

Effects of piperonyl butoxide synergism and cuticular thickening on the contact irritancy response of field *Aedes aegypti* (Diptera: Culicidae) to deltamethrin

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Abstract

BACKGROUND: Exploiting indoor-resting mosquitoes' innate behavioral responses to commonly used insecticide is crucial in vector control programs. Indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) treated with pyrethroids have become widely used for controlling dengue fever vectors. The present study tested the effects of piperonyl butoxide (PBO) synergism and cuticular thickening on the contact irritancy response of field *A. aegypti* (Diptera: Culicidae) to deltamethrin in Taiwan and Thailand.

RESULTS: The escape response of field mosquitoes treated with PBO was significantly elicited, with an escape percentage increase between 2- and 10-fold. In addition, the escape time was significantly lower in PBO-pretreated mosquitoes compared with field mosquitoes treated with deltamethrin alone. PBO-pretreated mosquitoes from seven out of 11 field strains exhibited a knockdown percentage of 11.23–54.91%, significantly higher than that of mosquitoes in corresponding strains treated with deltamethrin only. The Annan, Zhongxi, Sanmin, and North strains exhibited weak knockdown responses ($\leq 3.75\%$). The mortality of PBO-pretreated field mosquitoes increased 2- to 75-fold compared with those treated with deltamethrin alone (mortality: 0–6.70%). Furthermore, the effect of cuticular thickness on the escape response of field mosquitoes was significant, that is, the escape response marginally increased inversely to cuticular thickness. By contrast, cuticular thickness was not significantly associated with knockdown or mortality percentage.

CONCLUSION: Irritant behavior in mosquitoes was significantly elicited by PBO synergism. PBO incorporating deltamethrin IRS or LLINs may be effective for controlling dengue fever vectors.

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Keywords: excito-repellency; cuticular permeability; irritant behavior; indoor residual spraying; long-lasting insecticidal nets

1 INTRODUCTION

Indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) treated with pyrethroids have become widely used for controlling dengue fever vectors. Because mosquitoes typically rest indoors after a blood meal to facilitate the diuresis process,^{1,2} a growing body of research supports the efficacy of IRS and the use of LLINs in reducing the population of *A. aegypti* (Linnaeus) mosquitoes and preventing the transmission of dengue fever.^{3–8}

Insecticide resistance is the main challenge in efforts to control dengue fever. Two major mechanisms of pyrethroid resistance are detoxification through the overexpression of metabolic enzymes and mutation at targeted sites of the sodium channel.^{9–11} Because pyrethroid insecticide is widely used in space spraying, a rapid increase in *A. aegypti* mosquito resistance to pyrethroids is a considerable concern and may compromise the utility of IRS and LLINs. This paper is a continuation of our previous study,¹² which revealed that permethrin and deltamethrin exhibited low

repellent and irritant effects on field mosquitoes with increased insecticide tolerance in Taiwan and Thailand. The underlying factors of these delayed responses are associated with the sensory impairment of neurons due to the pleiotropic effect following target-site gene mutation in insecticide-resistant mosquitoes.¹³ However, the underlying factors are by no means exhaustive.

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