A STUDY ON ANOPHELES MACULATUS AND ANOPHELES SUNDAICUS IN SINGAPORE

By K. L. Chan

(Entomologist, Vector Control Unit, Ministry of Health, Singapore.)

INTRODUCTION

There are about 200 to 300 cases of malaria detected yearly in Singapore. Almost all these are imported from outside but because of the continued presence of the vectors *Anopheles maculatus* and *An. sundaicus*, transmission is still possible, especially when there is a breakdown in control services in potentially and entomologically dangerous areas on the island.

Singapore may be considered as having reached the consolidation—maintenance phase in a malaria eradication programme although no such eradication programme has ever been carried out.

This is a report of some entomological findings in a six months' study (10 March to 8 September 1966) at the Jalan Kayu area in Singapore. The objective of the study was to develop a more economical and effective method of controlling the vectors.

THE STUDY AREA

The study area, Jalan Kayu (Map 1), is located in the north-east of Singapore and south of the Royal Air Force Seletar Air Base. Historically more than half of the area to the north had never been controlled so that existing conditions were natural and entomologically possibly dangerous. Geographically, it is situated near the coast where the two vectors were known to be present.

Surveys made in the area from 28 February to 3 March 1966, revealed 22 brackish fish ponds breeding *An. sundaicus* and four seepages breeding *An. maculatus*. Of these, only one habitat of each species were located within the oiling boundary (Map 1).

METHODS

Densities of both species in the immature and adult stages were measured, immature by sampling of a fixed volume and surface area of water in four suitably chosen habitats, A,B,C and D (Map 1) and adult by adult trapping using human bait traps placed near the corresponding breeding habitats (Map 1).

Immature Stages

Sampling was done twice a week, on Tuesdays and Saturdays.

The sample size used was arbitrarily fixed at 270 cc., the size of a standard ladle used for larval collections. Sampling involved collecting 10 random samples from each of the four stations. To reduce errors due to sampling, the same collector, using the same collecting technique, was used throughout the study.

All stages, eggs to pupae, were collected and counted in the laboratory except from 10 March to 10 May when only larval and pupal stages were examined and counted.

Adult

Human bait traps modified from the "Malayan type" as in Colless (1959) were used for assessing density. Two men per trap were used, one acting as bait with bare body and legs and the other acting as mosquito catcher.

Catching was done once a week at the same time (7.00 - 11.30 p.m.) and day (Wednesday) at all the stations. Meteorological readings (temperature, relative humidity, wind) were taken concurrently with adult catches. Rainfall readings were obtained from the R.A.F. at Seletar which is adjacent to the study area.

