Insecticide Susceptibility of *Aedes aegypti* in Tsunami-affected Areas in Thailand

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Consequent to the World Health Organization’s (WHO) warning about an increased risk of vector-borne diseases such as malaria and dengue fever across the tsunami-affected areas in South-East Asia, the Ministry of Public Health, Thailand, responded with rapid mobilization of active health surveillance in order to supplement and strengthen the disease surveillance system in the affected areas. The activities were concentrated in the six provinces of Thailand affected by the tidal wave disaster on the western coastline, namely, Phuket, Phang Nga, Krabi, Ranong, Trang and Satun. One month after the surveillance in Phuket, Phang Nga, Krabi and Ranong (in Trang and Satun the situation rapidly returned to normal), the incidence of dengue increased but no evidence was at hand to establish any relationship between the cases and the tsunami occurrence. Although unusual outbreaks were reported during this period[1], rapid response to control any epidemic transmission of DHF and information on the susceptibility status of the insecticides which could be employed was a pre-requisite. Studies were, therefore, carried out to determine the susceptibility profile of larval and adult mosquitoes to larvicides and adulticides employed in dengue control programmes and in the tsunami-devastated areas. The susceptibility to DDT, the use of which in public health was withdrawn during 2003 due to its adverse effect both on wildlife and the environment, was also examined. This communication presents information on insecticide susceptibility of *Ae. aegypti* in tsunami-affected areas in Thailand, based on the standard WHO test using discriminating concentrations.

**Mosquito sampling**

Larvae of *Ae. aegypti* were collected indoors and outdoors from four tsunami-affected areas (Phuket, Phang Nga, Krabi and Ranong) having the highest number of dengue cases and high intensity use of insecticides.

A laboratory colony of *Ae. aegypti* from the Department of Medical Sciences, Ministry of Public Health, Thailand (DMSCs Lab) was used as a laboratory strain.

**Insecticide susceptibility test**

**Larval bioassay**

Larvae of late third to early fourth instar of F₂ generation of all strains were exposed to 0.02 mg/l concentration (WHO diagnostic dose) of temephos[2]. The group of 25 larvae were
exposed to temephos in 250 ml of dechlorinated tap water. Mortality was read 24 hours after insecticide treatment. A population is considered to be susceptible to temephos if, when exposed to a concentration of 0.02 mg/l, the per cent mortality is equal or greater than 98%. A resistant population is the one which shows less than 80% mortality.

As per this criterion, larvae from each place, except from Ranong province, were susceptible to temephos and showed 100% mortality with diagnostic dose of temephos. Larvae from Ranong were tolerant to temephos by showing 84% mortality within 24 hours of the treatment.

**Adult bioassay**

Non-blood-fed adult female mosquitoes aged 2–3-days-old were exposed to the diagnostic dosages of standard WHO insecticide paper††, with exposure times according to the insecticide used as recommended by WHO standard bioassay tests[^4]: fenitrothion 1% (1 h), permethrin 0.75% (1 h), deltamethrin 0.05% (1 h), cyfluthrin 0.15% (1 h) and DDT 4% (½ h). In each exposure tube 25 females were exposed to the insecticide paper, while the mosquitoes used as controls were exposed to paper without insecticide. Mosquitoes were transferred to clean holding tubes and provided with cotton pads soaked with 10% sucrose solution. The per cent mortality count was done 24 hours after the exposure. The resistance status was determined according to WHO criteria; a population is considered resistant if less than 80% of the population survives the diagnostic dose compared to the susceptible strain†††.

**Adult bioassay**

The results of the susceptibility test are given in the Table.

