THE WHAMPOA-KALLANG MALARIA OUTBREAK, 1974-5

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SYNOPSIS

An unusually large post-war malaria outbreak, the first of its kind in a highly urbanized area of Singapore, is reported. The outbreak was traced to at least one imported case from a neighbouring country endemic for malaria.

A total of 82 cases (76 *vivax*, 4 *falciparum* and 2 mixed) was reported. The majority (30.5%) were in the 15-24 age group. The highest morbidity rate, 2.29 per thousand population, occurred in the 25-34 age group. More males than females (1.16 : 1) were affected.

Both *Anopheles sundaicus* and *An. letifer* were present in the outbreak area, but available evidence indicated the latter species to be the more likely vector involved in the outbreak. This is the first time in Singapore's known history that this vector had ever been implicated in an outbreak in a highly urbanized area.

INTRODUCTION

This paper reports the largest post-war malaria outbreak of 82 cases with no deaths in a highly urbanized area of Singapore, the Whampoa-Kallang area which is largely the Kallang Basin. The outbreak occurred between December 1974 and March 1975, about 10 years after the area first came under urban development in 1963.

Kallang Basin, once a swamp, was known for several malaria outbreaks in the past.

Before World War II, Scharff *et al* (1937) reported an outbreak in 1935 due to *Anopheles sundaicus* breeding in numerous fish ponds. Sandosham (1965) mentioned of considerable malaria in Kallang Basin and of the presence of *An. sundaicus* as the only vector in the area during the Japanese Occupation. Intense breeding of this vector was found in numerous damaged derelict 'tongkangs' and other boats in the area during that time as a result of interruption of antimalarial works by military activities.

After the War, *An. sundaicus* continued to breed in Kallang Basin and malaria was reported from time to time. In 1948, an outbreak of 42 cases was reported. In 1971, 5 locally-contracted cases were notified from the area. In 1973, another small localised outbreak of 4 cases was reported around the Rangoon Road area to the west of the Kallang River.

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GEOGRAPHICAL FEATURES OF THE OUTBREAK AREA

In 1963, Kallang Basin came under urban development. Earthworks began that year. By 1968, 11 blocks of HDB flats with 2,344 housing units were built in Kallang Basin Neighbourhood 1 (Table I). An estimated 11,700 people soon occupied the flats. Construction is still continuing in the area at the time of writing this paper (February 1976). It is anticipated that by the end of 1976, a total of 89 blocks of HDB flats covering a total of 18,383 housing units would have been built, and an estimated population of 92,400 people would be occupying these flats (Table I).

Thus, rapid urbanization and industrialization had transformed the former swampy area dotted with fish and prawn culture ponds, into a well developed, residential, commercial and industrial estate. More than 90% of the area has now been completely developed.

The area is low-lying and drained by Kallang River and its main tributary, the Whampoa River. It is subjected to tidal influence. The daily maximum and minimum high and low water levels for the outbreak period, from October 1974 to March 1975, are shown in Fig. 1. The average maximum high water level for the six months was 2.74 m while the average minimum low water level was 0.55 m (Ministry of Culture, office diary, 1974, 1975). The highest water level in 1974 (3.2 m) was recorded on the last two days of that year (30-31 Dec. 74) while that for 1975 (3.3 m) was recorded on 29 and 30 Jan. 75 (Fig. 1).

DESCRIPTION OF THE OUTBREAK

The first case was notified as *vivax* malaria on 26 Dec. 74 with onset of fever on 13 Dec. 74. The patient was a 60 year-old Indian housewife staying at St. Francis Road. She was in India in 1969 and since then had not been to any malaria receptive areas. Four fever cases in the neighbouring houses were subsequently confirmed from blood films as *Plasmodium vivax* infections. Within one week, 8 locally-contracted malaria cases were notified, all within 0.4 km radius from the residence of the first case.

