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PESTICIDE AVOIDANCE BEHAVIOR IN *ANOPHELES ALBIMANUS*, A MALARIA VECTOR IN THE AMERICAS[1]

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ABSTRACT. The behavioral responses of 4 populations of *Anopheles albimanus* females to DDT, permethrin, and deltamethrin were characterized in excito-repellency tests. One test population (ST) from El Salvador has been maintained as a colony for 20 years. A second population (ES) from Guatemala was colonized in 1992. Third and fourth populations consisted of field-caught specimens from Toledo District (TO) of southern Belize in 1994 and Corozal District (CO) of northern Belize, respectively. Females of ES, TO, and CO populations rapidly escaped from direct contact with treated surfaces for each of the 3 insecticides. Similarities in escape responses of insecticide-resistant (ES) versus insecticide-susceptible populations (TO, CO) suggest that there is no relationship between physiological and behavioral responses of *An. albimanus* populations to DDT, permethrin, and deltamethrin. Females from all but the ST colony escaped in greater numbers from chambers without direct contact with treated surfaces than from control chambers ($P < 0.05$). Few females from the ST colony escaped from test chambers, regardless of which insecticide was used or whether contact was allowed, indicating that the ST colony has lost its capability to respond to insecticides. Repellent responses were significant; but they were not pronounced in 30-min exposures, and they were very pronounced in 4-h exposures. We conclude that irritant and repellent responses of malaria vectors to insecticides are important components of malaria control operations.

INTRODUCTION

Anopheles albimanus Wiedemann is a primary vector of malaria in many areas of Central and South America (Breeland 1974). DDT has been used extensively to control malaria transmitted by this vector. Today, resistance of *An. albimanus* to DDT occurs in several countries (Brown 1986), but it does not occur in others in spite of regular DDT use (Roberts and Andre 1994). Behavioral avoidance of DDT has also been reported to occur in some *An. albimanus* populations (Rachou et al. 1963). In combination, findings of DDT avoidance and DDT resistance in conspecific populations raise questions about the role of avoidance behavior in preventing malaria transmission and in selecting for insecticide resistance in malaria vectors. Avoidance of DDT by malaria vectors has been recorded in the presence and absence of physiological resistance (Lockwood et al. 1984), but the relationships, if any, between physiological resistance and behavioral avoidance are unknown.

The term "avoidance behavior" will be used to describe behavior that is stimulated by some combination of irritancy and repellency, with irritancy occurring after physical contact and repellency occurring without physical contact with insecticide. Excito-repellency, like avoidance behavior, also is a broad classification of behavioral responses including both irritancy and repellency.

Pyrethroids elicit behavioral responses in insects (Threlkeld 1985). Mosquito control through the use of pyrethroid-impregnated bed nets and intradomiciliary spraying of pyrethroids has been initiated in some countries, including a few countries of Central and South America (Beach et al. 1989, Curtis et al. 1989, World Health Organization 1989). The increased use of pyrethroids should be a major stimulus for extensive tests and field studies on pyrethroid avoidance behavior in New World vectors of malaria.

The complexities of excito-repellency testing, including methods of analyzing and interpreting test data, have resulted in no test method being adequate or fully accepted. No test recommended by the World Health Organization will discriminate between contact irritancy and noncontact repellency. However, an experimental test system described by Roberts et al. (1997) addresses a number of deficiencies attributed to existing behavioral tests. The new test system was used in this series of studies on relationships of avoidance behavior and physiological resistance in colonized and wild-caught populations of *An. albimanus* mosquitoes from Central America. The *An. albimanus* populations were characterized for isozymes, for esterases, for insecticide susceptibilities, and for the irritancy and repellency effects of DDT, permethrin, and deltamethrin (Chareonviriyaphap et al., unpublished data). Behavioral responses of four *An. albimanus* populations were compared using three different in-

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