Insecticidal susceptibility of the larvae of *Aedes albopictus*, *Culex quinquefasciatus* and *Cx. boninensis* (Diptera: Culicidae) collected from Chichijima, Ogasawara Islands, Japan

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Key words: *Culex quinquefasciatus*, *Aedes albopictus*, *Cx. boninensis*, mosquito larva, insecticides, susceptibility, Ogasawara Is.

**Abstract**: The susceptibility of *Aedes albopictus*, *Culex quinquefasciatus* and *Cx. boninensis* in Ogasawara Is. to eleven insecticides was tested in 1990. For *Ae. albopictus*, the LC$_{50}$ value of p,p'-DDT was 0.037 ppm, malathion 0.107 ppm, fenitrothion 0.013 ppm, propoxur 2.831 ppm, and permethrin 0.0096 ppm. For *Cx. quinquefasciatus*, the LC$_{50}$ values of p,p'-DDT was 1.201 ppm, malathion 0.071 ppm, fenitrothion 0.014 ppm, propoxur 1.617 ppm, and permethrin 0.016 ppm. For *Cx. boninensis*, an endemic species of Ogasawara Is., the LC$_{50}$ value of p,p'-DDT was 0.012 ppm, malathion 0.021 ppm, fenitrothion 0.0096 ppm, propoxur 0.622 ppm, and permethrin 0.0054 ppm. *Culex boninensis* is susceptible to all the insecticides tested and the LC$_{50}$ values of nearly all the insecticides were lower than those for *Cx. quinquefasciatus* and *Ae. albopictus*.

**INTRODUCTION**

*Culex tritaeniorhynchus* Giles from many localities in Japan has been reported to be resistant to organophosphate insecticides (Kamimura and Maruyama, 1983; Yasutomi *et al.*, 1986; Yasutomi and Takahashi, 1987). The insecticidal susceptibility of *Cx. quinquefasciatus*, *Cx. tritaeniorhynchus* and *Aedes albopictus* in Okinawa Prefecture, which is a subtropical area, was reported by Miyagi *et al.* (1994), Toma *et al.* (1992, 1993) and Yasutomi and Takahashi (1989). Recently, during a mosquito survey in Ogasawara Is., which belongs to the same subtropical region, *Cx. quinquefasciatus*, *Ae. albopictus* and *Cx. boninensis* were collected and subsequently colonized in our laboratory. The present paper deals with the susceptibility of these species to various insecticides.

**MATERIALS AND METHODS**

*Mosquitoes.* The three species of mosquito (*Cx. quinquefasciatus*, *Cx. boninensis*...
and *Ae. albopictus*) used in the present experiments originated from the larvae collected in May 1990 from Omura, Chichijima, Ogasawara Is., about 1,000 km south of Tokyo. The larvae of *Cx. quinquefasciatus* and *Cx. boninensis* bred in ditches while those of *Ae. albopictus* bred in artificial containers. These mosquitoes collected originally from different places were maintained separately as laboratory strains, and were used for the susceptibility test within 5 generations. The 4th-instar larvae of these mosquito strains were used for insecticidal tests.

**Larval bioassay.** The method for determining resistance of mosquito larvae to insecticides was that of Toma et al. (1992). The tests were carried out against twenty five 4th-instar larvae per cup containing distilled water. Larval bioassays were carried out with *p,p'-DDT*, malathion, fenitrothion, dichlorvos, fenthion, temefos, diazinon, bromofos, propoxur and permethrin. The insecticides were added to the cup containing the larvae and maintained at a temperature of 25±0.5°C. Each test consisted of at least four replicates of different concentrations. For each test a control was included which involved 25 larvae per cup containing distilled water without insecticide and maintained under the same conditions. The LC₅₀ values for larval mosquitoes were calculated from the lines between log concentration and mortality (probit). Resistance ratios for *Cx. quinquefasciatus* were calculated by comparing the LC₅₀ values with those for the standard susceptible strain from Ogasawara Is. as reported by Miyagi et al. (1994). For *Ae. albopictus*, the resistance ratio was calculated using as reference the Okinawa strain which showed the lowest LC₅₀ value in each insecticide as reported by Toma et al. (1992). For *p,p'-DDT* the resistance ratio was calculated using as reference the Nagasaki strain which showed the lowest LC₅₀ value according to Suzuki and Mizutani (1962).

