 | 690 |
| 2 years to under 4 years | 316 | 320 | 317 | 953 |
| 4 years to under 8 years | 590 | 604 | 600 | 1,794 |
| 8 years to under 14 years | 684 | 695 | 691 | 2,070 |
| 14 years and above | 2,220 | 2,267 | 2,225 | 6,712 |
| Total | 4,040 | 4,117 | 4,062 | 12,219 |

TABLE X

SIDE EFFECTS OF MASS DRUG ADMINISTRATION

| Nature of Side Effects | No. having them after first dose (23.9.64) | No. having them after second dose (30.9.64) | No. having them after third dose (2.10.64) |
|---|---|---|---|
| Severe | 6 | 9 | 0 |
| Moderate | 40 | 50 | 30 |
| Total | 46 | 59 | 30 |

changed to D.D.T. From the 25% D.D.T. emulsion, 5% solution was made for the spraying.

The procedure followed for the spraying activities, was that public health inspectors first informed the residents in the area, that they had to prepare their houses by removing all articles like photographs or drawings or paper from walls and cover up all perishable materials and foodstuffs with newspapers before the team of sprayers arrive in a day or two. One sprayer and two labourers with a supervisor formed a spraying team. There were 3 teams conducting the operations. The walls of both inside and outside of houses were sprayed at an average rate of 200 mg. per sq. foot D.D.T. of wall surface (see photo C). A total of about 690 houses were covered over a period of 6 weeks.

Photo C. Residual spraying with D.D.T.

b) *Swing Fogging*

As it was known that adult A. maculatus often rest outdoors in the bushes and valleys, swing fogging was considered a useful adjunct to the residual spraying activities. In order to carry this out effectively the swing fogging operations had to begin at dawn because the air would be heavier and would allow the fog produced to remain on the ground level for maximum effect, before the hot air caused it to rise with the heat of the sun. A specific day was planned for the operations. The day before, inspectors distributed a notice to residents informing them of the scheduled activities because the fogging machine usually made loud spluttering noises and may alarm villagers especially when heard before daybreak.

Six fogging machines were used and the insecticide was Dieldrex 15 (see photo D). The whole operation lasted about 5 hours. Bushes, outhouses and valleys within the "operation area" were covered.

Photo D. Swing fogging with Dieldrex 15.

iii) *Attack on Larval Vector*

As described in proceeding paragraphs, this area was typically a "Maculatus Area" because the topography and environmental conditions were ideally suited for the breeding of the vector A. maculatus. There were a number of dangerous ravines like the one in the Dairy Farm area, Housing and Development Board Quarry and the forest edge near the Kramat Habib Ismail. These ravines had been overgrown with vegetation and were inaccessible to the "oilers" to do an effective job. Also many seepages and sprawling side pockets of clear water in the granite quarries formed the main breeding grounds.

Drainage labourers were deployed from their normal work of maintaining permanent concrete drains to clear these ravines of their vegetation and they were also required to dig proper earth ditches to collect sprawling seepages so that these could be drained away (see photo E). About 30 men were employed in this work. Due to the difficult terrain and vast area involved, they took over three months to complete the job.

Photo E. Recently dug earth ditches to collect sprawling seepages and drain them away.

As soon as a ravine was cleared, the "oilers" moved in to do heavy oiling with anti-malarial oil mixture, at the rate of about 25 Imperial gallons per acre of water surface. Particular attention was paid to the side pockets. Regular weekly oiling was maintained.

## DISCUSSION

It may be pertinent at this juncture to collate the various factors leading to the outbreak at Fuyong Estate and discuss the vulnerable position of Singapore to the resumption of Malaria transmission after the disease had apparently disappeared from the Island.

### Site of Fuyong Estate

It has been said that if Malaria were to break out again in a relatively free Singapore, it would be around the Bukit Timah Forest Reserves. This was because the topography of the area was such as to be conducive to the propagation of the vector A. maculatus. The terrain is difficult with many granite hillocks, dangerous ravines, sprawling seepages and outcrops of springs. All these provided the breeding places for the vector.

### Weather conditions

From the meteorological data presented earlier, it was pointed out that prior to the date of the first reported case in early August of 1964, the weather conditions from the point of

view of a good rainfall, high relative humidity and optimum temperature, all favoured the proliferation of mosquitoes and no doubt of the vector A. maculatus also.

### Slack in Control Measures

There was a slack in the routine control measures for over a year due to labour problems. As a result, ravines were overgrown with vegetation, sprawling seepages were not drained away by the digging of ditches and the oiling was ineffective because water collections with overgrowths were inaccessible to "oilers". Hence without the checking force of a high standard of control measures, the proliferation of the vector was inevitable.

The 3 factors mentioned above must have combined to produce a situation for the increase in the density of the vector to a critical point. But without the presence of the malarial parasite, transmission still could not have occurred. However, the next two factors will show how easily the parasite could be introduced.

### Malarious Regions

There is no doubt that Singapore is surrounded by Malarious areas. Just across the causeway to the north is the main hinterland of Johore, where any case of pyrexia of unknown origin has to be diagnosed as Malaria, until proved otherwise. Outbreaks have been common in the districts of Pontian and Kota Tinggi. Almost hugging its other coasts towards the east, west and south are scattered Indonesian islands of the Rhio archipelago which are also Malarious. These surrounding regions provide the potential source of infection which could easily be introduced into the island because of the comparatively free communication between the peninsula and Singapore.