An outbreak was declared on 2 Jan. 75. By 18 Jan. 75, 18 cases were reported, all locally infected with *P. vivax* except for 2 cases in a family (husband and wife) who were infected with both *P. vivax* and *P. falciparum*. Another 12 locally-contracted *vivax* cases with onsets in late December and early January were notified within a month, bringing the total to 30 cases. An average of 12 cases were notified weekly for the subsequent 2 weeks and thereafter, 4 cases weekly. By 26 Feb. 75, a total of 71 cases were reported. Sporadic cases continued to be notified

TABLE I

HIGHRISE HOUSING UNITS AND ESTIMATED POPULATION IN KALLANG BASIN*

Kallang Basin Housing Project Phase	Project Period		No. of Blocks	No. of Units	Estimated Population
	Year Began	Year Ended			
Kallang Basin Neighbourhood 1 Phase 1	1964†	1968	11	2,344	11,700
Kallang Basin Neighbourhood 1 Phase 2	1969	1973	12	2,216	11,100
Kallang Basin Neighbourhood 2	1966	1972	13	2,191	11,000
Kallang Basin Neighbourhood 3	1971	1974	18	4,293	21,500
Kallang Basin Neighbourhood 4	1973	1976‡	21	3,896	19,500
Kallang Basin/Sims Avenue Phase 1	1967	1971	1	348	1,800
Kallang Basin/Sims Avenue Phase 2	1969	1972	4	855	4,500
Kallang Basin/Sims Avenue Phase 3	1971	1973	7	1,580	8,000
Kallang Basin/Sims Avenue Phase 4	1973	1976‡	2	660	3,300
Total	—	—	89	18,383	92,400

* Data from Housing and Development Board, Singapore.
† Earthworks began in 1963.
‡ Tentative date.

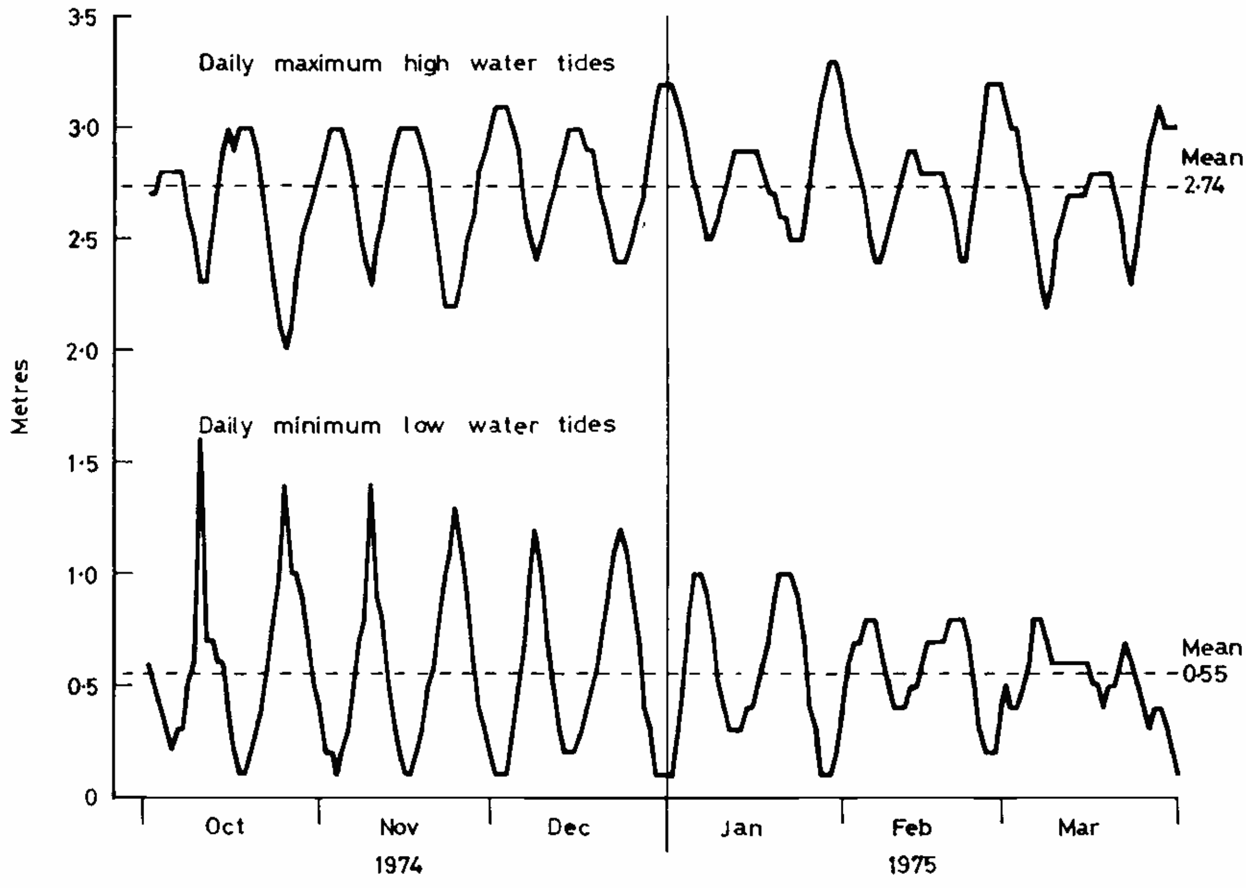

Fig. 1. Daily maximum and minimum tide-levels, 1974-5.

and by 21 Mar. 75, the total number of cases reported was 80. The 82nd and last case, was notified in June 75. This was an 83 year-old man with early onset in December.

