Behavioral responses of *Anopheles* species (Culicidae: Diptera) with varying surface exposure to pyrethroid-treated netting in an excito-repellency test system

Krajana Tainchum[1,3], Jirod Nararak[2], Wasana Boonyuan[2], Michael J. Bangs[2,4], and Theeraphap Chareonviriyaphap[1,2] ✉

[1]*Center for Advanced Studies for Agriculture and Food, KU Institute for Advanced Studies, Kasetsart University, Bangkok 10900, Thailand (CASAF, NRU-KU, Thailand), faasthc@ku.ac.th*
[2]*Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand*
[3]*Department of Pest Management, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand*
[4]*Public Health and Malaria Control Department, International SOS, Jl. Kertajasa, Kuala Kencana, Papua 99920, Indonesia*

Received 17 June 2016; Accepted 16 August 2016

ABSTRACT: Indoor Residual Spray (IRS) with insecticides has been a procedure used for decades to protect humans from biting mosquitoes and potential vectors of pathogens. The objective of this study was to determine the responses of three wild-caught species of malaria vectors exposed to pyrethroids of three different surface coverage percents using an excito-repellency test box. Each species was exposed to three insecticide-treated surfaces at varying exposure levels (full coverage, 50%, and 25% of the maximum allowable by the test system) to a single standard field dose of either lambda-cyhalothrin or alpha-cypermethrin. Larger numbers of mosquitoes escaped the treated chambers in the direct contact test compared to the spatial repellent chambers in all three different treated surface exposures. No significant differences in the percent of escaped mosquitoes were detected in the 50% and full coverage surface coverage exposures, whereas the 25% coverage produced significantly lower avoidance responses for both compounds. This study found that varying levels of surface exposure with synthetic pyrethroids can impact the behavioral avoidance responses of *Anopheles*; however, it may also be possible to reduce the amount of coverage to achieve similar avoidance actions. This information may assist policy makers in designing more cost effective strategies involving residual insecticides to control mosquito vectors. ***Journal of Vector Ecology* 41 (2): 254-264. 2016.**

Keyword Index: *Anopheles harrisoni, Anopheles epiroticus, Anopheles dirus*, excito-repellency, pyrethroid-treated netting, Thailand.

INTRODUCTION

Malaria continues to be an important cause of morbidity and mortality in Thailand, particularly along the border areas of the country (Suwonkerd et al. 2013). In Thailand, the primary vectors are night-biting *Anopheles* mosquitoes which belong to several species complexes. Seven anopheline species are considered primary (Tainchum et al. 2015) malaria vectors in the country, including *Anopheles dirus* Peyton & Harrison (Rosenberg et al. 1990, Green et al. 1991), followed by several species that have been incriminated as secondary or suspected human malaria vectors in Thailand, including *Anopheles epiroticus* Linton & Harbach (Rattanarithikul et al. 2006, Thongsahuan et al. 2011). Still other species, like *Anopheles harrisoni* Harbach & Manguin, a member of the Minimus Complex, are regarded as very poor or non-vector species in most circumstances (Tainchum et al. 2015). Despite advances in control through various methods, malaria abatement still relies on control of the vectors to combat transmission. This includes the use of chemical insecticides, especially residual applications of synthetic pyrethroids applied to indoor surfaces, and materials such as bed nets (Chareonviriyaphap et al. 2013). Studies have shown that indoor residual spraying (IRS) and insecticide-treated bed nets (ITN), either as stand-alone interventions or in combination, can provide substantial protection against malaria in the correct settings (Curtis and Mnzava 2000, Hamel et al. 2011, West et al. 2014).

Several pyrethroids have been extensively used for malaria vector transmission control, mostly with use on mosquito nets, primarily deltamethrin and permethrin (Chareonviriyaphap et al. 2013). Other synthetic pyrethroids, e.g., lambda-cypermethrin, alpha-cypermethrin, metofluthrin, and transfluthrin are being evaluated as spatial repellents in addition to their toxicity attributes (Potikasikorn et al. 2005, Achee et al. 2009, Mongkalangoon et al. 2009, Kongmee et al. 2012, Manda et al. 2013, Salazar et al. 2013). The continuing use of pyrethroids, even in the face of growing physiological resistance to active ingredients in vector populations, mandates further investigations on the significance of pyrethroid avoidance behavior (excito-repellency) in mosquitoes and control of transmission of vector-borne diseases. In general, avoidance behavior to insecticides by mosquitoes remains poorly understood and appreciated in the full context of vector control strategies. The role of excito-repellency actions of pyrethroids and other chemicals merit closer evaluation in disease control programs.

At least three chemical actions have been identified, including toxicity, contact excitation ('irritancy'), and noncontact spatial repellency (Roberts et al. 1997, Grieco et al. 2007, Achee et al. 2009, Dusfour et al. 2009, Mongkalangoon et