AN AUTOCIDAL OVITRAP FOR THE CONTROL AND POSSIBLE ERADICATION OF *AEDES AEGYPTI*†

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INTRODUCTION

Dengue haemorrhagic fever (DHF) has replaced malaria as the most important and serious mosquito-borne disease throughout tropical Asia and the Western Pacific. Hundreds to thousands of people die of the disease almost every year. After some 20 years of its history, no effective drug or vaccine has yet been developed for its treatment. Its control still depends largely on the control of the *Aedes* vectors, particularly *Ae. aegypti*, the principal vector.

Ae. aegypti can be controlled effectively by integrated measures (Chan, 1973a). In Singapore the *Aedes* premise index is reduced to 2%-5% by source reduction, health education, legislation and fogging of areas with more than 5% premise index (Chan and Ng, 1975). Further reduction does not seem possible in the absence of additional measures.

On a long term basis, the conventional method of controlling *Ae. aegypti* by using insecticides should be discouraged. This is because the use of insecticides has many disadvantages and undesirable side effects, e.g. insecticides are only palliative and temporary 'stop-gap' measures; they cannot suppress vector populations for long periods and must be used repeatedly for year-round control; their constant repetitive and unending use causes problems of environmental pollution and development of resistance in the vector; indiscriminate and careless use of insecticides leads to accidental poisoning to both the applicators and the public, and to unwarranted destruction of beneficial non-target insects and other animal life. Alternative methods that are safe, effective and economical should therefore be found. The use of ovitraps in *Ae. aegypti* control is one such method.

The ovitrap or oviposition trap was first developed in the United States for the surveillance of *Ae. aegypti* (Fay and Perry, 1965; Fay and Eliason, 1966). It was subsequently used as a surveillance device for detecting the presence of *Ae. aegypti* in low density areas in the *Aedes aegypti* eradication programme in that country (Jakob and Bevier, 1969; Thaggard and Eliason, 1969).

The American ovitrap was first modified and used in 1969 as a supplementary measure for the control of *Aedes* vectors in the Singapore Paya Lebar International Airport (Chan, 1973b). It was so effective that *Ae. aegypti* became eradicated from the airport one year after its introduction (Chan, 1973b). For six consecutive years, *Ae. aegypti* has not reappeared in the airport within the 800 metres boundary.

A new type of ovitrap specially designed and developed for the control of *Aedes* vectors in urban premises was recently experimented in two Singapore city areas (Chinatown and Rochor) with high *Aedes* density and DHF incidence. This paper presents the findings of one aspect of this study, namely the use of the attractiveness of the ovitrap for the possible eradication of *Ae. aegypti* in the Rochor experimental area.

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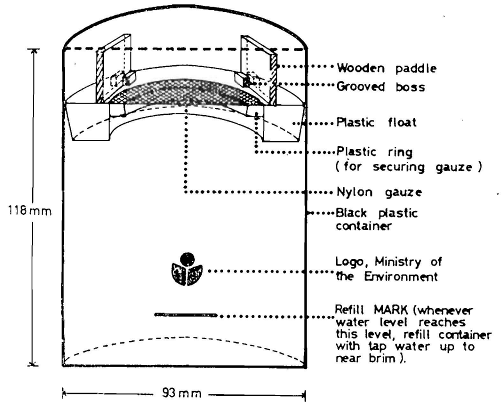

Fig. 1—Longitudinal section of autocidal ovitrap.

MATERIALS AND METHODS

The American surveillance ovitrap was modified into a control trap for *Aedes* vectors. Several models were designed and tested in the laboratory until the final model (Fig. 1) became autocidal, i.e. capable of continuously destroying the progeny of *Aedes* vectors from eggs laid, without human intervention, except for periodic refilling of the ovitrap with water when it has become dry.

