

BEHAVIORAL RESPONSES TO DDT AND PYRETHROIDS BETWEEN *ANOPHELES MINIMUS* SPECIES A AND C, MALARIA VECTORS IN THAILAND

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Abstract. Behavioral responses of two field populations of *Anopheles minimus* complex species A and C for contact and non-contact actions of chemicals were compared during and after exposure to operational field concentrations of DDT (2 g/m²), deltamethrin (0.02 g/m²), and lambda-cyhalothrin (0.03 g/m²) using an excito-repellency escape chamber. The two populations were collected from the Mae Sot District in Tak Province (species A) and the Tri Yok District in Kanchanaburi Province (species C) in western Thailand. Female mosquitoes of both populations rapidly escaped from chambers after direct contact with DDT, deltamethrin, and lambda-cyhalothrin. The non-contact repellency response to DDT and the two synthetic pyrethroids was pronounced with *An. minimus* species A; however, non-contact repellency was relatively weak with *An. minimus* species C, but remained significantly greater than the paired controls ($P < 0.05$). We conclude that strong contact irritancy was present in both test populations, whereas non-contact repellency also played a significant role in the escape response of *An. minimus* species A.

INTRODUCTION

Anopheles minimus s.l. Theobald is one of the most efficient malaria vectors throughout the eastern Asia.^{1,2} In Thailand, the *An. minimus* complex contains important vectors of malaria that are found exclusively in the forested hilly and clear forested foothill areas.^{3–6} *Anopheles minimus* s.l. was reported to be mostly endophilic and endophagic throughout its geographic range.⁷ After DDT was introduced to interrupt malarial transmission, *An. minimus* reportedly shifted to greater outdoor feeding and more zoophilic preferences for blood, particularly bovines.^{8,9} Even though DDT resulted in significant reductions of indoor-feeding mosquitoes, this control method did not completely interrupt transmission of malaria. This has been attributed partly to exophagic behavior of portions of the population and the persistence of a small number of vectors that enter and successfully feed indoors.^{10,11} Similar observations have also reported from Vietnam,¹² raising questions on behavioral variations within the *An. minimus* taxon.

Based on morphologic and genetic variations, at least two closely related species of the *An. minimus* complex have been documented in Thailand and both have been incriminated as efficient vectors of malaria.^{4,6} *Anopheles minimus* species A is the predominant species and distributed throughout the country,⁶ whereas species C appears restricted along the western Thailand-Myanmar border, particularly in Kanchanaburi Province.^{4,13} Additionally, *An. minimus* species D has been reported in Thailand, but sufficient information is lacking to support the proposed sibling species status.¹³ Although *An. minimus* species A and C occur in sympatry in western Thailand, notable ecoethologic variation in feeding and resting behaviors, degree of anthropophily, and other biological aspects may influence vector capacities of these two sibling species.^{12,14}

Anopheles minimus species A has shown a much greater (five-fold difference) endophilic behavior compared with spe-

cies C.¹² The *An. minimus* complex has also shown different response levels of response to intradomiciliary use of insecticides.^{15–19} In Thailand, indoor house spray has been routinely conducted to interrupt human-vector contact and transmission.¹⁹ Understanding the behavioral responses of different species of mosquitoes, even closely related sibling species, to insecticides can facilitate vector control by selecting and implementing the most effective interventions possible and help to target the primary disease vectors.

Behavioral responses, namely insecticide avoidance, can be separated into two important and distinct categories: contact irritancy and non-contact repellency. Irritant responses result from physical contact with chemical-treated surfaces, whereas repellency is an avoidance response devoid of making actual contact with insecticides.²⁰ Although behavioral responses have been recorded with various mosquito species and populations of *Anopheles* from Thailand using the excito-repellency test box,^{19,21–23} none have been recorded to compare the behavioral responses between species in the *An. minimus* complex (e.g., species A and C). Described herein are observations using the excito-repellency test system to quantitatively measure behavioral responses between wild-caught populations of *An. minimus* species A and C exposed to recommended field concentrations of DDT, deltamethrin, and lambda-cyhalothrin.²⁴

MATERIALS AND METHODS

Mosquito collection. *Anopheles minimus* complex mosquitoes were identified based on morphologic keys.^{15,25} Species were differentiated by the presence or absence of the humeral pale spot on the costal wing vein. *Anopheles minimus* A has a wing costa without the humeral pale spot whereas *An. minimus* C has the humeral pale spot. A diagnostic enzyme, octanal dehydrogenase, indicated 95% concurrence with species A, which does not have the humeral pale spot. This spot is lacking in 73% of species C.⁶ *Anopheles minimus* A and C adult females were collected off human volunteer baits during the evening hours (6:00 PM to 6:00 AM). These volunteers (collectors) worked for the Ministry of Public Health. Behavioral tests were performed within 24 hours of capture. All

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