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The Control of *Aedes aegypti* in South-East Asia and the Western Pacific

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INTRODUCTION

Whatever its origin and time and manner of introduction, *Aedes aegypti* is today a widespread and primarily urban pest and vector species throughout South-East Asia and the Western Pacific.

Organized control programmes aimed specifically, or even incidentally, at the control of *A. aegypti* anywhere in the above regions are comparatively few in number. Most of the programmes that do exist are restricted to international airports and seaports, in accordance with international sanitary agreements. Unfortunately, even in these places, the control programmes, with a few exceptions, have had little effect.

Following the recent outbreaks and rapid spread of dengue and haemorrhagic fevers, much interest has now developed in how this species, as well as *Aedes albopictus*, can be effectively and economically controlled in large population centres. Although, as indicated above, *A. aegypti* is mostly found in large cities in the area, reports from Thailand show that it is also common in small towns up-country. *A. albopictus*, with its possible role in the epidemiology of haemorrhagic and dengue fevers, represents both an urban and a rural problem and further complicates the planning of control measures.

The following review will describe control efforts in those places known to the author as well as those which have been reported in the literature. For most of those cities not mentioned, it may be assumed, unfortunately, that no work is being done against *Aedes (Stegomyia)* mosquitos. The review will commence at Karachi and move eastwards.

REVIEW OF COUNTRIES

Pakistan

Karachi. The *A. aegypti* situation in Karachi was most recently described by Mouchet.[2] While that city has a municipal mosquito-control service, its concern is mostly with *Culex pipiens fatigans*. *A. aegypti* is present but restricted in distribution, the index is low, and no specific measures are taken against it.

Dacca. There was a severe outbreak of dengue in this city in 1964. Little information appears to be available on mosquito distribution within the city, and there is no control work against the apparently common *A. aegypti* (personal communication from P. K. Russell, 1965).

India

Bombay. Control measures in Bombay are restricted to the airport and seaport only and were described by Khurana, Bhatia & Sharma (1957). At that time, the measures carried out were DDT residual spraying every three months and weekly oiling of all potential larval habitats. While good control was being obtained at the airport, measures at the seaport appeared ineffective. *Aedes* breeding in drinking-water containers on small vessels is also a problem.

Calcutta. Following the outbreak of dengue and haemorrhagic fever in Calcutta in 1963, *A. aegypti* control procedures in that city were critically reviewed by Wattal (1964). Some of the Calcutta corporation area had been previously sprayed with DDT as part of the national malaria eradication programme, and it appeared that the incidence of febrile illnesses was somewhat less in the DDT-sprayed ward than in the unsprayed ones (Ramakrishnan et al., 1964).

Wattal also surveyed the *Aedes* population of Calcutta following the July 1963 haemorrhagic fever outbreak; he found *A. aegypti* and *A. albopictus* breeding in the airport area and the former in water barrels and drums on barges and junks in the port. In the city, *A. aegypti* and *A. albopictus* were commonly found in both the sprayed and unsprayed wards. Mosquito-control staffs exist for the airport, seaport and city, but obviously their work was not effective against *Aedes*. He recommended a number of measures to control *Aedes* in Calcutta, including

[1] Vector Biology and Control, World Health Organization, Geneva, Switzerland.

[2] Unpublished report to WHO (1965).

elimination of breeding-sites, use of larvicides (oils and pyrosine), the use of pyrethrum spray against adults in selected areas and focal and peripheral belt spray of habitations by DDT at 1 g/m² (although he observed that the present organization would probably not suffice for the above work). About 530 persons are engaged in mosquito control, mostly in the city, but including the small staffs in the seaport and airport.

Rao & Anderson (1964) state, following a discussion on the vector(s) of haemorrhagic fever in India, that " The bionomics, habitats and current distribution of *Aedes* (*Stegomyia*) species, neglected in recent years in India, need to be restudied ".

Delhi. Krishnamurthy et al. (1965) surveyed *Aedes* in urban and semi-urban areas of Delhi and found *A. aegypti* in 14 of 40 sectors searched and *A. albopictus* and *A. vittatus* in one each. No particular measures are taken against *Aedes* spp., but parts of the city are sprayed twice during the malaria transmission season with DDT at 1 g/m². Arriving aircraft are also sprayed following exit of the passengers.