RESULTS AND INTERPRETATION

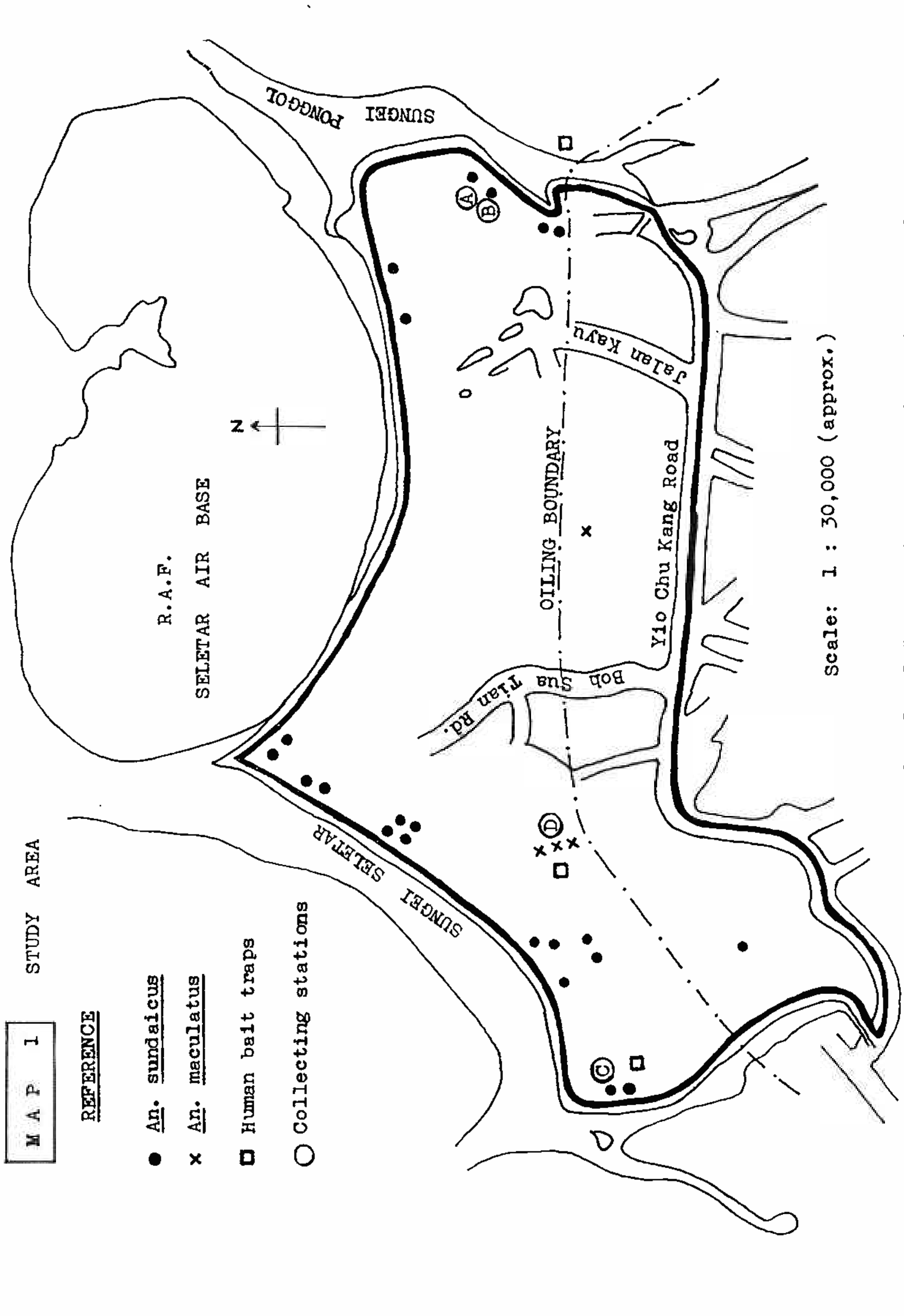
Anopheles maculatus

Fig. 1 shows adult and larval densities during the study period. Larval density was at a steady low throughout the six months while adult density showed one peak in April. No close correlation between the two was found, due probably to adult females showing less preference for human blood from May onwards in the presence of more preferred animal hosts during the succeeding months.

No clear correlation with rainfall was found.

Anopheles sundaicus

Fig. 2 shows *An. sundaicus* larval populations in the three ponds A, B and C and adult density at C. Larval density was highest in July at ponds