The autocidal ovitrap (Fig. 1) comprises 3 principal components:

(i) a black plastic container for attracting gravid and ovipositing *Aedes* female mosquitoes, black being the colour most attractive to *Aedes (Stegomyia)* species;

(ii) a plastic ring or float with air trapped inside its sealed hollow space, and with fine nylon netting to prevent the escape of emergent adult mosquitoes should this happen; and

(iii) two pieces of hard-board oviposition paddles which serve as suitable substrates for gravid ovipositing females and which are held in a vertical position by grooved bosses on the topside of the float.

About 2 months after preliminary observations in the Rochor study area ovitraps were placed inside 115 houses, 3 to each house, except for two houses where only single ovitraps were used. The *Aedes* premise index, breteau index, and density of larval and adult were measured weekly throughout the study period.

RESULTS

Habitats positive for breeding: Table 1 shows the percentage of habitats that were positive for *Aedes* breeding in the 115 premises examined weekly. It will be seen that there was much higher breeding of *Ae. aegypti* than *Ae. albopictus* in domestic habitats as well as in autocidal ovitraps. Autocidal ovitraps were about 81 times more attractive than habitats to gravid ovipositing *Aedes* females, as shown by the ratio of attractiveness between the two types of habitats (Table 1).

Fig. 2 shows graphically the same comparison between the attractiveness of autocidal ovitraps and domestic habitats in terms of percentage habitats found positive for *Aedes* vector breeding. The percentage of breeding in domestic containers fluctuated at a low level, with a mean of 0.2%. The percentage of breeding in autocidal ovitraps fluctuated at a considerably higher level after an initial buildup. By April 1975, the percentage of positive autocidal ovitraps had stabilized, and fluctuated at a mean of 18.4%. Again, it is apparent that *Ae. aegypti* was much more attracted to the autocidal ovitraps than was *Ae. albopictus*. The autocidal ovitraps were also much more attractive to *Ae. aegypti* than were domestic containers.

Premises positive for breeding: Fig. 3 shows a comparison between premises that had *Aedes* breeding in domestic containers and in autocidal ovitraps.

Table 1

Percentage of habitats positive for *Aedes* breeding in the Rochor study area.

Date of survey	Domestic habitats					Autocidal ovitraps					Ratio of attract-iveness (ovitrap: natural)
	No. exam.	No. breeding		% positive		No. exam.	No. breeding		% positive		
		aeg.+ alb.	aeg.	aeg.+ alb.	aeg.		aeg.+ alb.	aeg.	aeg.+ alb.	aeg.	
1974											
Dec. 16	482	7	7	1.5	1.5	-	-	-	-	-	-
26	482	2	1	0.4	0.2	-	-	-	-	-	-
1975											
Jan. 2	482	2	1	0.4	0.2	-	-	-	-	-	-
6	480	5	4	1.0	0.8	-	-	-	-	-	-
14	480	4	4	0.8	0.8	-	-	-	-	-	-
21	477	5	5	1.1	1.1	-	-	-	-	-	-
27	467	5	5	1.1	1.1	-	-	-	-	-	-
Feb. 3	488	3	3	0.6	0.6	-	-	-	-	-	-
17	482	1	1	0.2	0.2	-	-	-	-	-	-
24	479	3	3	0.6	0.6	338	2	1	0.6	0.3	0.9:1
Mar. 3	482	0	0	0	0	341	21	18	6.2	5.3	-
10	479	1	1	0.2	0.2	337	26	23	7.7	6.8	36.8:1
17	482	1	1	0.2	0.2	341	50	47	14.6	13.8	69.6:1
24	479	1	1	0.2	0.2	338	66	56	19.5	16.6	93.0:1
31	482	3	3	0.6	0.6	338	62	60	18.3	17.8	29.6:1
Apr. 7	482	2	2	0.4	0.4	338	61	56	18.1	16.6	43.0:1
14	462	1	1	0.2	0.2	326	50	43	15.3	13.2	69.7:1
21	475	1	1	0.2	0.2	335	75	60	22.4	17.9	106.6:1
28	475	2	2	0.4	0.4	335	63	55	18.8	16.4	44.8:1
May 5	480	5	5	1.0	1.0	338	68	59	20.1	17.5	19.3:1
12	467	1	1	0.2	0.2	329	68	56	20.7	17.0	98.4:1
19	478	1	1	0.2	0.2	335	53	46	15.8	13.7	75.3:1
27	472	3	3	0.6	0.6	329	54	46	16.4	14.0	25.7:1
June 2	459	0	0	0	0	329	61	50	18.5	15.2	-
9	480	1	1	0.2	0.2	338	69	60	20.4	17.8	97.2:1
16	477	1	1	0.2	0.2	335	68	59	20.3	17.6	96.7:1
23	472	0	0	0	0	335	61	55	18.2	16.4	-
30	482	1	1	0.2	0.2	341	66	56	19.4	16.4	92.2:1
July 7	482	0	0	0	0	341	76	66	22.3	19.4	-
14	482	1	1	0.2	0.2	341	77	69	22.6	20.2	107.5:1
21	460	0	0	0	0	326	64	62	19.6	19.0	-
28	482	0	0	0	0	341	61	58	17.9	17.0	-

