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TEMEPHOS (ABATE) AS A REPLACEMENT LARVICIDE FOR OIL FOR THE CONTROL
OF ANOPHELES MACULATUS, THE MAIN VECTOR OF
MALARIA IN PENINSULAR MALAYSIA

by

E. S. Thevasagayam,¹ Yap Siong² and George Philip³



1. INTRODUCTION

The principal vector of malaria in peninsular Malaysia is Anopheles maculatus which breeds mainly in small, clear, slow-moving streams and seepages. As a malaria control measure in most of the urban areas in the country, in addition to environmental and water management methods, oil has been used as the larvicide of choice for over 50 years. In about 5% of the streams where the water may be used for cultivation, DDT emulsion was used. The oil is bought by the Ministry of Health under government contract under the trade name "Shell Malariol GD" and is said to contain a fuel oil with a spreader and stabilizer. The oil is applied by various types of knapsack sprays, as a weekly routine.

In the rural areas where a malaria eradication programme was instituted in 1968, the control measure is DDT residual spraying at 2 g/m². In spite of the advent of many new larvicides that have come on to the market, no attempt was made to replace oil, although some of the municipalities, which have their own independent antimalaria programmes and purchase larvicides out of their own funds, have recently shifted to other synthetic larvicides. The main reasons for persevering with oil were that it will not induce resistance, it was relatively cheap, and there was the reluctance to change an old practice.

With the increase in the price of petroleum products in 1974, the price of antimalaria oil which used to be around US\$ 0.26 per imperial gallon in 1974 shot up to US\$ 0.62 in 1975, an increase of almost 125%. It was the sudden increase in the price of oil that necessitated the need to look for an alternate larvicide.

Temephos was shown to be a very effective larvicide for anopheline control at the very low dosage of 0.004 lb/acre (44.84 g/ha) by Moore & Breeland (1967) in the United States of America, Nasir & Latiff (1969) in Pakistan and by others. It is also known to be an insecticide of low toxicity to non-target organisms and is safe to use.

The present study was therefore undertaken to compare the cost/effectiveness of temephos 500E (50% EC) and 1% sand granule formulations with oil.

¹ WHO Entomologist, Malaria Eradication Programme, Kuala Lumpur.

² Entomology section, Malaria Eradication Programme, Kuala Lumpur.

³ Officer in charge, Sg Beranang Estate, Negri Sembilan.

2. DESCRIPTION OF STUDY AREA

2.1 Location

The study was conducted at Sungei Berangang Estate, Negri Sembilan (Fig. 1) about 50 km south of Kuala Lumpur, with the very active cooperation of the management of the estate which is a rubber plantation situated at the foothills of the main central range of mountains. It has 1300 acres (520 hectares) of which 1100 acres (440 hectares) have mature rubber trees and another 200 acres (80 hectares) have been cleared for replanting. There were 90 labour quarters and three staff quarters with a total population of about 440 people.

2.2 Rainfall

The annual rainfall at the estate for the three years 1973-1975 was about 80 inches (200 cm) but in 1974 (the year of the study) there was only 70 inches (175 cm). During 1974 the average number of wet days was 19 per month (5-21 range) with January, March and April averaging only five days, with September and November averaging 19.5 days. More than one inch (2.5 cm) of rainfall was recorded during 18 days of 1974 in two of which were more than four inches (10 cm). The rainfall figures for March to September 1974 are presented in Fig. 2.

2.3 Breeding places

Water seeps down from the hills along with many streams that criss-cross the estate and eventually drain off through three main streams. The total length of the watercourses was estimated to be about 6600 m. Water usually moves slowly at depths of 5-15 cm and at a width of 1-2 m, a situation ideal for An. maculatus breeding, larvae mainly occurring at the edges of those parts of the streams more exposed to sunlight. During heavy rain the streams are capable of draining off the entire precipitation in a matter of a day or two when the water becomes muddy and may run 1-3 m deep and 2-3 m wide. At such times the streams would be flushed of larvae but when the slow-moving clear water returns in a day or two some breeding can still be found. An. maculatus was found to breed in all the streams.