ANALYSIS OF CASES

1. Time distribution of cases

Fig. 2 shows the time distribution of cases based on dates of onset. The peak of the outbreak occurred in the 2nd week. Another smaller peak occurred during the 5th week just after intensified vector control measures were taken earlier on. This was probably due to the initial crops of cases acting as reservoirs of infection for the secondary cases.

With the insecticides taking effect, the number of cases dropped rapidly and the outbreak was completely controlled by the 13th week.

2. Distribution of parasite species

Table II shows the distribution of parasite species. The outbreak was dominated by *P. vivax* infection.

3. Age and sex distribution

All age groups were involved (Table III). The youngest patient was a 2 year-old boy and the oldest an 83 year-old man. The majority (30.5%) were in the 15-24 age group. This was higher than the 21.6% age distribution of the population in the area. The highest morbidity rate was in the 25-34 age group. This was due probably to greater mobility and exposure to the vectors of the people in this age group.

More males than females were affected (M/F = 1.16).

4. Ethnic distribution

The ethnic distribution of the cases was as follows: Chinese (70.7%), Malays (11.0%), Indians (14.6%), and others (3.7%) (Table IV).

5. Geographical distribution

Most of the cases were distributed to the west of Kallang River and especially within 0.8 km radius of both sides of Whampoa River (Fig. 3).

EPIDEMIOLOGICAL INVESTIGATIONS

1. Case surveillance

Active case detection especially amongst family and close contacts was carried out. 6,077 residents in the locality were screened and of the 144 blood films taken from those with fever, 17 (11.8%) were positive for malaria parasites.

Actions were also taken to check on absentees from schools in the vicinity. All medical practitioners were alerted on the situation. Special arrangements were made to examine blood films taken by private medical practitioners. 3 of the 9 films submitted by them were positive for malaria parasites. It was found that most private medical practitioners were treating fever cases as malaria on presumptive grounds, and with chloroquine only. A malaria case was not notified to the Authority at the request of the patient.

A 15 year-old boy from a malarious area in a neighbouring country, working and staying in a tyre shop at Lavender Street, was found positive for *P. vivax* during a case surveillance on 10 Jan. 75. Further investigations revealed that he came to Singapore on 14 Nov. 74 and developed fever 4 days after arrival. He was treated by a private medical practitioner for *vivax* malaria (confirmed by a blood film) with chloroquine only on 28 Nov. 74. This imported case was probably responsible for the initial *vivax* malaria cases of the outbreak, as subsequent *vivax* cases were located in the same vicinity, within 1.6 km (1 mile) radius from this index case.

The first introduced *vivax* case developed symptoms within 4 weeks from the onset of the index case and 2 weeks after he was treated by the medical practitioner.

2. Vector surveillance

A total of 45 larval surveys were carried out between 31 Dec. 74 and 5 Apr. 75. Two were positive for *Anopheles sundaicus* breeding. Four breedings were detected in puddles in the reclaimed land at Nicoll Highway and Sumbawa Road on 7 and 8 Jan. 75. These were within 1.6 km radius from the imported case at Lavender Street (Fig. 3).

Adult trapping was also concurrently carried out. A total of 64 trapping nights involving 512 man-hours were spent. One *An. sundaicus* female and one *An. letifer* female were caught among 1,048 culicines. The *An. sundaicus* female, caught on 20 Feb. 75, when dissected, was found to be negative for sporozoites. The *An. letifer* female was caught on 23 Jan. 75 near a patient's home by the side of Whampoa River. Whether or not it was infected with sporozoites could not be established as it was too dried up to be dissected.

CONTROL OF OUTBREAK

Control of the outbreak was directed mainly against the suspected vector *An. sundaicus.* This included residual spraying of premises to interrupt transmission, swingfogging to kill infected adult mosquitoes, clearing of overgrown vegetation to remove their potential resting places, and intensified control of potential breeding habitats on a 3-day oiling cycle.

