

Optimal Discriminating Concentrations of Six Synthetic Pyrethroids for Monitoring Insecticide Susceptibility in *Anopheles minimus* (Diptera: Culicidae), a Primary Malaria Vector in Thailand

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Abstract

Malaria is a serious mosquito-borne disease transmitted to humans by *Anopheles* mosquitoes. Seven species of *Anopheles* are important malaria vectors in Thailand and all remain susceptible to pyrethroid insecticides, despite decades of use in public health mosquito control programs. However, for a more refined and accurate approach to temporal monitoring of susceptibility patterns to commonly used pyrethroids to control adult *Anopheles* mosquitoes, it is preferred to have specific concentrations for more discriminating testing. A laboratory strain of *Anopheles minimus* Theobald was used to establish baseline concentrations for susceptibility to six different synthetic pyrethroids—deltamethrin, permethrin, bifenthrin, cypermethrin, α -cypermethrin, and λ -cyhalothrin using the World Health Organization (WHO) adult bioassay system. Final discriminating concentrations of each active ingredient were determined based on doubling LC₉₉ for each chemical to arrive at the following percent concentrations: deltamethrin (0.009%), permethrin (0.551%), bifenthrin (0.12%), cypermethrin (0.104%), α -cypermethrin (0.034%), and λ -cyhalothrin (0.019%). For permethrin, deltamethrin, α -cypermethrin, and λ -cyhalothrin, all revised percentages were lower than currently recommended discriminating concentrations by WHO. Using the newly derived concentrations, insecticide susceptibility tests were followed in a field population of *An. minimus* s.l. from Kanchanaburi Province. Deltamethrin, bifenthrin, and λ -cyhalothrin produced 100% kill, whereas permethrin, cypermethrin, and α -cypermethrin gave between 92.9 and 97.7% mortality, indicating lower sensitivity (tolerance). Routine monitoring of insecticide susceptibility in *An. minimus* wild populations throughout Thailand should continue to ensure that insecticides in use are effective to control this vector species.

Key words: *Anopheles minimus*, insecticide discriminating concentrations, pyrethroid, adult contact bioassay

Although there has been a significant reduction in malaria transmission in Thailand over the last three decades, it remains a serious health burden and threat in certain areas of the country (MOPH 2016). In 1988, the last peak transmission year, nearly 350,000 cases were recorded nationwide, thereafter followed by a steady decline in annual incidence to below 100,000 cases in 1995 with further declines in incidence since 1996 (Chareonviriyaphap et al. 2000). In 2016, only 13,607 cases were reported nationwide (MOPH 2016). In 2015, Thailand joined the Association of South East Asian

Nations (ASEAN) Economic Community (AEC) together with 10 other ASEAN countries with the intent on opening a more inclusive regional market economy. In doing so, the AEC encourages a greater number of low-wage migrant workers from neighboring countries bordering Thailand, such as Myanmar, Laos, and Cambodia to enter Thailand for employment opportunities and greater incomes. However, with extensive human migrant movement across borders, especially in more remote locations bordering Myanmar, the continuing threat of reintroduction of malaria infection into Thailand