2.4 Malaria in the estate

Malaria has been the most important cause of illness in the estate, 88 cases being reported from February to December 1973 and 54 in 1974. The first spraying cycle by the malaria eradication programme was undertaken in December 1974. Prior to that, antilarval oiling was carried out in some of the streams around the labour quarters only. Also in 1973/1974 there was a drug prophylaxis trial conducted by the Institute for Medical Research in which about 50% of the total population was involved.

3. MATERIALS AND METHODS

The study was carried out from March to November 1974.

3.1 The area of application

For the purpose of the trial four blocks were marked out on the estate as follows:

Block	No. of streams	Total length of streams - metres	Larvicide
A	3	1 205	Oil
B	2	1 000	Temephos 500E
C	4	1 530	Temephos 1% sand granules
D	2	230	Control

The blocks are shown in Fig. 1. Block A was chosen for oil as these were the streams where the estate was using oil in the past. Block D was selected for the sand granules as in this area the old trees had been felled for replanting, all the streams were heavily clogged with fallen trees, and only about 50% of the water surface was exposed which made the application of granules easier. Temephos emulsion was used in Block B, and Block D was the untreated control.

3.2 Laboratory studies

A few laboratory experiments were conducted with An. maculatus larvae from the colony maintained at the Institute for Medical Research, Kuala Lumpur. Temephos emulsion gave an LC₁₀₀ at a concentration of about 0.001 ppm. This was similar to the results obtained by Self & Pant (1966) with An. gambiae in Nigeria.

3.3 Larvicides and equipment used

3.3.1 Oil

The oil applied was Shell Malariol GD used throughout the country by the Ministry of Health as a larvicide for malaria control. The estate authorities were applying the oil with a Four Oaks spraycan with a cone nozzle on a weekly basis, and they continued to apply the oil during the trial. There was an interruption during the early part of the trial due to stocks running out but treatments were soon resumed. The oil was used in Block A in three streams, the total length being about 1200 m. The rate of application was about 10 litres of oil per 300 m which worked out to 180 gal/hectare (818 litres/hectare) or 72 gal/acre.

3.3.2 Temephos 500E (50% emulsion concentrate)

Temephos 500E was applied by a Hudson X-Pert sprayer with an 8002 nozzle. As shown in Fig. 1 this was used in Block B in two streams, the total length of which was about 1000 m. The larvicide was applied at the same speed as the oil, with one swath from one bank and another from the opposite side. Very often when the stream was narrow, one swath was adequate to cover its whole width. At this rate about 10 litres of the dilute was used to apply about 300 m of stream which worked out to about 0.09 kg/hectare or 0.036 kg/acre active ingredient.

3.3.3 Temephos 1% sand granules

Sand granules were applied in Block C where the total length of the stream was about 1530 m. They were applied directly by hand, distributing the granules as evenly as possible. Because of the blockage of the stream by fallen trees, there were stagnant pools all over which sometimes were 0.5 m in depth. The average rate of application was about 1 kg of granules per 300 m of stream which gave a dosage of 0.3 ppm active ingredient (approximately 0.5 kg/hectare or 0.2 kg/acre active ingredient).

3.3.4 Control

Block D which had about 230 m of streams was maintained as the untreated control.

3.4 Method of assessment

The method of assessment was by means of 50 larval dips along the edges of the stream and a count of the larvae collected. As An. maculatus was the only anopheline usually present in the streams such counts were adequate. Records were also kept of culicine larvae. After application, when there were very few larvae present, the number of dips was increased to about 200.

3.5 Frequency of application

After the initial survey and treatment, subsequent applications were made only when breeding was found, even if the larvae were only 1st and 2nd stage. In Block A during the first three months oil was applied on the usual weekly basis, after which the same method of applying only after the detection of larvae was followed. As far as possible the area was visited weekly and a larval survey carried out and larvicide applied only in the stream where larvae were found. Sometimes due to other staff commitments the interval was extended to two weeks.

4. RESULTS

4.1 Prevalence of An. maculatus (Table 1)

It can be seen from the results of the control area presented in Table 1 that An. maculatus is found in the estate throughout the year. In 31 investigations from March to November, maculatus larvae were found on all but five occasions. Fig. 2 gives the weekly rainfall with the number of maculatus larvae found. March and April are generally the peak months of maculatus in this country and the pattern is seen in the figure too. This peak is mainly the result of the heavy rains of December/January followed by fairly dry weather in March/April, with increased breeding resulting in malaria peaks from May to July. Although this is the general pattern, the figures as presented for the rest of the year do not follow the trend of a maculatus increase during the dry months following heavy rain. The availability of suitable breeding places seems to depend more on the distribution of rainfall rather than on the total rainfall. An inch (2.5 cm) of rain distributed over several days would produce much more breeding than if it fell in one or two days resulting in the flushing of streams. However in the present study breeding was found to occur regularly in sufficient numbers to be able to assess the various treatments.