**Results**

The susceptibility of *Ae. albopictus*, *Cx. quinquefasciatus* and *Cx. boninensis* larvae from Chichijima to eleven insecticides is summarized in Table 1. The LC₅₀ value of *p,p'-DDT* for *Ae. albopictus* was 0.037 ppm, and the resistance ratio against the Nagasaki strain (Suzuki and Mizutani, 1962) was 2.2. With organophosphates, the LC₅₀ value (and resistance ratio) of *Ae. albopictus* was 0.107 ppm (2.3) for malathion, 0.013 ppm (3.7) for fenitrothion, 0.045 ppm (1.6) for dichlorvos, 0.0050 ppm (0.9) for fenthion, 0.206 ppm (1.3) for diazinon, 0.011 ppm (1.0) for temefos, 0.379 ppm (1.6) for trichlorfon and 0.022 ppm (1.2) for bromofos.

With *p,p'-DDT*, the LC₅₀ value for *Cx. quinquefasciatus* larvae was 1.201 ppm, with a resistance ratio of 2.6. Among the organophosphates the LC₅₀ value (and resistance ratio) was 0.071 ppm (4.7) for malathion, 0.014 ppm (3.0) for fenitrothion, and 0.027 ppm (1.5) for dichlorvos. With the other organophosphates and permethrin, the resistance ratio ranged from 1.1 to 5.8. LC₅₀ of propoxur (a carbamate) was 1.617 ppm, with a resistance ratio of 7.3.

With *p,p'-DDT*, malathion, fenitrothion and dichlorvos, the LC₅₀ values for *Cx. boninensis* were 0.012, 0.021, 0.0096 and 0.016 ppm, respectively. Against propoxur and permethrin, the LC₅₀ values were 0.622 and 0.0054 ppm. With the exception of fenthion and temefos, the LC₅₀ values of the insecticides used in the experiments on *Cx. boninensis* larvae were lower than those of *Ae. albopictus* and *Cx. quinquefasciatus* collected from Chichijima, Ogasawara Is.

**Discussion**

Studies on the susceptibility of *Ae. albopictus* larvae to various insecticides were carried out in Amami Oshima by Ikeshoji et al. (1958) and in Nagasaki and Kanagawa Prefectures by Suzuki and Mizutani (1962). Recently, the susceptibility of the Tokyo and Nagasaki strains of this species (Takahashi et al., 1985) and the Okinawa strains (Wesson, 1990; Toma et al., 1992) has been reported. Against *p,p'-DDT*, the highest LC₅₀ value reported up to the present time was 0.855 ppm in the Tritomotejima strain in 1988.
Table 1  LC$_{50}$ values in ppm and resistance ratio (in parentheses) of *Aedes albopictus*, *Culex quinquefasciatus* and *Cx. boninensis* larvae collected in Chichijima, Ogasawara Is. in 1990.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>LC$_{50}$ (ratio)</th>
<th>LC$_{50}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Ae. albopictus</em></td>
<td><em>Cx. quinquefasciatus</em></td>
</tr>
<tr>
<td>Organochlorine</td>
<td>Ae. albopictus 0.037 (2.2***), Cx. quinquefasciatus 1.201 (2.6)</td>
<td>0.012</td>
</tr>
<tr>
<td>p,p'-DDT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organophosphate</td>
<td>Malathion 0.107 (2.3), Cx. quinquefasciatus 0.071 (4.7)</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>Fenitrothion 0.013 (3.7), Cx. quinquefasciatus 0.014 (3.0)</td>
<td>0.0096</td>
</tr>
<tr>
<td></td>
<td>Dichlorvos 0.045 (1.6), Cx. quinquefasciatus 0.027 (1.5)</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>Fenthion 0.0050(0.9), Cx. quinquefasciatus 0.0031(3.9)</td>
<td>0.0047</td>
</tr>
<tr>
<td></td>
<td>Diazinon 0.206 (1.3), Cx. quinquefasciatus 0.088 (5.8)</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>Temefos 0.011 (1.0), Cx. quinquefasciatus 0.0024(1.4)</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>Trichlorfon 0.379 (1.6), Cx. quinquefasciatus 0.192 (1.1)</td>
<td>0.161</td>
</tr>
<tr>
<td></td>
<td>Bromofos 0.022 (1.2), Cx. quinquefasciatus 0.0096(2.0)</td>
<td>0.0081</td>
</tr>
<tr>
<td>Carbamate</td>
<td>Propoxur 2.831 (1.1), Cx. quinquefasciatus 1.617 (7.3)</td>
<td>0.622</td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>Permethrin 0.0096(2.5), Cx. quinquefasciatus 0.016 (1.9)</td>
<td>0.0054</td>
</tr>
</tbody>
</table>

