IRRITABILITY TO DDT OF NATURAL POPULATIONS OF THE PRIMARY MALARIA VECTORS IN COLOMBIA

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ABSTRACT. Natural populations of *Anopheles albimanus*, *A. darlingi* and *An. nuneztouari* were tested for their irritability to DDT in different regions of Colombia. Individual anophelines were exposed to filter papers impregnated with 2% DDT and irritability was determined based on the number of flights a mosquito made in 15 min. All three species showed variability in their irritability to DDT. *Anopheles albimanus* showed irritability only in Bolivar, but not in three other regions. *Anopheles darlingi* showed no irritability in neither the Atlantic nor Llanos regions, while *An. nuneztouari* showed irritability in the Oriente but not in Uraba. The irritability to DDT shown in some populations of *An. albimanus* and *An. nuneztouari* may reduce the effectiveness of residual applications of this insecticide by causing the mosquitoes to seek untreated surfaces and/or leave the house to rest outdoors and thus avoid a lethal dose.

INTRODUCTION

Intradomiciliary application of DDT is used for malaria control in Colombia, and the effectiveness of the insecticide is dependent upon the postblood feeding behavior of anophelines. Anophelines after blood feeding must rest on the insecticide-treated internal surfaces of the house for a period of time sufficient to acquire a lethal dose. The mosquitoes can avoid contact with the insecticide by a natural tendency to rest outside houses (exophily) or due to irritation caused by contact with the insecticide (Pampana 1966). Mosquitoes may only absorb a sublethal dose of insecticide when the insecticide formulation causes a locomotor-stimulant effect on the mosquito (Elliott 1964). In some species of anophelines, the proportion which escapes the insecticidal action due to irritability can be high, limiting the effectiveness of indoor residual spraying with DDT (Muirhead-Thomson 1960).

This study was carried out to quantify the irritability to DDT of the primary malaria vectors (*Anopheles albimanus* Wiedemann, *A. darlingi* Root and *An. nuneztouari* Gabaldon) from various regions of Colombia.

MATERIALS AND METHODS

Various methods have been used to study the effect of DDT on the behavior of anophelines by quantifying the number of flights in irritability tests or measuring their ability to escape lethal contact with DDT surfaces in excito-repellency tests. At present there is no single, widely accepted method to measure insecticide irritability and its consequences (Coluzzi 1962, Brown 1964, Busvine 1964, Georghiou et al. 1972). The irritability tests were carried out during 1984 and 1985 following one of the steps (namely B) in a tentative method of determining the irritability of mosquitoes to insecticides proposed by the World Health Organization (WHO) Expert Committee on Insecticides (WHO 1960) and evaluated for efficacy by Brown (1964). Filter papers, one impregnated with 2% DDT, which according to Hecht and Hernandez (1960) correspond to 0.714 g/m², and a control paper without DDT, were attached to a wall and transparent plastic cones placed over the papers. The papers and cones were those supplied by the World Health Organization with their standard adult mosquito susceptibility and wall bioassay test kits, respectively (WHO 1981). Individual anophelines were simultaneously placed in each cone, and after a 3-min adaptation period, the number of flights during the subsequent 15 min was counted. This method was selected for its facility in carrying out the tests in the field without need of additional equipment. After the test, the anophelines were transferred to paper cups, killed and identified as to species. All tests were carried out between 0800 and 1100 hr. The walls were shaded, never sprayed with DDT or any other insecticide and were usually in a house used as a field laboratory.

The anophelines used in the tests were from human landing collections made at night (1800–2400 hr), inside and outside of the houses. They were held in clean paper cups (7 x 7 cm) until used in tests the following morning. Cotton pads containing a 10% sugar solution were provided to the mosquitoes. Only nonblood-fed mosquitoes were used in these tests because blood-fed mosquitoes show less flight activity (Hamon and Eyraud 1961, cited in Brown and Pal 1973).

The anophelines tested were from areas with malaria transmission and where indoor residual treatments of DDT are applied in 6-month cycles. The number of tests done in each area depended on the availability of anophelines. The data were analyzed using the t test for paired samples (Sokal and Rohlf 1981) to compare the number of flights of the mosquitoes exposed to DDT with the number of flights of the controls.
RESULTS AND DISCUSSION

Tests with An. albimanus were carried out in four regions: Guajira-Magdalena, Bolivar, Uraba and Pacifico (Table 1 and Fig. 1). The An. albimanus population from Bolivar showed a high degree of irritability, whereas the populations from the other regions showed no significant differences. The population of this species in Bolivar also differs from the other populations sampled here in that it has shown mortalities compatible with the presence of resistant individuals in DDT-susceptibility tests, whereas the others have shown susceptibility (Quinones et al. 1987). These results disagree with studies where DDT-resistant populations show less DDT-irritability (Brown and Pal 1973).

