Journal of the American Mosquito Control Association, 32(1):34–43, 2016

AVOIDANCE BEHAVIOR TO ESSENTIAL OILS BY *ANOPHELES MINIMUS*, A MALARIA VECTOR IN THAILAND

JIROD NARARAK,[1] SUNAIYANA SATHANTRIPHOP,[2] KAMAL CHAUHAN,[3] SIRIPUN TANTAKOM,[4] AMANDA L. EIDEN[5] AND THEERAPHAP CHAREONVIRIYAPHAP[1,6]

ABSTRACT. Essential oils extracted from 4 different plant species—citronella (*Cymbopogon nardus*), hairy basil (*Ocimum americanum*), sweet basil (*Ocimum basilicum*), and vetiver (*Vetiveria zizanioides*)—were investigated for their irritant and repellent activities against *Anopheles minimus*, using an excito-repellency test system. Pure essential oils were used in absolute ethanol at the concentrations of 0.5%, 1%, 2.5%, and 5% (v/v) compared with deet. At the lowest concentration of 0.5%, hairy basil displayed the best irritant and repellent effects against *An. minimus*. Citronella and vetiver at 1–5% showed strong irritant effects with>80% escape, while repellent effects of both oils were observed at 1% and 2.5% citronella (73–89% escape) and at 5% vetiver (83.9% escape). Sweet basil had only moderate irritant action at 5% concentration (69.6% escape) and slightly repellent on test mosquitoes (<50% escape). The results found that hairy basil, citronella, and vetiver are promising potential mosquito repellent products for protection against *An. minimus*.

KEY WORDS *Anopheles minimus,* deet, essential oils, excito-repellency

INTRODUCTION

Anopheles minimus Theobald is commonly found in high-density populations and also is the most important vector of malaria in Thailand (Tainchum et al. 2014). There are approximately 32 million people living along the Thailand borders, around 50% of the total population, who are at risk for contracting malaria. The undeveloped borders between Thailand–Myanmar remain the most heavily impacted area (BVBD 2013). Despite years of public health efforts and research progress, no effective vaccine for malaria has been made commercially available. Therefore, malaria prevention remains dependent on vector management and control strategies to reduce the risk of transmission (BVBD 2013). However, controlling malaria vectors like *An. minimus* has proven difficult due to their high abundance throughout the year and close proximity to humans (Chareonviriyaphap et al. 2003). In addition, this species is often in association with various human activities in agricultural systems such as stream pools, stream margins, irrigation ditches, and rice fields (Suwonkerd et al. 2013).

Chemical insecticides have been used as the primary mosquito control weapon. A clear understanding behavioral responses of mosquitoes to chemical compounds is of paramount importance for launching control program activities. Theoretically, chemical compounds can protect humans from mosquito bites in at least 2 different ways, by causing mortality or noncontact responses that modify mosquito behavior by inhibiting bloodfeeding (Roberts and Andre 1994, Thanispong et al. 2009). Most work on how chemicals function has been centered on toxicity, whereas less focus has been on the 2 types of behavioral avoidance responses: irritability and repellency (Grieco et al. 2007). The outcome of these 2 different forms of behavioral avoidance can be quantified using a specially designed excito-repellency test system (Chareonviriyaphap et al. 2004). Most excito-repellency studies have concentrated on synthetic chemicals, especially pyrethroids, which may result in environmental contamination (Corbel et al. 2013). Furthermore, due to the widespread use patterns spanning several decades, pesticides from 4 main chemical classes (e.g., organochlorines, organophosphates, carbamates, and pyrethroids) have been found to be ineffective due to the development of physiological resistance in several mosquito species (Chareonviriyaphap et al. 2013). For this reason, developing alternative compounds or new mosquito control methods is important. One potential alternative may be utilizing botanical compounds for insect repellents. These available sources can be safe and have become increasingly popular for domestic use against indoor and outdoor biting mosquitoes.

One of the most common, widely commercially available insect repellents is diethyl methyl benzamide (deet) (Fradin and Day 2002). As

[1] Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
[2] National Institute of Health, Department of Medical Sciences, Ministry of Public Health, Nonthaburi 11000, Thailand.
[3] Invasive Insect Biocontrol and Behavior Laboratory, Plant Science Institute, United States Department of Agriculture Agricultural Research Service, Beltsville, MD 20705.
[4] Department of Entomology, Faculty of Agriculture, Kasetsart University, Nakhonpathom 73140, Thailand.
[5] International Programs Tropical Agriculture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
[6] To whom correspondence should be addressed.