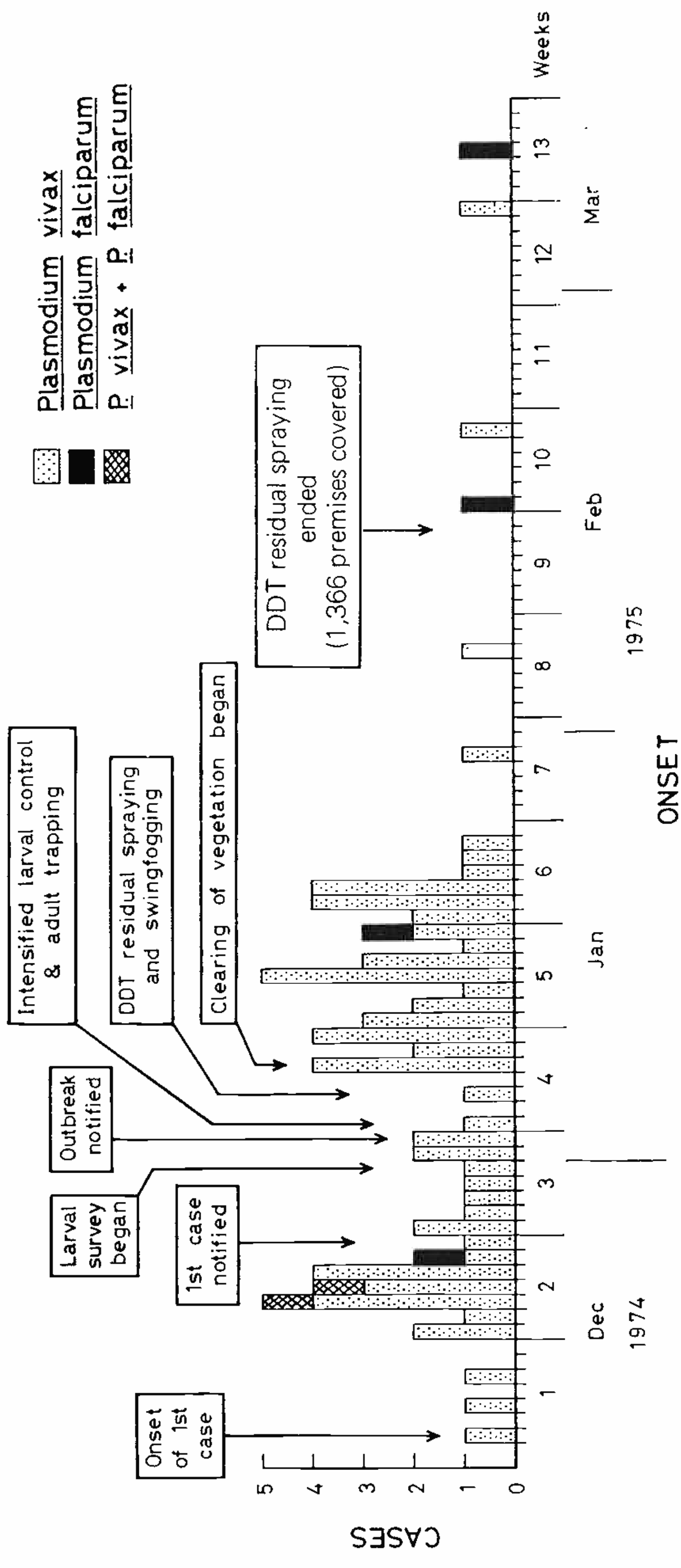

Fig. 2. Time distribution of malaria cases (based on dates of onset).

TABLE II

DISTRIBUTION OF PARASITE SPECIES

Parasite species	No. of Cases	%
P. vivax	76	92.7
P. falciparum	4	4.9
Mixed (Pv + Pf)	2	2.4
Total	82	100.0

TABLE III

DISTRIBUTION OF CASES BY AGE AND SEX

Age in years	Human Population*				Malaria Cases				Morbidity rate per 1,000
	Kallang	Whampoa	Total	%	Female	Male	Total	%	
0— 4	2,948	2,655	5,603	9.5	I	2	3	3.7	0.54
5—14	8,291	9,630	17,921	30.4	12	5	17	20.7	0.95
15—24	6,063	6,641	12,704	21.6	10	15	25	30.5	1.97
25—34	3,380	3,170	6,550	11.1	6	9	15	18.3	2.29
35—44	2,918	3,529	6,447	11.0	7	4	11	13.4	1.71
45—54	2,136	2,355	4,491	7.6	0	4	4	4.9	0.89
55+	2,785	2,400	5,185	8.8	2	5	7	8.5	1.35
Total	28,521	30,380	58,901	100.0	38	44	82	100.0	1.39

* Based on 1970 census, Dept. of Statistics, Singapore.