Irritability of DDT to An. albimanus has been found previously in Mexican and Central American populations. Experiments with colonized An. albimanus in Mexico showed irritability when exposed to a dose of 0.5 g/m² of DDT for 20 min, using transparent plastic cylinders with impregnated papers at each end (Mancera and Hernandez 1960). In El Salvador, Rachou et al. (1973), using excito-repellency boxes which allow mosquitoes to escape, found that 82-92% left the boxes when exposed to a dose of 2 g/m² DDT for 1 hr.

Although the different methods used prevent any direct comparisons of these results, the data indicate that there is a difference in DDT-irritability behavior between An. albimanus populations from Central America and Colombia, with the exception of the Bolivar population. In addition to the differences in irritability and susceptibility, Elliott (1968) reported that distinct differences existed in the pattern of biting periods and the biting peaks between populations of An. albimanus from the Magdalena Valley and Caribbean coast area, although differ-

Table 1. Irritability of DDT on three anopheline species from various regions in Colombia.¹

<table>
<thead>
<tr>
<th>Species/region</th>
<th>Treatment</th>
<th>No. of tests</th>
<th>Mean no. flights (±SD)</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>An. albimanus</td>
<td>Exposed</td>
<td>23</td>
<td>13.5 (18.4)</td>
<td>1.55</td>
</tr>
<tr>
<td>Guajira-Magdalena</td>
<td>Control</td>
<td>6.7 (8.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolivar</td>
<td>Exposed</td>
<td>172</td>
<td>172.6 (65.8)</td>
<td>8.42*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>36.4 (39.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uraba</td>
<td>Exposed</td>
<td>33</td>
<td>18.2 (18.6)</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>16.1 (13.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacifico</td>
<td>Exposed</td>
<td>108</td>
<td>18.5 (12.0)</td>
<td>1.66</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>15.7 (15.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An. darlingi</td>
<td>Exposed</td>
<td>23</td>
<td>12.2 (10.7)</td>
<td>0.86</td>
</tr>
<tr>
<td>Atlantico</td>
<td>Control</td>
<td>10.8 (7.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Llanos</td>
<td>Exposed</td>
<td>50</td>
<td>24.3 (26.2)</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>16.9 (16.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An. nuneztovari</td>
<td>Exposed</td>
<td>194</td>
<td>11.3 (6.5)</td>
<td>5.98*</td>
</tr>
<tr>
<td>Uraba</td>
<td>Control</td>
<td>7.4 (9.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oriente</td>
<td>Exposed</td>
<td>9.7 (9.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>11.8 (10.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Irritability determined from exposing mosquitoes to 0.714 g/m² DDT impregnated filter paper for 15 min. * Significant (P < 0.01; t test).
This species has been reported to have a 50:50 ratio of endophagy to exophagy (Elliott 1968). Elliott (1964) studied the kinetic response of mosquitoes to chemicals. DDT isozyme polymorphism (Narang et al. 1979).

Results of irritability tests with An. darlingi (Table 1) showed no irritability in the two populations tested, one from Atlantico and the other from the Llanos (Fig. 1). However, it has been reported that populations of this species in Brazil show evasion when tested with DDT in excito-repellency boxes (Charlwood and Paraluppi 1978, Hayes and Charlwood 1977, Roberts et al. 1984). As mentioned above for An. albimanus, the different methods for measuring irritability to insecticides makes it difficult to compare results. However, these differences in DDT irritability behavior between An. darlingi from Colombia and Brazil could be related to the highly polymorphic larval polytene chromosomes (Tadei et al. 1982, Tadei 1985) as well as isozyme polymorphism (Narang et al. 1979).

Anopheles nuneztovari showed no irritability in the Uraba region, but the populations from the Oriente, along the border with Venezuela, showed a significant degree of response (Table 1 and Fig. 1). In this region the species has been reported to have natural exophilic and exophagic tendencies (Gabaldon 1981), and in Colombia this species has been reported to have a 50:50 ratio of endophagy to exophagy (Elliott 1968). Therefore, DDT residual spraying probably has a role in these behavioral characteristics. DDT evasion by this species has also been documented in excito-repellency tests near Manaos, Brazil (Charlwood and Paraluppi 1978). Elliott (1972) suggested that there are at least two species under the name, An. nuneztovari, because of the variation in its biting behavior. In the same way Kitzmiller et al. (1973) point out that this species could be a complex because of the differences in the X chromosomes of various populations.

The irritability to DDT shown in some populations of An. albimanus and An. nuneztovari could reduce the effectiveness of residual applications of this insecticide by causing the mosquitoes to seek untreated surfaces, leave the house to rest outdoors, or both, and thus avoid a lethal dose. However, any direct estimates of such effects would require carefully designed field studies on biting habits, resting habits and related behavior. Also, these data indicate that the DDT irritability behavior could be different between populations of the same species and the residual insecticides may vary in effectiveness from one region to another because of these differences. It is necessary to carry out a surveillance of the level of irritability in natural populations in order to interpret the effects of this phenomenon on the control measures with DDT in malaria control programs. The methodology used in this study is a simple method that could be used to carry out that surveillance.

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