

# Behavioral Responses of Malaria Vectors, *Anopheles minimus* Complex, to Three Classes of Agrochemicals in Thailand

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**ABSTRACT** Behavioral responses of two wild-caught populations of *Anopheles minimus* complex, species A and C, exposed to operational field doses of three commonly used agricultural insecticides, carbaryl (carbamate), malathion (organophosphate) and cypermethrin (pyrethroid), were characterized using an excito-repellency test system. Test populations were collected from different localities in Kanchanaburi Province, western Thailand. Both populations showed strong irritancy by quickly escaping test chambers after direct contact with individual surfaces treated with each insecticide compared with match-paired untreated controls. Noncontact repellency response to cypermethrin and carbaryl was significantly pronounced in both A and C populations, but comparatively weak when exposed to malathion. Noncontact repellency produced much weaker escape response in both populations, but in some species–chemical combinations, it remained significant compared with controls. We conclude that contact irritancy is a major behavioral response of both A and C when exposed directly to any of the three compounds, whereas only cypermethrin produced a significant repellency response in species A.

**KEY WORDS** behavioral avoidance, carbaryl, cypermethrin, malathion, *Anopheles minimus* complex

The development of pesticide resistance by arthropods is a primary concern for management of agricultural and human pests and disease vectors. Over 50 yr of extensive use of a variety of synthetic organic compounds used to control arthropods has resulted in the selection of insecticide resistance in >500 species, of which >100 are mosquitoes (Culicidae) (Brown and Pal 1971, Georgiou 1990, Roberts and Andre 1994). Over a decade ago, the World Health Organization estimated that 40% of the 506 insect species of medical importance had evidence of resistance to various insecticides (WHO 1992). Most documented cases of resistance have involved organochlorine, organophosphate, and carbamate class compounds compared with the relatively more recent introduction of broad-spectrum pyrethroids (Brogdon and McAllister 1998).

Although resistance to insecticides in mosquitoes has been reported in many areas of the world, some mosquito species have not developed resistance in spite of the apparent heavy and pervasive exposure to pesticides used in public health and agriculture (Roberts and Andre 1994). One plausible explanation for

these findings is the role of avoidance behavior, i.e., the innate response by an insect after exposure to compounds that can elicit profound irritant and/or repellent reactions, thereby limiting direct contact with lethal toxicants. By avoidance alone, selection pressure to increase frequency of resistant genotypes in the mosquito population is slowed or mitigated (Chareonviriyaphap et al. 1997).

Behavioral avoidance can be separated into two distinct responses: contact irritability and noncontact repellency, collectively termed excito-repellency (Davidson 1953, Rawlings and Davidson 1982, Roberts et al. 1997). Irritability occurs when an insect is stimulated to move away from an insecticide after direct physical contact with the chemical residue, whereas repellency occurs when the insect detects chemicals from a distance and avoids treated surfaces before making physical contact (Roberts et al. 1997, Potikasikorn et al. 2005). The relative importance of either form of behavioral avoidance is more clearly demonstrated when using a specially designed excito-repellency test system (Roberts et al. 1997, Chareonviriyaphap et al. 2002). This test system has repeatedly proven useful for quantitative evaluation of excito-repellency in mosquito species against various insecticidal compounds in Thailand (Sungvornyothin et al. 2001; Chareonviriyaphap et al. 2003, 2004; Kongmee et al. 2004; Potikasikorn et al. 2005).

Thailand is an important commercial producer of natural rubber, rice, corn, palm oil, cassava and oranges, all major export-earning crops. Most crop pro-

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