

12. Primate Malaria

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Pulau Tioman has been recognized as a severely malarious area for many years. However, published material on this subject is quite limited and most of the information available must be gleaned from unpublished reports primarily found in the files of the Institute for Medical Research in Kuala Lumpur. The 1949 report of Dr. J. W. Field, at that time Senior Malaria Research Officer of the Institute for Medical Research, contains the most complete medical background available on the island. Briefly the medical history of this island begins in 1924 with the establishment of a dispensary at Kampong Juara on the east coast. There is a verbal report of a "great epidemic" in 1926 which killed many people and caused the east coast of the island to be virtually abandoned. Interestingly enough there is still only one inhabited kampong (village) on this side of the island and the extent of secondary jungle covered former clearings is mute testimony to the fact that human habitation was much greater in this area in the past. The etiology of this epidemic is still unknown but Dr. Field believes that a "virulent outbreak of *falciparum* malaria" cannot be excluded. In 1930, the present dispensary at Kampong Tekek on the west coast of the island was constructed.

Efforts to control malaria were instituted between 1937 and 1942. This consisted of clearing and oiling of the main streams at Kampong Tekek and Kampong Juara. These efforts were apparently unsuccessful. Dr. Field visited Tioman in 1941 and reported that the malaria incidence was higher on the island than he had observed any place else in Malaya.

During the years of World War II a Japanese garrison was quartered on the island but no apparent effort was made to improve the health of the population during this period.

In 1947 the island was visited by Dr. McGarity, the Health Officer of East Pahang, and the dispensary was re-opened. Through the auspices of the Institute for Medical Research, a program for the massive administration of paludrine to the population of the island was undertaken. Due to commitments of the Institute staff in Selangor and Negri Sembilan, no actual survey was carried out prior to the initiation of this program. However the impression at this time was that there was much general sickness and that the incidence of malaria was high.

In order to evaluate the effect of paludrine administration a survey was conducted on the island in 1948 (Table 1).

TABLE 1
Spleen and parasite rates on Pulau Tioman, April 1948

	Spleen Rates			Parasite Rates		
	No. Exam.	No. Enl.	%	No. Exam.	No. Pos.	%
Children ...	169	95	56	133	31	23
Adults ...	231	94	41	231	9	4
Total ...	400	189	47	364	40	11

In this particular survey 25 per cent of the diagnosed cases were *Plasmodium vivax*, 32 per cent were *P. falciparum* and 43 per cent were *P. malariae*. No conclusions were drawn as to the effectiveness of paludrine administration but it was felt at this time that the spleen rate was lower in the children than might have been expected and that the parasite rate was lower than would be indicated by the spleen rate. At this time the Senior Malaria Research Officer in the Institute for Medical Research recommended that paludrine prophylaxis be continued under the supervision of a trained hospital assistant.

Dr. J. W. Field led a survey team to Pulau Tioman in 1949. The report of this effort is currently on file at the Institute for Medical Research in Kuala Lumpur. Unfortunately, the actual amount of malaria on the island at this time is unknown. Dr. Field's group took more than 500 blood smears which were returned to the IMR in Kuala Lumpur for examination. Unfortunately all of these smears were contaminated with a spore-forming bacillus and were difficult to evaluate. Thirty-three specimens could be reported as positive but this cannot be assumed to represent the total positive films taken at the time. It is interesting to note, however, that 12 per cent of the positive films were diagnosed as *P. vivax*, 52 per cent as *P. falciparum* and 36 per cent as *P. malariae*. Recommendations were made at this time for the continued administration of paludrine with a concomitant spraying of houses. Follow-up surveys were to be conducted in 1950. There is no record that such a follow-up was made.

The next recorded effort made to ascertain the status of malaria on Pulau Tioman was done in 1955. Dowling and Hughes (1959) reported the results of an Army investigation on the island (Table 2). The impetus for this visit resulted from the occurrence of several cases of malaria among British personnel who had visited the island. Incidentally this is the only published report available at the present time.