Burma

Rangoon. A. aegypti and *A. albopictus* are both very common species in this city, the former species being widely found breeding in fresh water stored in clay jars and 55-gallon (250-litre) drums as well as in smaller water containers such as vases. No specific control measures are undertaken against these species, although the Ministry of Health is concerned about control of *Aedes* in view of the probable disease problem involved. *Aedes* spp. are still reported at the international airport and its vicinity.

Thailand

Bangkok. A. aegypti is widespread and very common throughout the city and in all of its suburbs. Larvae are found in virtually any stored fresh water, particularly in the large glazed-clay jars used for storing water for drinking, cooking and bathing. Rudnick (1965) believes that *A. aegypti* has almost completely displaced *A. albopictus* in this city. The Bangkok municipality maintains a division of mosquito control, with a staff of 80 men. Its budget for the year 1965 was about 2 000 000 ticuls (Tcs), or about US$10 000, for insecticides and Tcs 300 000 ($15 000) for staff, or a total of $25 000. Its work includes all activities against any mosquito species in the municipal area. Work against *A. aegypti* is based on larviciding, fogging and perifocal spraying of the vicinity of cases of haemorrhagic fever. Judged by the plenitude of *Aedes* within the city, the programme has had little effect against this species. The municipality has asked the Government for an additional $15 000 yearly, at the time of writing, for control of *A. aegypti.*

The Ministry of Public Health has conducted a pilot project covering a population of 15 000 in about 1700 houses in a suburb of Bangkok. This programme consists of a yearly spraying with DDT at the rate of 2 g/m², plus twice-monthly inspections of all houses in the area and re-treatment where necessary. The staff includes 11 men, plus a supervising physician. The estimated yearly cost of about $5250 does not, however, include transport, insecticide or half-day supervision by the medical director. This project was undertaken in an area of rather better-than-average housing. Despite its initial success in reducing the *A. aegypti* index, the development of a very high degree of DDT-resistance in larvae taken from the area is apparently the reason for a steady increase that has been noted in the *A. aegypti* index. Based on the cost figures from this project, control of *A. aegypti* in all of Bangkok, using the same methods and materials, would cost about $800 000 to $1 000 000 yearly. This cost is well beyond the financial capabilities of either the Ministry or the municipality. The control picture in Bangkok is further complicated by the presence of about 6000 registered river-boats, almost all of which have fresh-water containers that are likely breeding-sites for *A. aegypti.*

DDT residual spraying (5%) was done at one time in the area of the international airport, but this has ceased, and *A. aegypti* and other mosquito species are common at the airport and throughout its perimeter.

Malaysia

Kuala Lumpur. Both *A. aegypti* and *A. albopictus* are commonly found throughout the city. The only control measure currently practised is the residual spraying of the international airport with dieldrin. The municipality also attempts to keep a 400-yard (ca 360-metre) *Aedes*-free belt around the airport, but heavy breeding occurs just beyond this limit. The choice of dieldrin is based upon the findings of Macdonald (1958) that Malayan *A. aegypti* were relatively tolerant to DDT. Earlier, Macdonald (1957) described experiments on the control and eradication of *A. aegypti* in Malaya. Field trials were carried out at Jeram, Kapar and Port Swetten-

ham, all on the west coast of the peninsula. From these experiments, Macdonald concluded that spraying techniques would be more effective than the use of pellets and recommended perifocal spraying with dieldrin. At present, there are 400 antimalaria and anti-mosquito workers employed in the city of Kuala Lumpur at an annual cost of M$800 000, or about US$266 000, but this force cannot completely control the *Aedes* populations except in the area of the airport. In a recent inspection of a kampong neighbourhood, half a mile (800 m) from the airport, *Aedes* was found breeding in 5 out of 6 houses visited.

Penang. The municipality of Georgetown, whose population is 273 000, has an anti-mosquito section which divides its work into malaria control and mosquito control, the latter referring to culicine control. The budget for the section is M$301 794, or about US$100 000, a year including M$224 000 for the salaries of 16 anti-mosquito inspectors and 160 labourers. No residual spraying is done; only larviciding with oil and the clearing of empty containers. This coverage of the area, linked with the fact that there are comparatively few storage containers for fresh water, seems to result in only incidental breeding of *A. aegypti* and *A. albopictus* being found.