TABLE IV

DISTRIBUTION OF CASES BY ETHNIC GROUPS

Ethnic group	Population by ethnic groups *				Malaria Cases	
	Kallang	Whampoa	Total	%	No.	%
Chinese	24,994	26,489	51,483	87.4	58	70.7
Malays	1,747	1,047	2,794	4.8	9	11.0
Indians	1,599	2,477	4,076	6.9	12	14.6
Others	181	367	548	0.9	3	3.7
Total	28,521	30,380	58,901	100.0	82	100.0

*Based on 1970 census, Dept. of Statistics, Singapore.

1. Residual spraying

This was the most important measure in the control of the outbreak. It was not implemented until 6 Jan. 75, four weeks after the onset of symptoms of the first case on 13 Dec. 74. The spraying operation took six weeks to complete and ended on 15 Feb. 75. A total of 1,366 premises were sprayed with 5% DDT. 409 litres of DDT emulsion and 8 kgm of DDT wettable powder were used in the operation.

2. Swingfogging

This was also one of the most important measures in interrupting malaria transmission in the area. To destroy infected adult vectors, 0.2% bioresmethrin from Reslin 10/10 (the trade name for an insecticide containing 10% of the active ingredient bioresmethrin, a synthetic pyrethroid, and 10% of the synergist piperonyl butoxide) was dispensed in kerosene by adding one part of Reslin to 49 parts of kerosene.

The operation began on 6 Jan. 75 and ended on 12 Mar. 75. A total of 1,939 premises were fogged. Fogging was also directed at the rank vegetation surrounding the construction sites along Whampoa River between Jalan Kebun Limau and Serangoon Road on 21 Jan. 75, in the grounds of Singapore Vocational Institute on 23 Jan. 75, and in the Kolam Ayer area on 21 Feb. 75.

