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CONTROL OF *AEDES AEGYPTI* (LINN.) IN SOUTHEAST ASIA

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Introduction: As measured by the criteria of ability to disperse and to adapt to varying environments, *Aedes aegypti* must be reckoned as a distinctly successful species. The best present evidence is that the species originated in Africa and spread from there to most of the tropical and subtropical areas of the world, most often with the unknowing assistance of man. Once having become established in a favorable area it may be eliminated only with considerable expenditures of time, money and human ingenuity. That eradication is possible, given these elements, is amply demonstrated by the campaigns conducted in tropical America under the aegis of the Pan American Health Bureau. However, difficulty has been encountered even in that generally successful program due to the emergence of insecticide resistant strains of *aegypti* in recent years.

The urban areas of SE Asia offer a particularly favorable environment for *A. aegypti*. The climate permits breeding throughout the year, with population fluctuations due chiefly to rainfall variations. The inhabitants of Bangkok, Saigon, Rangoon, and many other cities and towns, store enormous amounts of water for household use. This is because they either lack adequate piped water, or because the water pressure in the available systems fluctuates so widely. The number of water storage containers in Bangkok, a city of over two million, almost staggers the imagination. The structure of Bangkok and of other cities in the region makes survey and control operations extremely difficult, since the houses are set very close together, frequently on piling over water, and often without discernable pattern. Thus, despite the importance of *Aedes aegypti* as a pest mosquito, and despite its importance as a vector of at least dengue and chikungunya viruses, relatively little has been done for the control of *aegypti* in SE Asia. In Bangkok, for instance there have been isolated attempts at control during outbreaks of hemorrhagic dengue disease, but no city-wide long term program. Until quite recently the budget available did not permit even a pilot control project in Bangkok, much less in the other urban areas of Thailand. In some of these towns the *aegypti* population may be even higher per unit dwelling than in Bangkok. To varying degrees the same situation prevails in the other countries of SE Asia. When one considers the complexity and expense of the *A. aegypti* eradication program recently organized in the southern part of the United States it is apparent that the relatively less developed areas of SE Asia face a truly herculean task if they are to rid themselves of *aegypti*.

General remarks on control: The control of *Aedes aegypti* depends to a great degree on the understanding and cooperation of the local population. Public education and information are therefore even more important than they are in other mosquito control operations. The householder can decrease breeding to a considerable extent by eliminating all unnecessary water containers, and by the proper disposal of water-holding trash. The use of tightly fitted covers on necessary containers will also help eliminate breeding. Such measures must be emphasized constantly by public health education officers. The degree of public cooperation in Bangkok is quite high during hemorrhagic fever epidemics, but tends to slack off when few cases were occuring.

Even more cooperation from the public is required when insecticide application is to be made to potable water containers, and the need for public education is correspondingly greater. There is a natural resistance on the part of many to the addition of chemicals to water intended for human consumption, even when the relatively inconspicuous forms of brickettes or granules are employed. Experience elsewhere indicates that such programs can be successful, if properly handled and properly explained.

In the final analysis, the control of *aegypti* in the urban centers of SE Asia must depend on the introduction of adequate piped water supplies, and other sanitary measures. This obviously is a longterm process which will also involve a considerable cultural change for the local populations. In the interim, reliance must be placed primarily on chemical control. Fortunately, no truly feral strain of *aegypti* has appeared in SE Asia, despite a few records of treehole breeding in cities. Thus, *aegypti* is still a domestic species in Asia, accessible to the chemical control methods discussed below. Should it ever adapt to life in the vast forests of SE Asia the situation would be quite different.

Larval control: Use of larvicides appears to be the most generally successful method of *aegypti* control. In Malaysia and Thailand this has frequently taken the form of "perifocal spraying" with DDT. This consists of the spraying of actual or potential breeding sites and the surrounding areas where emerging adults or ovipositing females may rest. This same general method is being employed to some extent in the eradication programs in the New World. There appears, however, to be an enhanced opportunity for development of resistance where the immature stages and adults are exposed to the same insecticide in this manner. Strains of *aegypti* resistant to DDT have been encountered in Thailand, Malaysia and Vietnam. Resistance to dieldrin has also been encountered in Bangkok, and it seems likely, based on the experiences in the Caribbean area, that resistance to chlorinated hydrocarbon insecticides will spread fairly rapidly in SE Asia where these insecticides are rather widely used. Where *aegypti* are still susceptible to DDT or dieldrin, however, there is every justification for using these insecticides since they are inexpensive and readily obtained. Where this is done, the responsible personnel should be careful to obtain good base-line data on *aegypti* susceptibility, and should remain alert to changes in these levels. DDT may be applied in the form of a spray or emulsion. Dieldrin may also be applied in these forms, or in the form of cement brickettes which may be added to potable water supplies with relative safety.

More recently, a number of new insecticides of low mammalian toxicity have been tested in the United States, Thailand and elsewhere, with particular reference to their possible use in potable water supplies. Brooks et al. (1965) reported on a number of compounds which were effective in water storage drums in the West Indies. They found that wettable powder and emulsion concentrates produced a coludy appearance in the water which was unacceptable to the local populace. Granular formulations were much more satisfactory and one compound, American Cyanamide 52,160 (now known as Abate), gave over five weeks of larval control at 1.0 parts per million (p.p.m.). Sasa et al (1964) conducted laboratory tests on a colonized strain of *A. aegypti* in Bangkok and found that the organic phosphate insecticides were generally more effective than the chlorinated hydrocarbons. Two compounds, Sumithion and fenthion, were particularly effective, giving over 95 per cent kill at 0.006 p.p.m.