TABLE 2
Spleen and parasite rates on Pulau Tioman, June 1955

Spleen Rates			Parasite Rates		
No. Exam.	No. Enl.	%	No. Exam.	No. Pos.	%
120	93	61	120	70	58

Among the positive cases 69 per cent were *P. vivax*, 23 per cent were *P. falciparum* and 8 per cent *P. malariae*. This survey reported above was performed primarily on children 10 years of age and under. Spleen rates and parasite rates were highest in the group 4 years of age and under. Recommendations were made that one dose of chloroquine be administered to all people on the island and that a prophylactic dose of paludrine be given weekly for six weeks. In addition it was recommended that insecticide fogging, as well as residual house spraying, be undertaken. These recommendations were accepted and, with the cooperation of Army personnel from Singapore, were carried out in September, 1955. Follow-up surveys were conducted in May 1956. The results of the survey are briefly summarized below (Table 3).

TABLE 3
Spleen and Parasites rates on Pulau Tioman, May 1956

Parasite Rates			Spleen Rates		
No. Exam.	No. Enl.	%	No. Exam.	No. Pos.	%
126	22	17	125	3	2.4

As would be expected the efforts instituted by the Royal Army Medical Corps influenced the general status of malaria on this island by a considerable degree. Spleen rates were approximately 70 per cent lower and parasite rates were approximately 95 per cent lower in 1956 than in 1955. However it should be noted that two of the positive cases were *P. falciparum* in infants born during the time when spraying procedures and the massive administration of drugs were undertaken. Since the drug administration was a short-term effort, it may be assumed that neither of these children had been given prophylactic therapy. Unfortunately the presence of two infants in this community demonstrating patent infections with *P. falciparum* one year after this concentrated attack on malaria is also presumptive evidence that effective transmission never really ceased on the island. In addition it should be noted that the follow-up survey was conducted primarily on the school children and this is the group that would have been most prone to take the full drug treatment the previous year. Under these circumstances, the 1956 survey probably does not represent an adequate sample of the total susceptible population living on the island at the time. In other words such a short-term project could not be expected to cause any lasting change in the human malaria pictures on the island, and later figures indicated the expected re-emergence of malaria as a significant disease problem.

Information relative to the status of malaria on the island between 1956 and 1960 has been obtained through the cooperation of the Pahang State Health Department in Kuantan. The dispensary has been functioning and anti-malarial drugs are and have been available to those individuals who requested them. In addition the hospital assistant travels around the island by boat every two weeks with what is called a travelling dispensary. Residual spraying of houses is carried out, but due to the transport problem this can only be accomplished once each year. A blood survey was conducted by the Pahang State Health Department on Pulau Tioman in August, 1960 in which 733 blood films were examined (Table 4).

TABLE 4
Parasite rate on Pulau Tioman, August 1960

No. Examined	No. Positive	% Positive
733	101	14

The species distribution in the positive films was 64 per cent for *P. vivax*, 28 per cent for *P. falciparum* and 9 per cent for *P. malariae*. This survey serves to confirm the species shift that had been reported in 1955 and the transient nature of results obtained against malaria by short-term drug administration and insecticide fogging.

The latest available information on the status of malaria on the island is from a survey conducted in August of 1962 by members of the Malaria Control Section of the Pahang State Health Department. The results of this survey are seen in Table 5.

TABLE 5
Parasite rate on Pulau Tioman, August 1962

No. Examined	No. Positive	% Positive
206	39	19

The species distribution in the positive films was 49 per cent for *P. falciparum*, 28 per cent for *P. vivax*, 8 per cent for *P. malariae*, 8 per cent for mixed infections, and 7 per cent of the positive films were not identified as to species.

The species distribution of malaria on Pulau Tioman has shown some interesting changes since 1948. Four surveys have been carried out and Table 6 shows several interesting developments over this period of 14 years. In 1948 the crude

parasite rate in this population was only 11 per cent and the majority of these were, surprisingly enough, diagnosed as *P. malariae*. A period of seven years elapsed before another malaria survey was conducted on the island and further changes occurred during this interim. There was more than five times as much malaria in the total population as in 1948, with *P. vivax* showing a 13 fold increase; and *P. falciparum* was four times as abundant in 1955 as in 1948. The incidence of *P. malariae* remained virtually unchanged. From these figures certain conclusions can be drawn relative to the anti-malaria activities on the island during this period. As previously noted recommendations for paludrine administration and the residual spraying of houses were made in 1948 but it must be assumed that these measures at best were only sporadically carried out between 1948 and 1955.