Table 1 (cont'd)

Date of survey		Domestic habitats					Autocidal ovitraps					Ratio of attract-iveness (ovitrap: natural)
		No. exam.	No. breeding		% positive		No. exam.	No. breeding		% positive		
			aeg.+ alb.	aeg.	aeg.+ alb.	aeg.		aeg.+ alb.	aeg.	aeg.+ alb.	aeg.	
Aug.	4	475	0	0	0	0	335	56	50	16.7	14.9	-
	11	472	0	0	0	0	332	73	59	22.0	17.8	-
	18	461	0	0	0	0	329	70	60	21.3	18.2	-
	25	458	0	0	0	0	323	56	46	17.3	14.2	-
Sep.	1	480	1	1	0.2	0	338	40	31	11.8	9.2	59.2:1
	8	467	1	1	0.2	0	329	55	51	16.7	15.5	83.0:1
	15	441	0	0	0	0	311	49	42	15.8	13.5	-
	22	461	0	0	0	0	323	40	39	12.4	12.1	-
	29	448	0	0	0	0	320	59	55	18.4	17.2	-
Total	(A)	15113	31	31	0.21	0.21	10665	1820	1594	17.1	15.0	81.3:1
	(B)	12712	25	25	0.20	0.20	8970	1655	1449	18.5	16.2	97.1:1

(A) = 24 Feb. 75-29 Sep. 75, (B) = 31 Mar. 75-29 Sep. 75.

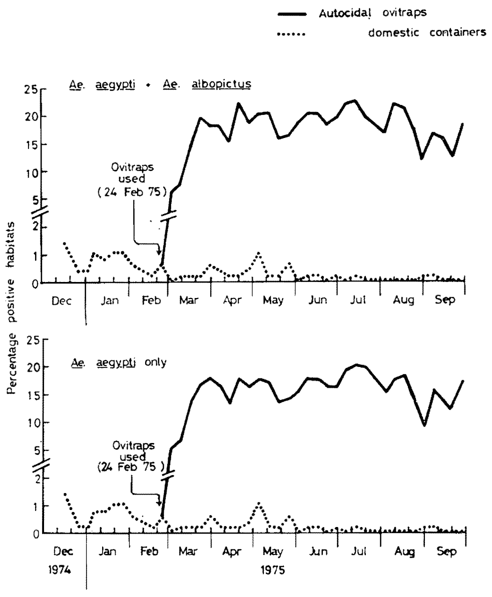

Fig. 2—Percentage of positive autocidal ovitraps and domestic containers, Rochor study area.