MAP 1. LARVAL HABITATS AND COLLECTING STATIONS

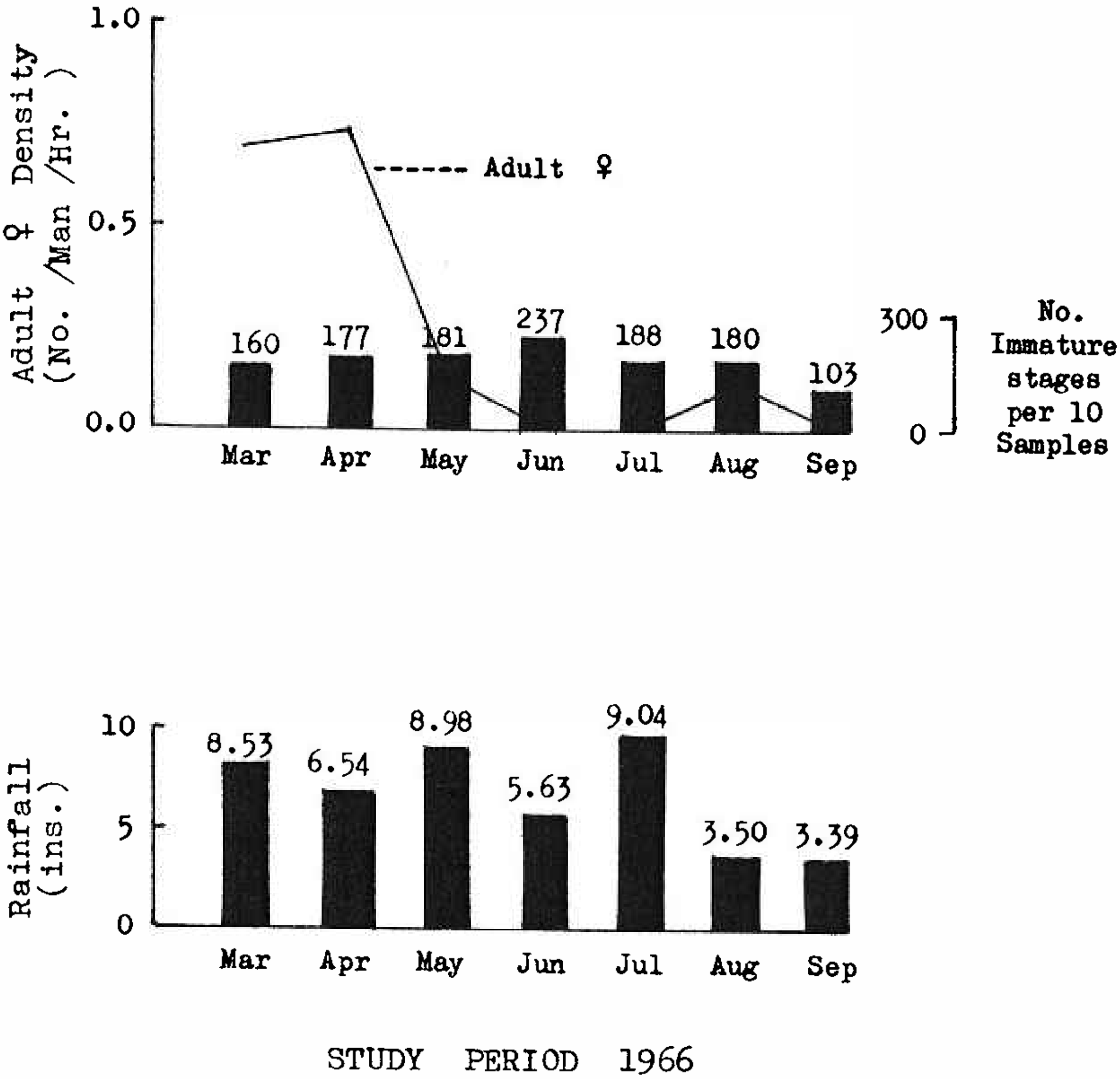


Fig. 1. *An maculatus* adult and larval densities at station D

A and B and in May at C, thus showing that there was no real seasonal periodicity in the population as a whole in the area except that higher densities in all the ponds occurred between the period end of April and end of July.

Larval populations in each pond were found to be related to pond conditions rather than rainfall although population peaks in all three ponds coincided with heavier rainfall in May and July (Fig. 2). This is so as all the ponds were never dry during the study period and rainfall could not have affected the availability of water in the ponds except to lower their salinity.

Observations on pond conditions according to the manner of fish and prawn rearing by farmers in the area showed that all ponds followed the same cycle pattern of changes. Disused, neglected ponds after fish rearing usually contained little water and some vegetation typically *Entoromorpha* species. These usually bred profuse numbers of mosquitoes, typically *Culex sitiens* and *Anopheles sundaicus*, the former usually occurring in higher numbers and usually preceding the latter, with some overlap. When the ponds were again utilized for fish rearing usually planned to coincide their harvesting with Chinese New Year, they would be dug to the desired depth and filled with brackish water through sleuce gates which connect the ponds to rivers. At this time, the mosquito populations would fall somewhat. Fishes, and sometimes prawns, were then introduced and together with them the vegetation and food they feed on. When this happened, the mosquito populations would fall off to a low minimum or disappeared completely. The conditions of the ponds became rather stable during the fish rearing period and continued to be so until the fish and prawns were harvested