In 1960 the crude parasite rate on the island had dropped to 14 per cent. This is reflected in drops in the prevalence of all three species. *P. falciparum* was back to essentially the same level as in 1948 while *P. vivax* was still three times as common in 1960 as in 1948, though the incidence of this species had decreased markedly since 1955. Only a little more than one per cent of the population were infected with *P. malariae* in 1960. The 1962 survey showed a disconcerting increase in the amount of sub-tertian malaria on the island. *P. vivax* had continued to decrease and *P. malariae* remained at low level; however, *P. falciparum* was more than twice as prevalent in 1962 as in 1960. At the present time there is no explanation for the recent increase in this species of *Plasmodium* on Pulau Tioman.

The current program for malaria control on the island involves two specific procedures. The houses on the island are sprayed with residual insecticides once each year and prophylactic chloroquine and paludrine is theoretically provided for every individual on the island. However the hospital assistant reported having 1,343 patient visits in both the permanent dispensary at Kampong Tekek and in the travelling dispensary in the first half of 1962. A diagnosis of malaria was made in 123 of these patient visits. Most of these were based on a clinical rather than a parasitological examination; however, the 19 per cent crude parasite rate reported in August, 1962 is based on parasitological examinations.

There is no doubt that there is an intensive level of malaria transmission on the island. The number of *P. falciparum* cases reported in the 1962 survey is alarming and indicates a considerable increase in the amount of this species of malaria on the island since 1960.

In spite of yearly spraying of the houses and the dispensing of large quantities of chloroquine and paludrine the incidence of malaria on the island has remained quite high. At present it would seem that the residual insecticide program is exerting little influence on the malaria picture in this area. One spraying each year, especially when this may be delayed several months due to transport difficulties and always hampered by a number of houses that are locked and cannot be sprayed, is probably not sufficient to break effectively the malaria transmission cycle. The combination of chloroquine prophylaxis and an increase in the amount of sub-tertian malaria is quite interesting. There are two possible explanations for this situation. Either the *P. falciparum* found on the island is resistant to chloroquine or the drug, even though both supplied and dispensed, is not actually taken by the island's inhabitants. Until further information is available it is probably reasonable to assume that the drug is not effectively taken by most of the people.

An incidental finding in the August, 1962 survey that is not related to malaria but has caused much interest was the discovery of two blood films which were positive for *Wuchereria bancrofti*. There have been no previous reports of filariasis from Pulau Tioman. It is not known at present whether these cases are permanent inhabitants or were transient fishermen from the mainland. This problem is currently under investigation.

TABLE 6
Malaria on Pulau Tioman, 1948-1962

Year	No. Exam.	No. Pos.	% Pos.	Species Break-down					
				<i>P. falciparum</i>		<i>P. vivax</i>		<i>P. malariae</i>	
				No. cases	% Exam.	No. cases	% Exam.	No. cases	% Exam.
April, 1948	364	40	11	13	3.57	10	2.74	17	4.67
June, 1955	129	70	58	16	13.3	48	40.0	6	5.0
August, 1960	733	101	14	28	3.8	64	8.7	9	1.2
August, 1962	206	39	19	19	9.2	11	5.3	3	1.4

STATUS OF MALARIA VECTORS

Data collected prior to World War II have been lost and there is only a verbal record of the *Anopheles* collected during this period. Larval surveys had produced *A. aitkeni*, *A. barbirostris*, *A. hyrcanus*, *A. kochi*, *A. leucosphyrus*, *A. maculatus*, *A. subpictus*, *A. sundaicus*, *A. umbrosus*, *A. vagus* and *A. watsoni*. However, the character of any individual larval survey would vary markedly between dry and rainy seasons. In adult night catches *A. maculatus* and *A. sundaicus* were the predominant mosquitoes. These observations are abstracted from the now recorded verbal records prior to World War II and from the survey conducted by Dr. Field in 1949.

In September 1961, additional data on the anopheline fauna of the island was collected by a team from the Institute for Medical Research. *A. maculatus*, *A. sundaicus* and *A. barbirostris* predominated in larval collections at this time.