The usual premise index or percentage of premises positive for *Aedes* breeding,

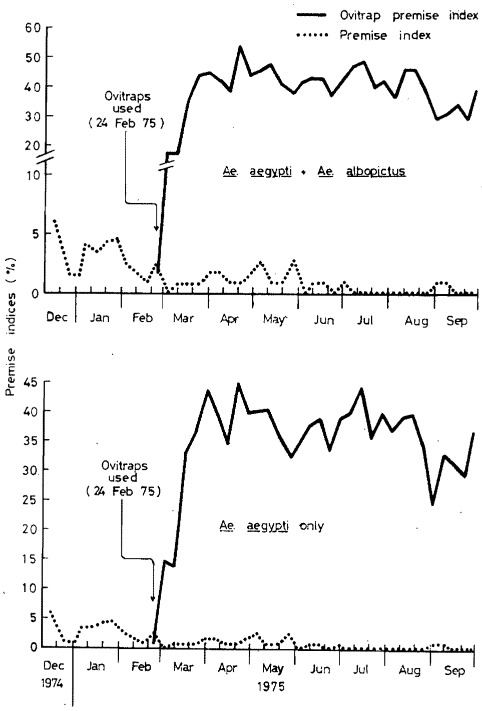

Fig. 3—Premise indices in Rochor study area.

fluctuated between 6.1% initially in December 1974 and 0% towards July 1975, averaging at 1.3%.

The ovitrap premise index, i.e. percentage of premises with at least one autocidal ovitrap positive for *Aedes* breeding, fluctuated at 41.3% by the end of March 1975 after an initial buildup from 2% in February when it was introduced, thus showing that the use of ovitraps had increased the premise index by 31 times, i.e. from 1.3% to 41.3%. The autocidal ovitrap is thus again shown to be much more attractive than domestic habitats.

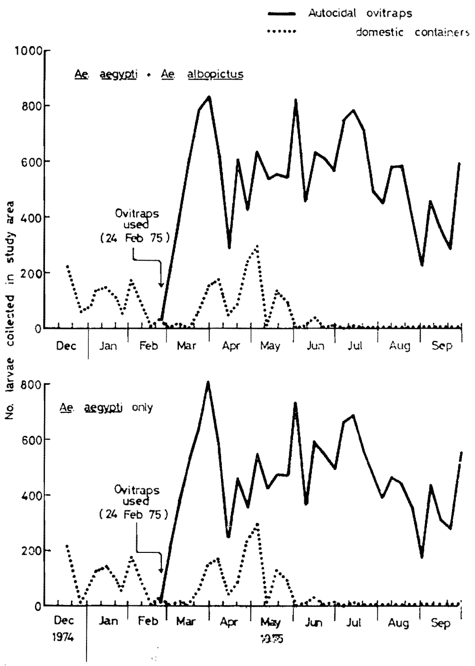

Fig. 4—No. larvae collected in autocidal ovitraps and in domestic containers, Rochor study area.

Larvae in breeding habitats: Fig. 4 shows the number of larvae collected weekly from domestic habitats and from autocidal ovitraps. The weekly total number of larvae collected from domestic habitats in the study area of 115 houses fluctuated between zero and 300 per collection with an average of 48. The weekly total number of larvae collected from autocidal ovitraps, on the other, fluctuated at a much higher level. From 20 at the time of introduction, it increased sharply to 834 about one month later and thereafter fluctuated between 834 and 286, with a mean of 550.

Thus, the superior attractiveness of the autocidal ovitrap is again demonstrated. That it is particularly attractive to *Ae. aegypti* is also abundantly clear.

DISCUSSION

In the control of DHF, the control of the principal vector, *Ae. aegypti*, is most important. Any device or method employed for its control should be directed principally at this vector.

Ae. aegypti is a highly anthropophilic mosquito. In Singapore, it is fully domesticated and dependent on man for its survival. All its activities such as breeding, feeding, resting and mating, are carried out in the domestic environment. Man is the chief, in most cases, the only, source of its blood meal and the provider of its breeding habitats. Its control thus depends largely on man changing his habits of storing water in and around the house. For this, health education and legislation are important means for preventing and controlling its breeding. However, it is Singapore's experience that these and other integrated measures, including fogging of areas with more than 5% premise index, cannot suppress the premise index below 2%. Further suppression must involve the use of additional supplementary measures, such as the ovitrap.