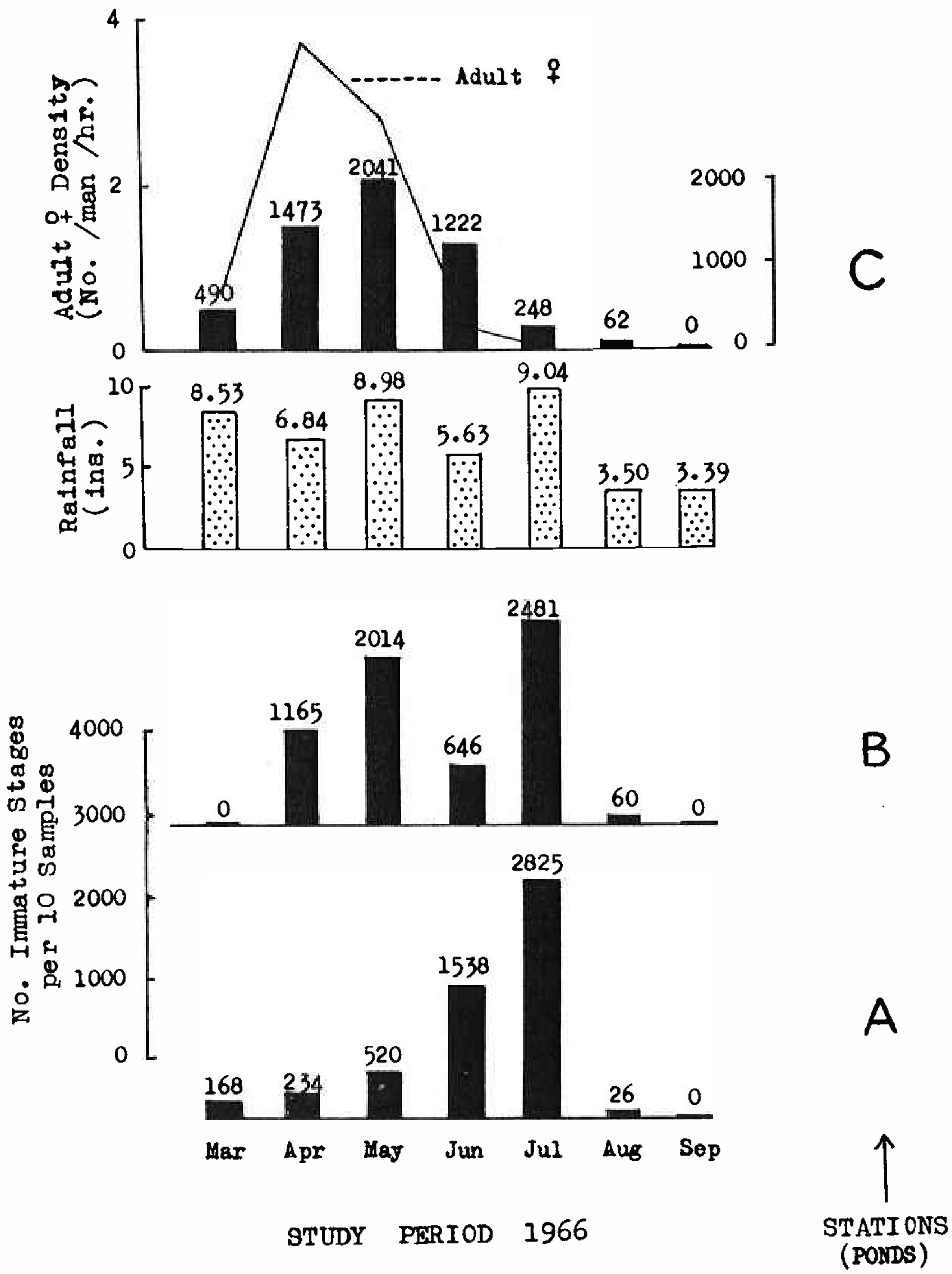


Fig. 2. *An. sundaicus* adult and larval densities at Jalan Kayu, Singapore.