Further larval collections were made in April of 1962 during the period when the team from the University of Malaya was present on Pulau Tioman. Collections along the coastal areas produced numerous *A. maculatus*, *A. barbirostris* and *A. aitkeni*. Interestingly enough, no *A. sundaicus* larvae were found. Collections made in seepage pools and rock pools deep in the rain forest in the center of the island gave the ubiquitous *A. aitkeni* and the very interesting addition of *A. riparis*.

THE ECOLOGY OF HUMAN MALARIA ON PULAU TIOMAN

With the information currently available a fairly definite understanding of the basic features of the ecology of human malaria on the island can be determined. The human population is currently concentrated in three areas on the island. Kampong Tekek (a complex of several kampongs oriented along a five mile stretch of open beach) on the west coast, Kampong Mokut on the south coast and Kampong Juara on the east coast. In the past the population was probably considerably greater but was still confined to the narrow strips of coastal plain adjacent to the open beach areas. Under the circumstances it can be seen that all of the human inhabitants of the island live in virtually the same environment. This environment consists of a narrow flat strip of sandy soil given over for the most part to coconut plantings. This area is laced with many small tidal streams which create innumerable brackish to fresh water pools which are ideal for breeding of *A. sundaicus*, *A. bazai* and *A. barbirostris*. Even *A. maculatus* has been found in this area. This narrow coastal plain ends abruptly with the beginning of the steep hills which cover most of the island. In this area, usually within a few hundred yards of the kampong houses, man has created an ecological area remarkably well suited to the proliferation of *A. maculatus*, the most effective vector of human malaria in Malaya. The forest on the lower aspects of the hills is cleared for tapioca and dry rice plantings. Such hill clearings provided large seepage areas which are the breeding sites of choice for *A. maculatus*. Since new areas are constantly being cleared, there are always fresh breeding sites available.

Thus we have man residing in the midst of ideal breeding areas for two proven vectors of malaria in Malaya. Unfortunately, an ecology more beautifully attuned to the continued transmission of malaria would be difficult to imagine.

The status of the disease in the human population testifies to this continuous transmission. Virtually all of the children are infected when they are quite small and many die. Spleen rates have been very high in the children under five years of age, with concomitant high parasite rates in this age group. On two occasions following short-term but intensive anti-malaria campaigns the parasite rates have been temporarily reduced to fairly low levels. Generally, as the surviving children grow older a rather high level of immunity develops. Adults will, on

occasion, show patent parasitemias and frequently have enlarged spleens but do not show the usual clinical response to the presence of the parasite. This is the picture seen in other areas where malaria is hyperendemic and long standing. Primarily, morbidity and mortality is confined to the children in the population, with adults being capable of maintaining the parasite but showing little or no clinical response. This has apparently been the malaria picture for many years on the island.

Some control measures have been undertaken. As has been noted, since 1956 residual spraying with BHC (Gammexane) has been carried out, and since 1960 spraying with dieldrin has been attempted. However, this has been done only once each year. Drugs are available on request by the island's inhabitants. However with a crude parasite rate of 19 per cent (1962) there is no doubt that a high level of malaria transmission still occurs on the island.

The general ecology is complicated by the peculiar location of the island. During the monsoon season, numbers of fishing boats arrive and stay for considerable periods on the protected west coast of the island. This means a transient population of several hundred arrive on the Pulau Tioman from the mainland each year. Thus the opportunities for bringing in new strains of malaria parasite is always present.

SIMIAN MALARIA ON PULAU TIOMAN

With the advent of Eyles' (1960) discovery that at least one of the monkey malarias in Malaya is transmissible to man via mosquito, the total ecology of primate malaria on Pulau Tioman becomes somewhat more complex. In order to determine the frequency with which this transmission of monkey malaria to man occurs in nature, a United States Public Health Service Team came to Malaya to carry on basic investigations into simian malaria in cooperation with the Malaria and Filariasis, and Entomology divisions of the Institute for Medical Research. In September, 1961, members of this team visited Pulau Tioman for general reconnaissance. Blood films from seven monkeys were made at this time. Five of these smears were positive from which *P. inui* and *P. knowlesi* have been definitely identified. It should be noted that one of the negatives was very young and one smear was made from an animal which had been dead for some hours and was therefore very difficult to read. In April, 1962, a second visit to the island by members of this research group was made and eight additional monkeys were examined all of which were positive. Once again *P. knowlesi* was isolated and two identifications of *Hepaticystis* sp. were made (Table 7).