4.2 Effectiveness of larvicides (Table 1)

4.2.1 Oil

Although oil was supposed to be applied weekly by the estate, it was not applied up to 20 April and then again from 20 August to 16 September, because oil was in short supply. From 20 April to 10 June oil was applied weekly after which it was applied only when the streams were positive for larvae.

From the results presented in Table 1 it is evident that oil is effective as a larvicide when well applied. Occasionally an odd larva or two appears to survive the application. As the oil kills by physical action, there is every likelihood that a few larvae may survive under the protection of overhanging vegetation. Sometimes streams were found to be free of larvae for two to three weeks after application although the oil film disappears within a few hours of application. The absence of larvae may be due to natural flushing or to the oil left over on the vegetation discouraging egg laying by the female.

4.2.2 Temephos 500E

The results presented in Table 1 show that at a dilution of 1:1000 temephos 50% emulsion gave excellent control with only one instance where larvae were found one week after application. Otherwise 100% kill was obtained and the effect usually lasted up to two weeks and often longer. Larvicide caught in the overhanging vegetation is probably being washed down gradually giving continuous kill.

4.2.3 Temephos 1% sand granules

Temephos granules at the dosage of 0.3 ppm also gave very good results which lasted up to four weeks. The blockage of the streams here (as explained earlier there is little movement of water except during a heavy downpour) probably resulted in the larvicide being retained in the stream for long periods.

4.2.4 Toxicity to non-target organisms

Although no special study was made to assess toxicity to non-target organisms, it was possible to observe that large numbers of tadpoles and a few fish including the guppy, Poecilia reticulata, which were found in the streams were not affected by the application of either the oil or the temephos formulation. Rongsriyam et al. (1968) also observed that temephos application did not affect the guppy. Patterson & Wilson (1966) found that temephos applied at 0.4 lb/acre (448 g/ha) did not affect the tadpoles.

5. DISCUSSION

5.1 Effectiveness

As far as effectiveness was concerned, there was little difference between the oil and the two temephos formulations used at the recommended dosages, all larvicides generally giving 100% kill. When applied thoroughly under close supervision, the effect of oil lasted for at least two weeks in most instances, temephos emulsion two to four weeks and sand granules, four weeks or longer.

Oil is generally applied at weekly intervals throughout the country by the malaria control programme. It is not uncommon to find breeding if a weekly application has been missed. It is not possible to state from the results of the present study whether the larvicides could be applied at longer than weekly intervals, but at least with temephos it is worth further study to see if a fortnightly interval could be introduced equally effectively.

5.2 Other considerations

5.2.1 Cost

The most important factor to consider is the cost which is compared in Table 2 at the prices prevailing in 1975. It is obvious that temephos emulsion is the cheapest with temephos granules costing 7.8 times more and oil 9.2 times more than temephos emulsion. In 1975 the estimated cost of oil for the Ministry of Health alone (excluding municipalities) was about Mal. \$ 1 million (US\$ 0.4 million). If the oil is replaced by temephos emulsion, at the present rate of weekly application, the cost of temephos would be about Mal. \$ 0.1 million (US\$ 0.04 million) resulting in an immediate saving of Mal. \$ 0.9 million (US\$ 0.36 million). If temephos proves to be effective at fortnightly applications then the saving would be double.

5.2.2 Convenience

For every gallon (4.55 litres) of oil transported, the equivalent temephos emulsion would be 4.5 cc or 1000 times less in bulk. An oiler on an average would use about four to five charges of a spraycan per day which at 3 gal (13.6 litres) per charge would be about 15 gal (68 litres) or 45 gal (204.5 litres) for a team of three. This requires an extra workman to carry the oil to the oiler at the worksite and thus the practice of having a "runner" (sometimes two) for each team was adopted to push a cart with a 45 gal drum of oil to supply the oilers. With temephos the sprayman would only have to carry four to five small dispensers (vials) of 9 cc each to the field for his day's work. Water for dilution is readily available everywhere.