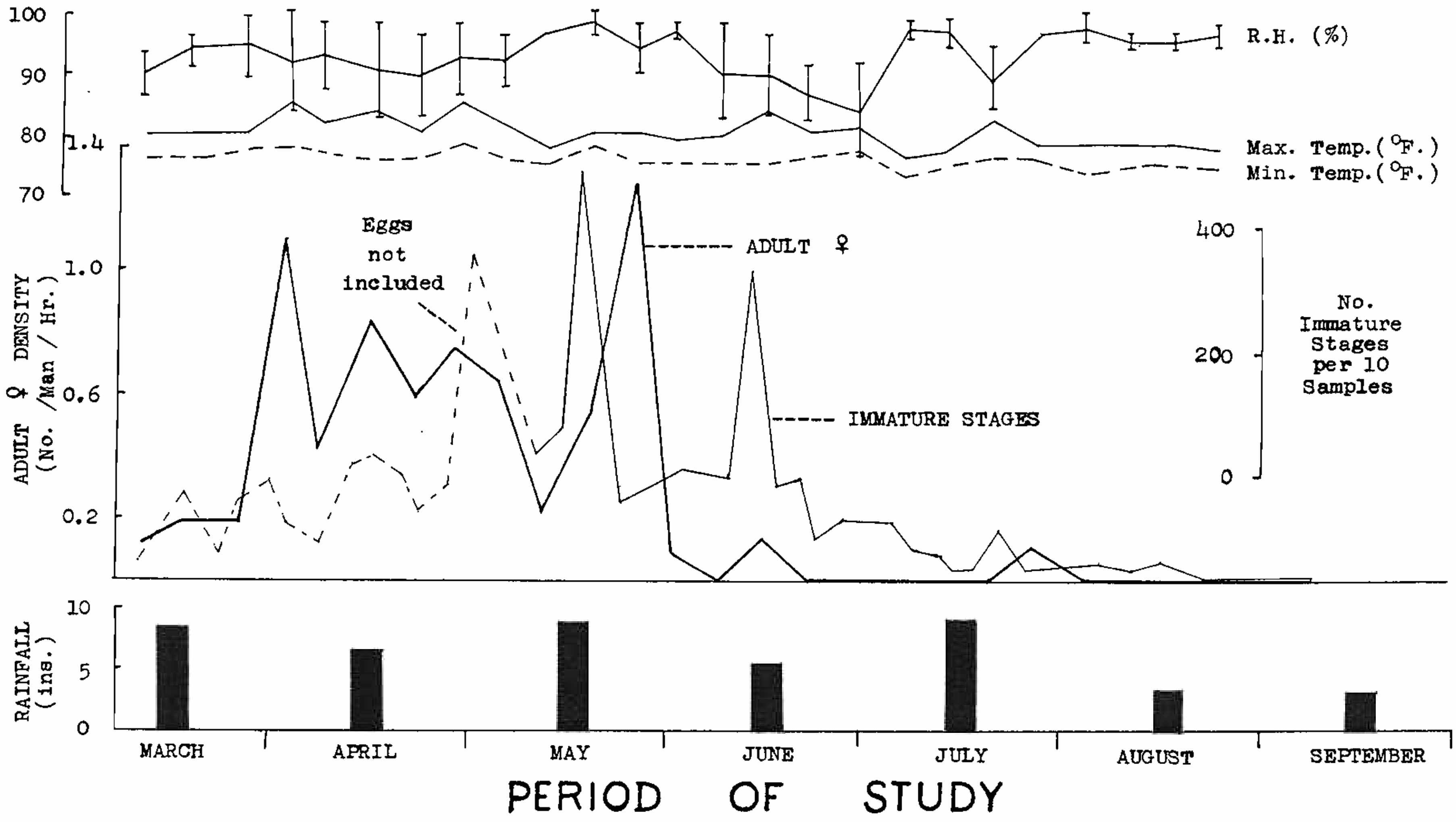


Fig. 3. An. sundaicus Density and Weather Conditions at Station C, 1966.