**Table.** Comparative susceptibility to insecticides at diagnostic concentrations using WHO filter paper assays of adult Aedes aegypti, lab susceptible and field strains

<table>
<thead>
<tr>
<th>Strain</th>
<th>Permethrin 0.75% (1h)</th>
<th>Deltamethrin 0.05% (1h)</th>
<th>Cyfluthrin 0.15% (1h)</th>
<th>Fenitrothion 1% (1h)</th>
<th>DDT 4% (½ h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMSCs Lab</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>29.8</td>
</tr>
<tr>
<td>Ranong</td>
<td>42.8</td>
<td>83.3</td>
<td>91.7</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Phang Nga</td>
<td>64.0</td>
<td>93.8</td>
<td>90.0</td>
<td>100</td>
<td>16.0</td>
</tr>
<tr>
<td>Phuket</td>
<td>2.0</td>
<td>72.0</td>
<td>88.0</td>
<td>100</td>
<td>4.0</td>
</tr>
<tr>
<td>Krabi</td>
<td>14.3</td>
<td>71.0</td>
<td>88.9</td>
<td>100</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Aedes aegypti* from the laboratory strain was susceptible to all the insecticides tested, except DDT, by producing 100% mortality within 24 hours of the treatment.

The adult susceptibility from the four provinces revealed that the mosquitoes from each place were susceptible to fenitrothion, resistant to permethrin and highly resistant to DDT.

[^4]: All insecticide-treated paper were purchased from WHO Vector Control Research Unit, Penang, Malaysia.
[^††]: Abbott’s formula[^3] was used to correct the observed mortality in larval and adult susceptibility test.
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**Susceptibility by provinces**

**Ranong province and Phang Nga province**

*Ae. aegypti* was found moderately resistant to permethrin while tolerant to cyfluthrin and deltamethrin, with some difference in the degree of the susceptibility.

**Phuket province**

*Ae. aegypti* was found resistant to deltamethrin, highly resistant to permethrin and tolerant to cyfluthrin.

**Krabi province**

*Ae. aegypti* was highly resistant to permethrin, resistant to deltamethrin and tolerant to cyfluthrin.

**Discussion**

For temephos susceptibility, the results showed that *Ae. aegypti* (both wild and lab strains) when exposed to the WHO diagnostic dosage of 0.02 mg/l were found susceptible in all the studied areas except Ranong province, where it was found tolerant to temephos. Prolonged use of temephos in Ranong province could be one possible reason. Temephos (Abate) is an organophosphorus insecticide that has been used as larvicide against *Ae. aegypti* in Thailand since 1967[5].

The widespread use of insecticide has led to selective insecticide resistance in mosquitoes. There are many reports of temephos resistance in Caribbean countries. In Thailand, not much data for temephos resistance have been generated except at Tha Chana, Surat Thani province, Nakorn Sawan province and Mae Sod in Tak province (A. Ponlawat, submitted in J. Medical Entomology). The rotation programmes for resistance management are recommended in these areas.

DDT was the first insecticide that was used for the control of *Ae. aegypti* in Thailand where cases of DHF had been reported since 1964[6] and resistance was reported in places where DDT residual sprayings had been carried out. During the 1970s organophosphorus was introduced for *Ae. aegypti* control, followed by synthetic pyrethroids in the late 1980s. For decades, DDT has been used for malaria control as an insecticide in Thailand. The widespread use of DDT has led to selective insecticide resistance in mosquitoes. There are many reports of temephos resistance in Caribbean countries. In Thailand, not much data for temephos resistance have been generated except at Tha Chana, Surat Thani province, Nakorn Sawan province and Mae Sod in Tak province (A. Ponlawat, submitted in J. Medical Entomology). The rotation programmes for resistance management are recommended in these areas.

Data on the application of synthetic pyrethroids from the Provincial Health Office and the Vector-borne Disease Control Unit showed that permethrin was used in many places for more than five years for routine control of adults during outbreak of this disease. This was followed by deltamethrin, cyfluthrin and fenitrothion use in some selected areas. The results from all studied areas indicated 100% susceptibility to fenitrothion. Permethrin resistance could have resulted from cross-resistance with DDT. Moreover, the use of household insecticides, especially aerosol where the active ingredient is mainly permethrin[9], might have contributed to the resistance of the species. Deltamethrin, the insecticide that followed permethrin, induced resistance in some studied areas.
Even though the use of cyfluthrin has just started in some places but it has precipitated tolerance in some areas. This may be because of the cross-resistance from permethrin and deltamethrin that have the same mechanism of action.

Data on insecticide susceptibility in each area will provide baseline data for planning control programmes and making decisions about insecticide usage in these areas.

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References