In some urban areas bulk storage tanks, sometimes of 5000 gal capacity, are maintained to ensure regular supply, but bulk storage often results in pilferage. Such costly and cumbersome practices could be avoided by using temephos.

5.2.3 Applicability

Oil cannot be applied in streams from which water is taken for cultivation as oil will scorch plants whereas temephos could be used in all types of water. When a stream is a little polluted, oil tends to coalesce quickly instead of remaining as a film thereby reducing its effectiveness. Temephos would be equally effective even with some pollution as it mixes with the water. In parts of the stream that may be missed from oiling due either to poor application or overhanging vegetation, larvae may still survive. As the temephos emulsion mixes thoroughly with the water, even missed areas would be reached by the insecticide/water mixture.

5.2.3 Supervision

Temephos has the disadvantage compared with oil in respect to supervision. The oil is evident in the stream for some hours after application and a supervisor going into the area later could see if the stream had been recently oiled. Oil also scorches the vegetation on the sides. Areas missed for two weeks would show fresh growth. Temephos leaves no signs by which it could be detected after application. Supervision, therefore, must be at the time of application or by a larval survey.

5.2.4 Resistance

Larvae do not develop resistance to oil as the killing action is physical rather than physiological. Oil is still effective in Malaysia after 50 years of use. Temephos may produce resistance in the years to come, but if it can be used for five to 10 years, the savings would be substantial enough to make it worthwhile.

5.2.5 Toxicity and hazards

Temephos has been shown to be a safe larvicide with very low toxicity to warm-blooded animals. At an oral LD₅₀ of 1300 mg/kg and dermal LD₅₀ of more than 5000 mg/kg body weight to female rats, temephos is safer than DDT, the comparative figures for DDT being 113 mg/kg and 2510 mg/kg respectively.

Observations during the present study gave no indication of any toxicity at the dosages used to fish or tadpoles found in the streams. Therefore temephos could be used with safety in all types of streams where oil is used at present.

5.3 Conclusions

Temephos is a very effective larvicide and safe to use against An. maculatus. The emulsion formulation costs about nine times less than oil, and is much more convenient and

easy to apply. It could replace oil as larvicide for malaria control in peninsular Malaysia, resulting in an annual saving of about Mal. \$ 0.9 million (US\$ 0.36 million), at 1975 costs. (Temephos emulsion did replace oil in peninsular Malaysia beginning in 1977.)

6. SUMMARY

A petroleum based oil has been used for over 50 years in the urban areas of peninsular Malaysia as a larvicide for the control of An. maculatus, the principal malaria vector in the country. Due to the sudden increase in the price of oil-based products in 1974, the need arose to look for alternatives to oil. In the present study, two formulations of temephos (temephos 500E - 50% EC and sand granules 1%) were compared with oil in a field trial at Sg. Beranang Estate, Negri Sembilan, about 50 km south of Kuala Lumpur.

The results showed that all three products performed well and that temephos 500E was the cheapest. At the effective dosage of 0.09 kg/hectare or 0.036 kg/acre a.i., temephos 500E was about nine times less than the cost of oil and about 7-1/2 times less than the cost of 1% sand granules at 1975 prices. Temephos 500E has since replaced oil as the larvicide against An. maculatus in peninsular Malaysia.

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TABLE 1. RESULTS OF ANTILARVAL TREATMENTS WITH OIL, TEMEPHOS 50% EC AND 1% SAND GRANULES, CARRIED OUT AT SG. BERANANG ESTATE, NEGRI SEMBILAN DURING 1974