TABLE I

PAROUS RATE OF *AN. SUNDAICUS* AT STATION C BASED ON OVARY DISSECTIONS

Date	Week	No. parous	Total	No. with stomach oocysts	No. with sporozoites
March 10	1	1	1	—	—
17 & 18	2	1	2	—	—
26 & 27	3	1	2	—	—
April 2	4	4	10	—	—
7	5	—	7	—	—
15	6	3	14	—	—
22	7	1	1	—	—
28	8	5	9	—	—
May 5	9	3	9	—	—
12	10	—	2	—	—
19	11	2	5	—	—
26	12	6	21	—	—
June 2	13	—	—	—	—
8	14	—	—	—	—
15	15	2	2	—	—
June 22— July 27	16—21	—	—	—	—
August 3	22	—	1	—	—
August 10— Sept. 7	23—27	—	—	—	—
TOTAL		29	86	—	—

Overall parous rate = 29/86 = 0.337

'p' (3-day cycle) = $\sqrt[3]{0.337} = 0.696$

Probability of survival through one day = 69.6%

Daily mortality = 30.4%

TABLE II

PAROUS RATE OF *AN. MACULATUS* AT STATION D BASED ON OVARY DISSECTIONS

Date	Week	No. parous	Total	No. with stomach oocysts	No. with sporozoites
March 10	1	—	5	—	—
17 & 18	2	—	—	—	—
26 & 27	3	—	—	—	—
April 2	4	—	2	—	—
7	5	—	2	—	—
15	6	—	—	—	—
22	7	—	—	—	—
28	8	3	3	—	—
May 5	9	—	1	—	—
May 12— July 27	10—21	—	—	—	—
August 3	22	1	1	—	—
August 10— Sept. 7	23—27	—	—	—	—
TOTAL		4	14	—	—

Overall parous rate = 4/14 = 0.286

'p' (3-day cycle) = $\sqrt[3]{0.286} = 0.6588$

Probability of survival through one day = 65.9%

Daily mortality = 34.1%

when, once again, the cycle of changes would be repeated.

Adult density at stations A and B was very low due likely to deviation of adults from the human baits to a herd of cattle stabled close to the trapping sites.

Breakdown of *sundaicus* larval and adult densities at station C (Fig. 3) shows close relationship between the two with larval density preceding the adult as expected.

There was no relationship between adult density and rainfall and also between adult density and relative humidity. There was however a correlation between adult density and daily mean temperature (correlation coefficient 0.399) during April and May when the population was highest. This could be due to a keener chemoreceptive sense of the mosquitoes at higher temperatures when the human host perspired and attracted them more. As the air was still on almost all the nights of catch, it was not possible to determine whether wind affected adult biting density.

Parous Rate and Probability of Survival

Tables 1 and 2 show the parous rate and probability of survival through one day respectively of *Anopheles sundaicus* and *An. maculatus*. The overall parous rate for the whole study period was 0.337 for *sundaicus* and 0.286 for *maculatus*, giving respectively 0.696 and 0.659 for the value of 'p' (probability of survival through one day) based on a 3-day gonotrophic cycle normal for tropical climatic conditions (Detinova, 1965).

Dissections of the gut and salivary glands of females revealed the absence of stomach oocysts and sporozoites, thus indicating low or absence of malaria parasite reservoir in the area.

DISCUSSION AND CONCLUSION

Density-wise, *Anopheles maculatus* can be eliminated as an important malaria vector in the Jalan Kayu area since there were only four small larval habitats and the total population was low as indicated by both adult and larval densities.

Anopheles sundaicus, on the other hand, poses a number of questions, but on basis of the lack of oocysts and sporozoites, can be considered as not important in the Jalan Kayu area.

Unlike *An. maculatus* which is a more efficient vector under natural conditions (Sandosham, 1965), *An. sundaicus* requires high densities to cause epidemics (Colless, 1952). Its low sporozoite rate in nature and its low attraction to human blood (Reid, 1961) makes it epidemiologically unimportant at low populations. In the Jalan Kayu area, its population numbers were significantly high but the numbers caught at human bait were considerably low by proportion, indicating that it was not much attracted to man for blood. Its capacity as a vector would therefore be low. The absence of sporozoites and oocysts indicates that either few adult females reached the critical age of 10 days or more for malaria transmission to occur, or more likely that there was insufficient parasite reservoir in the area although from time to time malaria cases were reported in the area.

This study shows that to control *An. sundaicus* breeding in brackish fish ponds in costal areas of Singapore, it is necessary to know the history and condition of such ponds. Control should be carried out only when the ponds are breeding the mosquito. This would not only be economical but could also be done easily and effectively. Information on the stage of development of ponds could be obtained from the farmers through some kind of reporting system.

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