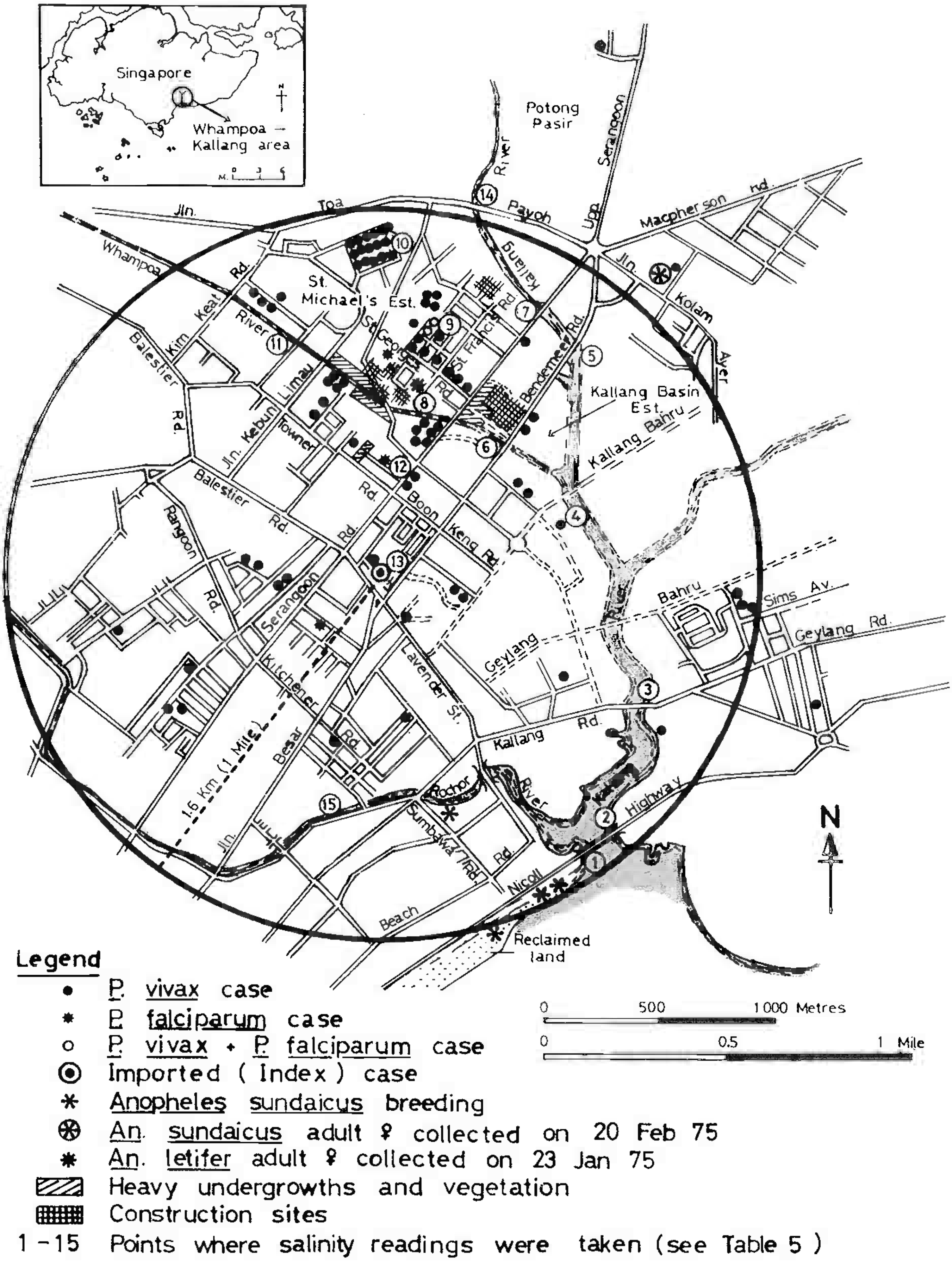

Fig. 3. Geographical distribution of cases in relation to tidal influence and adult harbourages at Whampoa-Kallang area, 1974-5.

3. Clearing of vegetation

Vegetation along the drainage reserve of Whampoa River at Jalan Kebun Limau and Serangoon Road was cleared in the early part of January 1975. Clearance of the heavy undergrowths in an undulating plot of land next to the Housing & Development Board flats at St. George's Road began in February 1975 and was completed in March 1975.

4. Drug prophylaxis

This was not indicated as the outbreak was localised and vector control measures implemented had been effective to contain the outbreak.

DISCUSSION

Malaria outbreaks within Singapore city in highly urbanized areas were considered virtually impossible (Chan, *et al*, 1971) because of the virtual absence of vector breeding habitats within the city due to effective routine antilarval measures and to almost total urbanization of the city. The present outbreak therefore shows that there was a breakdown in vector control.

Retrospective evaluation shows a combination of three factors to be responsible for the outbreak:

(1) constant influx of parasite carriers from neighbouring malaria endemic countries;

(2) a dense human population with little or no immunity; and

(3) presence of vectors in the area.

1. Influx of parasite carriers

The constant influx of parasite carriers from neighbouring malaria endemic countries is one of the most important factors in the origin of local malaria outbreaks. There is no doubt that parasite carriers amongst contract workers coming to Singapore could trigger off an outbreak in the presence of vectors. The index case, a 15 year-old foreigner, was shown epidemiologically to be the reservoir of infection for the early cases of the outbreak. Other undetected parasite carriers from neighbouring endemic countries could have similarly given rise to other cases in the outbreak.

2. Lack of immunity

The majority of children born in the 1950s had by 1975 become teenagers and young adults below 25 years of age. Due to the disappearance of indigenous malaria by the mid-1950s (Chew, 1968), they had never contracted malaria previously and were therefore without immunity against the disease when it struck. It is thus significant that this age group had the highest malaria attack rate (30.5% in the outbreak were 15-24 years old, and 54.9% of the total cases were below 25 years of age).

3. Presence of vectors

The detection of vector breeding and adults in the area indicated that there was a breakdown in vector control services and that the outbreak was due to the presence of infected adult vectors. The occurrence of the first few malaria cases on either side of large patches of overgrown vegetation (trees, shrubs and grasses) along the Whampoa River at Jalan Kebun Limau and Serangoon Road, suggested strongly that adult vectors had been resting in the thick vegetation.

4. Vectors responsible for outbreak

No conclusive evidence could be adduced as to which of the 3 possible vectors present in Singapore (i.e. *An. maculatus*, *An. sundaicus* and *An. letifer*) was actually responsible for the outbreak. However, *An. maculatus* could be dismissed altogether. It was not collected in any of the larval surveys or adult trappings. Besides, the brackish terrain was unsuitable for its breeding. Being low-lying and subject to constant tidal influence, it was not conducive to *maculatus* breeding. No suitable freshwater habitats were found. Although adult females of the species could have flown or been blown by winds into the area from adjacent areas, this is considered unlikely.