* Ratio was calculated against the LC$_{50}$ value for *Ae. albopictus* from Okinawa Prefecture with the smallest value reported by Toma et al. (1992). ** Ratio was calculated against the LC$_{50}$ value for *Cx. quinquefasciatus* (a susceptible strain from Ogasawara Is.) reported by Miyagi et al. (1994). *** Ratio was calculated against the LC$_{50}$ value for a Nagasaki strain with the smallest value to p,p'-DDT (Suzuki and Mizutani, 1962).

(Toma et al., 1992) while the lowest value was 0.017 ppm in the Nagasaki strain (Suzuki and Mizutani, 1962). In the present data for the species in Chichijima, Ogasawara Is. in 1990, the LC$_{50}$ value of p,p'-DDT was 0.037 ppm, and the resistance ratio against the Nagasaki strain with the smallest LC$_{50}$ value was 2.2. It is clear that the level of resistance to p,p'-DDT is low for *Ae. albopictus* in Chichijima. The LC$_{50}$ values of the other insecticides for the strain from Chichijima were apparently similar to those of the strains of Okinawa Prefecture reported by Toma et al. (1992). From these results, *Ae. albopictus* larvae in Chichijima are therefore susceptible to these insecticides.

With p,p'-DDT, the highest LC$_{50}$ value (and resistance ratio) for *Cx. quinquefasciatus*, reported up to the present time was 5.66 ppm (12.2) in Amami Oshima in 1958 (Ike-shoji et al., 1958). Miyagi et al. (1994) carried out susceptibility tests for the species in seven islands of Okinawa Prefecture and found that the species was susceptible to ten insecticides but resistant to malathion. The resistance ratio for the susceptible strain of Ogasawara Is. ranged from 1.1 to 5.8 against all the insecticides tested except propoxur. Against propoxur, the LC$_{50}$ and the resistance ratio were 1.617 ppm and 7.3. As indicated by the present tests, the strain has not developed resistance as of the present time.

*Culex boninensis* is an endemic and common species in Ogasawara Is. This species breeds in ditches and artificial containers such as drums, concrete containers and plastic containers, etc., near dwellings together with *Cx. quinquefasciatus* and *Cx. halifaxii* Theobald. *Culex boninensis* was more susceptible to the insecticides, except fenthion and teme-
fos, than *Cx. quinquefasciatus*, and was more susceptible to all the insecticides tested than *Ae. albopictus*.

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**References**


**摘 要**

小笠原諸島父島におけるネットイエカ *Culex quinquefasciatus*, ヒトスジシマカ *Aedes albopictus*, オガサワライエカ *Cx. boninensis* 幼虫の殺虫剤感受性について

1990年に小笠原父島で採集したネットイエカ、ヒトスジシマカ、およびオガサワライエカの幼虫に対する殺虫剤感受性テストを行った。ヒトスジシマカ幼虫の*p,p'-DDT*に対するLC50値は0.037 ppmであり、malathionには0.107 ppm、fenitrothionには0.015 ppm、propoxurには2.831 ppm、permethrinには0.0096 ppmであった。ネットイエカの*p,p'-DDT*に対するLC50値は1.201 ppmであり、malathionに対して0.071 ppm、fenitrothionに対して0.014 ppm、propoxurに対して1.617 ppm、permethrinに対して0.016 ppmであった。オガサワライエカ幼虫の*p,p'-DDT*に対するLC50値は0.012 ppm、malathionに対して0.021 ppm、fenitrothionに対して0.0096 ppm、propoxurに対して0.6221 ppm、permethrinに対して0.054 ppmであった。オガサワライエカは、テストを行ったほとんどの殺虫剤に対して、ネットイエカやヒトスジシマカより感受性が高かった。今回テストを行った父島産のいずれの種も感受性であることが明らかになった。