Treatment	Average No. of <i>An. maculatus</i> larvae/50 days									
	Block A Shell Malariol GD			Block B Temephos 500E		Block C Temephos sand granules 1%				Block D Control
Date	1 570 m	2 460 m	3 175 m	4 315 m	5 685 m	6 490 m	7 430 m	8 230 m	9 380 m	10 230 m
8.3.74	22	4	0	17	5	20	-	-	0	12
27.3.74	25	0	164	<u>16</u>	<u>32</u>	<u>8</u>	<u>36</u>	-	<u>20</u>	21
1.4.74	82	20	0	0	1*	0	0	<u>40</u>	0	92
8.4.74	72	65	18*	<u>16</u>	<u>6</u>	0	0	0	0	40
15.4.74	73	80	8*	0	0	6*	0	0	0	8
20.4.74	<u>40</u>	<u>9</u>	<u>0</u>	0	0	0	0	0	0	5
29.4.74	<u>1</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>2</u> *	0	<u>6</u> *	0	0	70
8.5.74	<u>3</u>	<u>0</u>	<u>20</u>	0	<u>2</u>	0	<u>13</u>	<u>2</u>	0	3
15.5.74	<u>0</u>	<u>0</u>	<u>7</u>	0	0	0	0	0	0	0
21.5.74	<u>0</u>	<u>0</u>	<u>20</u>	0	0	<u>15</u>	0	0	0	5
27.5.74	<u>0</u>	<u>0</u>	<u>0</u>	0	<u>7</u>	0	0	0	0	5
4.6.74	<u>0</u>	<u>0</u>	<u>0</u>	0	0	0	0	0	0	0
10.6.74	<u>0</u>	<u>4</u>	<u>0</u>	0	<u>8</u>	<u>8</u>	0	0	<u>19</u> *	8
17.6.74	0	0	0	0	0	0	0	0	0	4
26.6.74	0	0	0	0	0	0	0	<u>4</u>	0	30
4.7.74	0	<u>9</u>	0	0	0	<u>8</u>	0	0	0	21
8.7.74	<u>15</u>	0	<u>11</u>	<u>3</u>	<u>5</u>	0	<u>6</u>	0	0	18
17.7.74	0	0	0	0	0	0	0	0	0	11
22.7.74	0	0	<u>10</u>	0	0	0	0	4	0	82
30.7.74	0	0	0	0	0	-	-	-	-	12
12.8.74	62	6	0	<u>4</u>	<u>1</u>	-	-	-	-	10
19.8.74	10	27	0	0	0	-	-	-	-	10
26.8.74	7	3	4	0	0	-	-	-	-	0
3.9.74	18	8	18	0	<u>2</u>	-	-	-	-	0
16.9.74	36	<u>10</u>	<u>20</u>	<u>6</u>	0	-	-	-	-	50
30.8.74	0	0	0	0	0	-	-	-	-	0
7.10.74	0	0	0	0	0	-	-	-	-	23
14.10.74	0	0	0	0	0	-	-	-	-	28
28.10.74	0	<u>1</u>	<u>3</u>	<u>3</u>	<u>5</u>	-	-	-	-	9
4.11.74	<u>4</u>	0	0	0	0	-	-	-	-	8
11.11.74	0	0	0	0	0	-	-	-	-	9

* 1st and 2nd stage larvae only. Number underlined means that larvicide applied on this date.

TABLE 2. COST COMPARISON BETWEEN TEMEPHOS (50% EC AND 1% SAND GRANULES)
 AND OIL AS OBTAINED FROM TRIALS CONDUCTED AT SG BERANANG
 ESTATE, NEGRI SEMBILAN DURING 1974

Larvicide	Temephos 500E (50% EC)	Temephos 1% sand granules	Oil "Shell Malariol CD"
DILUTION	1:1000	Nil	Nil
Approximate length of trial stream	1000 m	1530 m	1200 m
Average amount of larvicide/30 m	10 litres (dilute)	1 kg	10 litres
Dosage per acre per hectare	0.036 kg a.i. 0.09 kg a.i.	0.18 kg a.i. 0.072 kg a.i.	16 gal/72 litres 40 gal/180 litres
Unit cost of larvicide US\$	56.00/US gal ¹	1.16/kg ¹	0.64/imp. gal ²
Cost of larvicide per hectare US\$	\$ 1.12	\$ 8.40	\$ 11.6
Cost of larvicide per acre US\$	\$ 2.80	\$ 20.88	\$ 25.60
Cost ratio	1	7.5	9.2

¹ As obtained from the suppliers on 1 May 1976.

² Government contract price in 1975 - Mal. \$ 1.55/imp. gal in bulk
 Mal. \$ 1.66/imp. gal in 45 gal drums
 Average Mal. \$ 1.60 = US\$ 0.64.