### Mobility of Population

Singapore has a relatively mobile population when compared to the peninsular mainland. A good segment of its people living in the northern section of the island like Upper Bukit Timah and Woodlands areas, very often cross the causeway to visit relatives, friends or go on business trips to the southern parts of Johore. They may stay for a few days, during which they become infected and then return to Singapore. It was therefore of some significance that the first reported case gave a history of a visit to Johore. The likelihood of an imported case sparking off the transmission of Malaria in the present outbreak was very real.

### Malaria, a notifiable Disease

In a place like Singapore where indigenous Malaria has apparently disappeared but where a large number of imported cases are still being reported[10], an efficient and constant surveillance of cases becomes mandatory. The source of any case must be thoroughly investigated and spread from that case prevented. This entails compulsory notification and swift action. It may be pointed out that Malaria has just recently been made a legally notifiable disease under the Quarantine and Prevention of Disease Ordinance (1955). Hitherto notification was purely voluntary. It is possible that many general practitioners have not yet become fully aware that they have now to notify all malaria cases.

When a country is malarious in the sense that cases are rampant, then in such a situation, compulsory notification has relatively not as much epidemiological value. But when a country is gradually being freed from Malaria, every single case assumes importance because it is a reservoir of infection and potentially dangerous. It must be eradicated before it sparks off an outbreak when there is a sufficient concentration of vectors around. Eradication of parasites in a few cases by chemotherapy is an easier task than eradication of the vectors. Hence notification is essential so that the reservoir of infection could promptly be eliminated and the danger of an outbreak prevented. The inclusion of Malaria in the list of notifiable disease though belated is a step in the right direction for the eradication of any new focus of infection.

The essence of a successful anti-malarial service is that there should be a surveillance organisation efficient enough to recognise reintroduction at the earliest possible moment.

### Appraisal of Anti-malarial Measures

The aim of the anti-malarial measures in Singapore has been that of Malaria Control rather than Malaria Eradication. These two concepts must be distinguished, for the ethos of the measures employed are not entirely the

[10]In 1963, a total of 273 Malaria cases were reported, 20 of which were suspected to be of doubtful local origin. In 1964, a total of 180 Malaria cases were reported. 41 were indigenous cases. In 1965, 201 Malaria cases were reported and in 1966, 216 Malaria cases were reported.

same. (See definitions by MacDonald[11]). There is also a third concept of Vector Eradication which though an attractive idea is not so generally attainable[2] in many countries and also in Singapore, because of the presence of a number of different species of vectors here *viz.* A. maculatus, A. sundaicus, and A. nigerrimus. There is hence a necessity to re-examine the programme for continuous and unending Malarial Control work.

The control measures hitherto employed have been largely anti-larval, in the form of permanent drainage and oiling operations. This is correct in view of the fact that Singapore is very urbanised. Anti-adult activities like residual spraying of all houses becomes a tremendous task and not practicable. However, there is this question of permanent works versus oiling which should be re-assessed again, especially in the administrative rural areas of Singapore like the Bukit Panjang and Jurong Districts.

In the early 1930's the pioneers of Malaria control for the rural areas laid strong foundadations for a good anti-malarial service. They carried out a large number of drainage schemes rendering many dangerous ravines safe by constructing many miles of open channel drains, subsoil pipes and familar wash-wells. Construction activities were suspended after 1959. But despite the large amount of permanent concrete drains laid since the 1930's, there still remains a number of ravines in the more thickly forested hills where at present there are only natural earth drains. These have not been made permanent then, because the hillocks are of granite origin and earmarked to be tapped. To do so would have been uneconomical if quarries were to be opened up. In such a situation, the temporary measure of oiling was carried out.

As mentioned previously, before spraying of oil could take place, the water-bearing areas have to be clared of impediments and vegetation. Hence the human factor has to be considered. In this instance, labour controversy became an important factor leading to the proliferation of the vector.

There is no doubt that permanent works will in the long run be more economical after its high initial outlay than the moderate cost but continuous temporary control measures of oiling*. Since there are still a number of places where conditions allow permanent drains to be laid, the resumption of construction works is advocated.

## SUMMARY

1. A brief history of Malaria in Singapore was given.
2. The epidemiological features of the malaria outbreak at Fuyong Estate was described.
3. The likely factors leading to the outbreak were traced.
4. Measures taken to intercept the transmission of malaria were reported.
5. An appraisal of the anti-malarial service was made.

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[11] MacDonald, G. (1958): The Epidemiology & Control of Malaria, London Oxford University Press—p. 174. Definitions of:—

a) *Malaria Eradication* means the ending of the transmission of Malaria and of the reservoir of infective cases in a campaign limited in time and carried to such a degree of perfection that when it comes to an end there is no resumption of transmission.

b) *Malaria Control* implies the reduction of the disease to a prevalence where it is no longer a serious public health problem, carrying the implication that the programme of work will be unending, maintaining control by continuous active work.

c) *Vector Eradication* means the total eradication of all members of the vector species concerned so that they do not breed when campaign against them is ended. Attractive idea but not so generally attainable that it can be recognised as an objective except in special circumstances.

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