The available evidence and data collected indicate that either *An. sundaicus* or *An. letifer* or both could have caused the outbreak. For *An. sundaicus*, both larval breeding and adult presence were demonstrated. Furthermore, the largely brackish area had a history of malaria outbreaks. However, there are difficulties in explaining the vectorial role of *An. sundaicus* in the area. First, its breeding was too low for transmission to occur. For an outbreak to occur at all, there must have been about 2,500 females in the area for one single female to be infective, the sporozoite rate of *sundaicus* in nature being 0.04% or 1 in 2,500. The 4 habitats with low breeding and the single uninfected female trapped in 512 man-hours, show that the minimum density required for the species to transmit malaria was not available during the outbreak period. Second, breeding of the species was located some distance away from the initial and most active site of transmission, namely, around St. Michael's Estate. The 4 breeding habitats located at the coastal region where land reclamation was taking place, were about 3 km or 2 miles away from St. Michael's Estate. This distance is at about the limit of the flight range of the vector. Tidal salinity readings taken in the outbreak area during the outbreak period one year later, however, show that *An. sundaicus* breeding in the area was possible (Table V).

An. letifer could also be incriminated as responsible for the outbreak. It is a typical vector of coastal low lands (Sandosham, 1965; Reid, 1968), well exemplified by the outbreak area. Its breeding occurs principally in "pools and drains . . . of the coastal plain", typically in "villages, estates, and

TABLE V

SALINITY READINGS AT VARIOUS POINTS IN THE OUTBREAK AREA TAKEN DURING THE OUTBREAK PERIOD (NOVEMBER-MARCH)

Station No.	Locality	% sea water			
		14 Nov 75	22 Nov 75	13 Feb 76	17 Feb 76
1.	Kallang River Mouth	71.1	28.7	80.0	83.2
2.	Kallang River under Merdeka Bridge	69.5	25.0	68.4	81.1
3.	Kallang River under Kallang Road	39.5	10.3	38.4	83.2
4.	Kallang River, Kallang Close	14.5	0.9	0.5	83.2
* 5.	Kallang River, Bendemeer Road	7.9	0.7	0.4	50.5
6.	Whampoa River, Bendemeer Road	16.1	0.6	0.5	82.6
7.	Kallang River, Serangoon Road	2.1	3.2	39.2	59.5
8.	Whampoa River, St. George's Road	8.2	0.6	31.3	54.2
9.	Drain, St. Wilfrid Road	0.5	2.1	5.2	0.6
10.	Drain, St. Michael's Estate	1.4	1.6	0.4	39.0
11.	Whampoa River near Jln. Kebun Limau	2.4	4.2	0.6	84.2
12.	Drain, Bajerai Lane	0.3	4.5	1.2	1.2
13.	Drain, Lavender Street	0.9	0.0	0.3	0.7
14.	Kallang River, Jln. Toa Payoh	0.8	3.7	38.7	71.6
15.	Geylang River, Jln. Besar	0.8	2.1	0.4	1.3
	Time of sampling (hours)	1500-1600	0920-1205	1435-1610	1055-1200
	Tide	low	low	low	high
	Precipitation	dry	dry	dry	rainy
	pH	6.5-7.6	6.6-8.2	6.7-7.7	6.1-7.6

*Stations 5-12 within box refer to outbreak area where malaria transmission was most active (see Fig. 3).

Notes:

1. Readings in above table were determined from a salinity meter YSI (Yellow Springs Instrument) Model 33 S-C-T (Salinity-Conductivity-Temperature) from the Anti-Pollution Unit, Princess House, Alexandra Road, Singapore 3.
2. The chloride content in parts per million (ppm) may be calculated from the following formula:

$$\text{ppm Cl} = \frac{\text{Salinity \%}}{1.8} \times 10^4$$

3. The following scale would also be helpful in determining chloride content from sea-water:

0	25	50	75	100	% sea water
0	0.9	1.8	2.7	3.6	Salinity %
0	5,000	10,000	15,000	20,000	ppm Chloride

Remarks

1. *An. sundaicus* breeds in brackish water with a range of 0.15 to 97.1% sea-water. Fair numbers breed in 3-50% sea-water. Maximum breeding occurs in 10-20% sea-water (Sandosham, 1965).
2. *An. letifer* breeds in fresh-water with not more than 3% sea-water (Sandosham, 1965).