The use of the ovitrap in the surveillance of *Aedes* vectors is recommended by the World Health Organization (WHO, 1972). It is a sensitive and accurate device for detecting the presence of *Ae. aegypti* in port and airport areas. It is also recommended for the detection of this species in certain urban situations such as schools and hospitals and is recommended for use in low density areas (WHO, 1975). However, it has not been recommended for use in the control of *Aedes* vectors, whether under low density areas or in special situations such as ports, airports, schools and hospitals.

The first documented use of the ovitrap as a control device for *Aedes* vectors was that reported by Chan (1973b) in the Singapore Paya Lebar International Airport. This was also the first documented account of the eradication of *Aedes aegypti* from an airport by this device.

The present study using the improved ovitrap or autocidal ovitrap is also the first documented account of using this device for the control and possible eradication of *Ae. aegypti* in an urban environment. The present study has shown that the autocidal ovitrap, designed by the authors, is superior to all other domestic containers including ant traps and jars, the most preferred breeding habitats of *Ae. aegypti* and *Ae. albopictus* in nature (Chan *et al.*, 1971). Its superior attractiveness is due to the combination of two characteristics preferred above all others, by *Aedes (Stegomyia)* species, namely, the black colour of the container and the special properties of the hard-board paddles as oviposition substrates.

The present study shows that through gradual trapping and killing of the progeny of *Ae. aegypti*, and through gradual reduction of the mosquito population, eradication of this mosquito is possible, as was demonstrated at the Paya Lebar International Airport (Chan, 1973b). Eradication would theoretically be most rapid when domestic habitats are first reduced to a minimum by intensified integrated control. Total eradication of the species may not, however, be simple. There will always be the problem of constant re-introduction of the species through air, sea and land travel.

It is unlikely that the autocidal ovitrap could be used for the eradication of *Ae. albopictus* as this species is little affected. Being less domesticated than *aegypti*, it still utilizes many natural habitats such as tree holes, fallen leaves, leaf axils, etc, in forested areas. The control and eradication of *Ae. albopictus* is thus more difficult.

The use of autocidal ovitraps may be compared to the use of genetic measures. Like genetic methods, it works best when the natural mosquito population, in this case the number of domestic habitats is first reduced to a minimum. The number of natural domestic habitats must be significantly less than the number of autocidal ovitraps used. The ratio between these two types of habitats at which eradication is possible has not yet been determined.

The use of autocidal ovitraps in an integrated control programme has many advantages. First, unlike insecticides and biological agents, such a mechanical device does no apparent harm to the environment. Second, it is specific, being effective against only container breeders like the *Aedes* vectors, particularly *Ae. aegypti*. Third, it creates no environmental pollution or insecticide resistance problems. Fourth, it can be easily implemented in the home. All that is required is the periodic replacement of water that is evaporated. However, the removal of any of its parts must first be made fool-proof before it could be implemented on a country-wide basis. Otherwise it would itself become a major breeding habitat. Fifth, it is economical, each trap costing only about S$ 2 and, except for the paddles which would rot with time, would last almost indefinitely if the plastic parts are properly constructed. Sixth, it can be placed anywhere in the home to achieve maximum control, e.g. in the kitchen and bathroom and near water sources where the adult mosquitoes rest. Seventh, it saves manpower required in the routine inspection of premises by public health officers.

SUMMARY

A revolutionary, autocidal ovitrap has been developed as a promising weapon for the control and possible eradication of *Ae. aegypti*, the principal vector of dengue haemorrhagic fever (DHF), in urban high DHF endemic areas. A study carried out with this trap in a highly endemic area for DHF in Singapore city, namely the Rochor area, has shown this trap to be superior to all other domestic habitats in attractiveness to ovipositing *Ae. aegypti* females.

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