FIG. 1. SG. BERANANG ESTATE, NEGRI SEMBILAN SHOWING THE TRIAL BLOCKS A, B, C AND D AND THE STREAMS NUMBERED

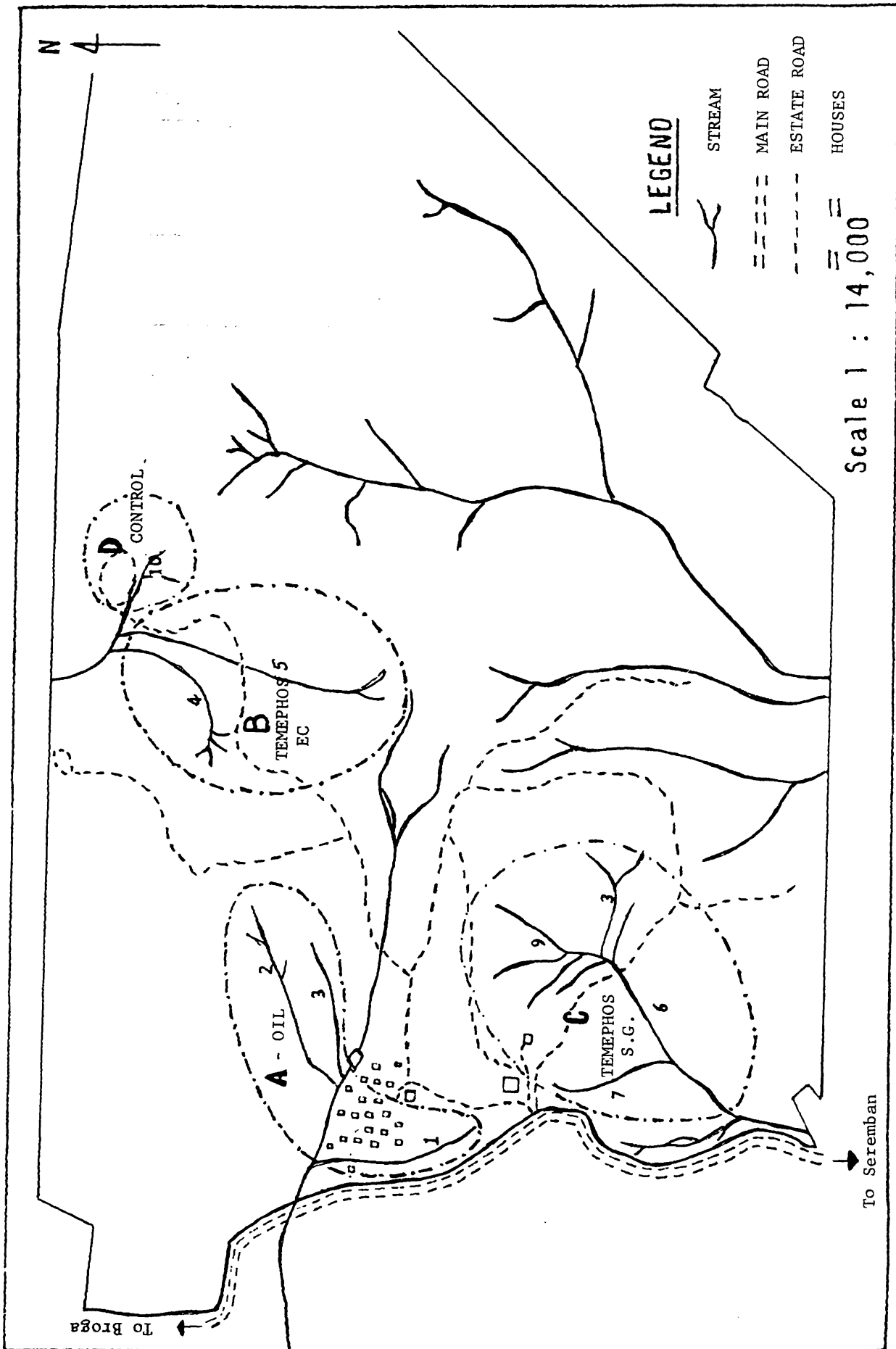


FIG. 2. WEEKLY RAINFALL AT SG. BERANANG ESTATE AND AN. MACULATUS LARVAE COLLECTED PER 50 DIPS FROM MARCH TO SEPTEMBER 1974