In a later series of tests in Bangkok, Lofgren et al. (1966) obtained an LC-50 of 0.011 p.p.m. for Sumithion and 0.0055 p.p.m. with fenthion. In this series of tests two additional compounds were also found to be highly effective against wild caught *aegypti* larvae in Bangkok. These were Abate, with an LC-90 of 0.004 p.p.m., and Dursban with an LC-90 of 0.0018 p.p.m.

Lofgren et al. (1966) also showed very low levels of Abate, Dursban and Shell SD-8211 (in to 0.1 to 1.0 p.p.m. range) gave complete kill or *aegypti* larvae for periods up to six weeks in the usual type of water storage jar used in Bangkok. Tests presently underway indicate that this control, at least with Abate and Dursban, may extend for at least twenty weeks under the conditions encountered in Bangkok.

These organic phosphate insecticides appear to offer considerable promise for the long term control of *aegypti* larvae. Their extremely low mammalian toxicity is also encouraging, but it is obvious that complete toxicological information and clearance must be obtained before they can be recommended for routine programs involving the treatment of drinking water.

During the Bangkok studies Lofgren et al. had an opportunity to examine the DDT, dieldrin, Abate and malathion resistance status of *aegypti* larvae from several areas of the city. These areas were chosen for representation of various economic levels, and presumably various insecticide exposure. All of the samples showed definite but variable resistance to DDT. Definite resistance to dieldrin occured in one area in the tourist and business center, incipient resistance in three others, and none in the fifth. There was no resistance to malathion or Abate in any of the areas. These results parallel the presumed use of insecticide in the city and emphasize the need for consideration of the insecticide resistance status of local *aegypti* populations before any large scale program is undertaken.

Adult control: Chemical control of adult *A. aegypti* is a useful adjunct to larval control under most circumstances. This is particularly true in the use of thermal or mechanically generated aerosols for the rapid reduction of adult populations in the face of an actual or threatened epidemic of an *aegypti*-borne disease. The Thai Ministry of Public Health has employed chlorinated hydrocarbon insecticides in hand-held thermal aerosol generators to considerable effect in Bangkok and other urban centers in Thailand threatened by hemorrhagic fever outbreaks. The construction of most Asian cities makes these small machines more generally useful than the larger pieces of equipment. Lofgren et al. (1966) conducted tests on caged *aegypti* females reared from wild-caught larvae in Bangkok. Fenthion was the most effective of the six compounds tested as thermal fogs generated in a Swingfog generator. Over 98 per cent kill was obtained with concentrations of 0.5 per cent and 1 per cent insecticide. Sumithion and malathion were a little less effective, requiring 1 per cent to 2 per cent for more than 90 per cent kill. Baygon, Schering 34615 and Naled required concentrations of 2 per cent to more than 4 per cent for comparable results.

Residual spraying, other than the perifocal effect mentioned under larval control, has not been used to any great extent specifically for *aegypti* control in SE Asia. Some contact is inevitable in areas which have been sprayed with DDT or dieldrin for malaria control. *A. aegypti* collected in some small towns in Thailand which had been sprayed for some years for malaria control showed extreme resistance to DDT. (Anon., 1964.) However, in Thailand, and over much of mainland SE Asia malaria is primarily a rural disease and reaches its greatest level of endemicity in areas where *aegypti* is rare or absent. The cities of the area, where the greatest concentrations of *aegypti* are found, are as a rule malaria-free and not sprayed. There are a number of excellent compounds, such as malathion available for residual treatment in DDT resistant *aegypti* areas (Schoof and Jacob, 1964) should this be desirable.

Other control methods: Several newer methods of mosquito control, including the use of parasites, ths sterile male technique, genetic manipulation and others have been proposed for *aegypti* control, or are under actual development. None of these have been applied as yet in SE Asia. All of them depend to a great extent on preliminary detailed observations on *A. aegypti* in the field in the target area. Excellent observations on *aegypti* have been made by Macdonald in Malaysia (1956) and limited data are available for Thailand (Scanlon, 1965), but much more information is needed. The World Health Organization has recently established an *Aedes aegypti* study unit in Bangkok, similar to the unit which did such outstanding work on *Culex quinquefasciatus* Say in Rangoon and it is anticipated that the detailed data needed for advanced control methods will be available in the future.

Very recently the U. S. Air Force and the U. S. Public Health Service have cooperated in studies of *aegypti* control in Puerto Rico by the aerial dispersal of low volumes of highly concentrated malathion. Preliminary data from the tests are quite encouraging, both as regards larval and adult control. While this method is probably much too expensive for routine use in SE Asia, it does offer promise for the rapid reduction of *aegypti* populations in an epidemic situation.

Summary: *Aedes aegypti* is an extremely abundant domestic mosquito in the population centers of SE Asia. Most of the breeding takes place in stord potable water, and such storage is a cultural practise likely to remain necessary far into the future, until adequate piped water can be supplied. Education and sanitation can assist in reducing the *aegypti* population, even under the present conditions, but for really effective control recourse must be had to insecticides, including the treatment of household water supplies. Strains of *Aedes aegypti* resistant to DDT and other chlorinated hydrocarbons have been found in Thailand, Malaysia and Vietnam and doubtless occur elsewhere in SE Asia. Fortunately, newer insecticides, such as Abate, Dursban, Fenthion and Sumithion show great promise for *aegypti* control. Several have such low mammalian toxicity and are so effective against *aegypti* larvae that they may be acceptable for drinking water treatment. Abate and Dursban, in particular, have a very prolonged effect in water containers at extremely low concentrations. Malathion is an effective insecticide for thermal fogging for rapid reduction of adult populations.

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