kampongs situated close to a river . . . in the narrow strip of land that is generally left uncleared along the river bank'' (Sandosham, 1965). This description of Sandosham (1965) fits perfectly the immediate terrain of the original site of the outbreak where transmission was most active. *An. letifer* also ''has preference for water discoloured by decaying leaves, etc., lying on peaty land with vegetation in or overhanging the water'' (Sandosham, 1965), a description which again fits perfectly the potential habitats found in the outbreak area. That *An. letifer* was a most likely vector is also supported by the fact that it is ''a long-lived anopheline under natural conditions'', with an average life span of 38 days and a range of 20-59 days under laboratory conditions (Sandosham, 1965). Dissections of wild-caught *An. letifer* in Klang, Malaysia, showed a high natural sporozoite rate of 0.7%, i.e. one infective female in every 143. In the coastal plain of Selangor, *An. letifer* was found to be more prevalent during the last four months of the year (i.e. September-December when rainfall was high, its peak occurring in October (Sandosham, 1965). This October peak periodicity again fits well with the time of malaria transmission in the present outbreak.

Yet another factor favouring *An. letifer's* vectorial role in the outbreak area is that its breeding "extends slightly into the brackish water zone" with salinity not exceeding "3% sea water" (Sandosham, 1965). Tidal salinity readings taken of the outbreak area show that the salinity in the immediate vicinity of the initial site of transmission was in this range, i.e. mostly under 3% sea water. This factor alone strongly suggests that *An. letifer* was the more likely vector than *An. sundaicus.*

Furthermore, although only one female *An. letifer* was caught in human bait trap catches, it is very significant that it was caught near a patient's home by the side of Whampoa River at St. George's Road which is at the initial most active transmission site of the outbreak (i.e. around St. Michael's Estate). The single *An. sundaicus* female, on the other hand, was caught some distance away from this site, at Kolam Ayer Estate, where only one sporadic case occurred.

Thus, from a consideration of all available evidence, it would appear that *An. letifer* had a greater vectorial role than *An. sundaicus* in the outbreak. The actual vectorial role of either species could only have been clinched had sporozoites been demonstrated in the salivary glands of adult females caught in the area.

5. Measures taken to prevent another outbreak

Since the successful control of the outbreak, measures had been taken to prevent another outbreak. Vector and disease surveillance activities had been stepped up. Priority vector control areas had been demarcated for routine control. Contract workers during medical examination are now selectively screened for malaria parasites. All labourers' quarters ('bangsals') at construction worksites had been regularly sprayed with 5% DDT emulsion. Since the outbreak, a total of 353 'bangsals' had been sprayed by the end of 1975. Mass blood surveys are now carried out in association with any notified introduced malaria case to uncover the reservoir of infection. Medical practitioners had been urged to cooperate by immediate notification of all malaria cases and to treat all *vivax* malaria radically to prevent relapses. All malaria cases on discharge from hospitals are being followed up monthly for 6 months.

In order to contain the disease and to prevent further outbreaks, every notified local and suspected local case is now treated as the first case of an outbreak. Control measures previously implemented only under emergency situations are now carried out immediately to prevent further spread of the disease.

The above measures had proved highly effective in containing the disease thus far.

ACKNOWLEDGEMENTS

We wish to thank colleagues in the Ministry of the Environment who had helped in the investigations, surveillance and control of the outbreak. We are grateful to Mr. Ng Say Kiat, and Miss Chew Lai Meng of the Vector Control & Research Department, Ministry of the Environment, for reproducing the figures.

REFERENCES

1. Chan K. L., Chew P. K. and Koh T. S.: "Malaria outbreak at Pulau Tekong in Singapore". Singapore Med. J., 12(5), 276-283, 1971.
2. Chew P. K.: "The outbreak of malaria at Fuyong Estate in Singapore". Singapore Med. J., 9(2), 111-126, 1968.
3. Reid J. A.: "Studies from the Institute for Medical Research, Malaysia, No. 31. Anopheline Mosquitoes of Malaysia and Borneo." Institute for Medical Research, Government of Malaysia, Kuala Lumpur, Malaysia, 1968.
4. Sandosham A. A.: "Malariology with special reference to Malaya." University of Malaya Press, xvi + 349 pp. 1965.
5. Scharff J. W., Fario B. W. G. and Nicholas W. A.: "Malaria—Mosquito Control in Rural Singapore". Singapore Govt. Printer, 1937.