Singapore

Both *A. aegypti* and *A. albopictus* are found in Singapore, but nowhere with any great frequency. Anti-mosquito work here is limited to antimalaria work around the city. Mosquito-control work at the international airport is intensive, and reports of *Aedes* are very rare. The large-scale rehousing projects in Singapore, consisting of the construction of multi-storied apartment houses, have resulted in the replacement of many urban slums as well as much of the kampong or rural-type housing within the city and a concomitant reduction in *A. aegypti* larval habitats. A vector control section has recently been created by the Ministry of Health and has already begun a survey of *Aedes* breeding and distribution throughout the city.

Viet-Nam

Saigon. The *Aedes* population of Saigon has been surveyed and both *A. aegypti* and *A. albopictus* are widespread in the city. Both species are resistant to DDT, and *A. aegypti* adults are resistant to dieldrin. No current control programme is being undertaken, and health education has been recommended to persuade people to cover properly their fresh-water containers together with the use of insecticides other than the chlorinated hydrocarbons if control work is undertaken.

Hong Kong

A. aegypti has not become established in Hong Kong. However, *A. albopictus* is one of the two most important pest mosquitos in the colony, the other being *Culex fatigans*. *A. albopictus* is commonly found breeding in tree-holes, holes in bamboo scaffolding and, to a lesser extent, in artificial containers. The emphasis in mosquito-control work is on the destruction or prevention of larval habitats. No information was available on the budget of the mosquito-control section, but including both salaries and materials, the pest-control section, which is at present responsible for mosquito control in the New Territories only, has a total budget of about US$10 000 a month.

Philippines

Manila. Mosquito control in Manila is the responsibility of the section of Insect and Vermin Control of the Division of Sanitation of the Manila Health Department. *A. aegypti* and *A. albopictus* breeding is common during the rainy season. For mosquito control, the municipality has 170 men, including supervisors. The aid of the Boy Scouts has been enlisted in spraying houses with hand-sprayers and a commercial insect spray. Dichlorvos fogging has also been carried out and the results evaluated with human baits before and after fogging. Eighty thousand pesos yearly are spent on materials and supplies, and 400 000 pesos yearly on salaries, for a total of 480 000 pesos, or about US$84 000 a year. However, control of all species is admittedly insufficient, and particularly so with *Aedes* spp.

DISCUSSION

Although not all of the large urban centres of the regions have been covered by the above review, it can be seen that *A. aegypti* and *A. albopictus* control is largely ineffective. There are several reasons for this, only one of them being that very little of the present mosquito-control effort is specifically directed toward the control of these two species.

In most of the countries of the regions discussed here, the habits of the populations are such as to encourage *Aedes* breeding. Rain-water is stored in a variety of containers around homes, and an enormous effort would be required, through health education, legislative enforcement and the provision of

alternative sources, to change this habit. Widespread use of domestic insecticides, as well as antimalaria campaigns, apparently has given rise to high levels of resistance to the chlorinated hydrocarbon insecticides. Faced with the multitude of breeding-sites in such cities as Bangkok, Rangoon and Manila, reliance on the traditional methods of frequent inspection and re-treatment may prove to be completely uneconomical when the costs of labour, transport and insecticide approach US$0.50 per person-year, as they already do in some cities. In order for control operations to be at all economically feasible, one of several approaches must be made:

(*a*) The number of breeding-sites must be drastically reduced by public co-operation, although it is realized that this is difficult when it goes against traditional practices of water storage.

(*b*) A long-lasting larvicide of low mammalian toxicity in a suitable formulation must be made available.

(*c*) The major types of larval habitats of *A. aegypti* and *A. albopictus* must be delimited and a decision made as to where most of the control efforts are to be made.

(*d*) Far more information must be obtained on many aspects of the biology of *A. aegypti* and *A. albopictus*, such as distribution, insecticide susceptibility, dispersion and preferred larval habitats, on which rational campaigns can be based. Unfortunately, at present such information is available for few if any areas in the regions under consideration here.

When such information becomes available, control campaigns can be planned on a more rational, if more limited, basis, even utilizing presently available methods and materials. Faced with the necessity of developing effective control procedures, WHO will soon undertake studies to obtain such basic information. This has already been done by establishing an *Aedes* Research Unit in Bangkok to carry out research on the biology, ecology and insecticide susceptibility of *Aedes* (*Stegomyia*) spp. in Bangkok and elsewhere in Thailand, with a view to establishing effective and economic control procedures. After such data as these have become available, it will be possible to consider the manner in which new insecticides, new formulations and even new concepts of control, such as the use of sterilants and of genetic and cultural methods, can best be supplied.

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