TABLE 7

Monkey malaria on Pulau Tioman, 1961-62

No. Examined	No. Positive	% Positive
15	13	87

Aspects of the transmission of the monkey malarias on Pulau Tioman is much less clear than that for the human malaria. All of the monkeys on the island belong to a subspecies of the common mainland *Macaca fascicularis* or long-tailed macaque (*Macaca fascicularis laeta*). Although only 15 animals have been examined to date, 13 or 87 per cent have proven to be positive for haemosporidian parasites. Obviously a very high level of transmission is occurring on the island among these lower primates.

Unlike the human inhabitants of Pulau Tioman, the monkeys range the entire island from the tree and garden cultivation along the coast to the primary forest in more inland parts of the island (see Medway, this *Bulletin*, p. 16). The kampong

people complain of the deprivations of the monkeys in and around the village. As yet little specific information is available concerning the actual vectors of the monkey malarias. *A. maculatus* and *A. sundaicus* are quite susceptible in the laboratory to at least one species of monkey malaria from Malaya. There is no doubt that these animals do range through the *A. maculatus* and *A. sundaicus* infested areas on the island. However, there is considerable doubt as to whether these mosquitoes actually feed on monkeys.

A most interesting feature relative to the ecology of the simian malarias on the island is the isolation of *A. riparis* larvae from seepage pools in the hill forest. *A. riparis* belongs to the *A. leucosphyrus* group which includes three proven vectors of monkey malaria, *A. hackeri* (Wharton and Eyles, 1961), *A. balabacensis intro-latus* (Eyles, et al., 1962) and *A. leucosphyrus* (Wharton et al., 1962) on the mainland. *A. riparis* has been found quite susceptible, in the laboratory, to one species of monkey malaria. *A. leucosphyrus* and the related *A. balabacensis* have both been caught biting man (Macdonald and Traub, 1960) and more recently have been attracted to monkey bait. *A. riparis* is common in Malayan forest but has never been caught on bait of any kind.

At the present time, little can be said relative to the ecology of the monkey malarias on the island. At least one proven vector is present and several other highly susceptible mosquitoes are relatively abundant in this area. The true potential for the transmission of these lower primate malarias to man is yet to be evaluated.

SUMMARY

The medical history of Pulau Tioman has been briefly reviewed. Malaria has been a prominent feature in the few recorded reports of investigations by various workers who have visited the island. Attempts have been made to control this disease which have included at least one program for massive, short-term administration of anti-malarial drugs. The incidence of malaria among the human inhabitants of the island was lowered after the more intensive campaigns but since these were of a more or less temporary nature, a high degree of transmission was quickly regained.

The nature of malaria in the human population is typical of other hyperendemic areas where virtually all of the children are infected very early in life with a high level of both morbidity and mortality. Adults frequently show enlarged spleens and occasionally patent parasitemias but rarely demonstrate a typical clinical response to the presence of the parasite.

Currently teams of sprayers visit the more populous areas of the island, but this does not usually occur more than once each year and the last malaria survey in 1962 gave a crude parasite rate of 19 per cent. There is no doubt that there is still a high level of transmission occurring on the island.

The status of malaria vectors on the island has also been reviewed. The human population is largely restricted to the narrow coastal plain which is wedged between the sea and steep hills which dominate the topography of the island. This area provides ideal breeding sites for *A. maculatus* and *A. sundaicus*. There seems to be little doubt that these two species are primarily responsible for the hyperendemic state of human malaria on the island.

Recent investigations into simian malarias on the island are reviewed. The monkey population is large and is confined to *Macaca fascicularis laeta*, a subspecies of the common long-tailed macaque found on the mainland. Blood films from 15 animals have been examined of which 13 were found to be positive for haemosporidian parasites. The ecology of simian malaria and its possible relationship to human malaria on Pulau Tioman is discussed.

ACKNOWLEDGEMENTS

Dr. Field's report is unpublished but appears in the files of the Institute for Medical Research, Kuala Lumpur. Reports of malaria surveys on Pulau Tioman since 1948 were also taken from the files of the Institute for Medical Research. Appreciation is also expressed to the Pahang State Health Department, Kuantan for making their records available and for providing much information concerning malaria control activities on Pulau Tioman.

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