Article

Synergistic Behavioral Response Effect of Mixtures of *Andrographis paniculata, Cananga odorata,* and *Vetiveria zizanioides* against *Aedes aegypti* (Diptera: Culicidae)

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Simple Summary: In several Asian and Latin American nations, severe dengue is the main cause of serious disease and death. Dengue viruses are transmitted to humans via the bite of an infected *Aedes* species. Personal protection measures may be an effective method of avoiding mosquito bites. Nowadays, consumers are increasingly interested in commercial repellent products containing plant-based ingredients because they are perceived as "safe" in comparison to long-established synthetic repellents. We tested a binary plant-based mixture formulation of *Cananga odorata, Vetiveria zizanioides,* and the crude extract of *Andrographis paniculata* on laboratory and field strains of *Aedes aegypti* using an excito-repellency test system. The results showed that a mixture of *V. zizanioides* and *A. paniculata* at a 1:4 ratio was better than DEET. These results could lead to the further development of a combination of *V. zizanioides* and *A. paniculata* as active ingredients in a repellent that could be tested in human trials.

Abstract: Each binary mixture formulation of *Vetiveria zizanioides* (L.) Nash (VZ) with *Andrographis paniculata* (Burm.f.) Wall. ex Nees (AP) or *Cananga odorata* (Lam.) Hook.f. & Thomson (CO) and AP with CO at 1:1, 1:2, 1:3, and 1:4 ratios (*v:v*) was investigated for behavioral responses on laboratory and field strains of *Aedes aegypti*. Irritant and repellent activities of each formulation were compared with *N,N*-diethyl-3-methylbenzamide (DEET) using an excito-repellency test system. The result demonstrated that the mixture of VZ:AP in all combination ratios was the most effective in inducing an irritancy response against the laboratory strain (56.57–73.33%). The highest percentage of escaped mosquitoes exposed to the mixture at a 1:4 ratio (73.33%) was significantly different from DEET (26.67%) ($p < 0.05$). Against the field strain, the strongest escape response of AP:CO at a 1:1 ratio in the contact trial (70.18%) was significantly different compared with DEET (38.33%) ($p < 0.05$). There was a weak non-contact escape pattern in all combinations of VZ:CO against the laboratory strains (6.67–31.67%). These findings could lead to the further development of VZ and AP as active ingredients in a repellent that could advance to human use trials.

Keywords: binary mixture; repellence; *Andrographis paniculata; Cananga odorata; Vetiveria zizanioides;* excito-repellency; *Aedes aegypti;* DEET

1. Introduction

Many areas of the world are at risk from mosquito-borne diseases; in particular, the incidence of dengue has increased substantially worldwide in recent decades [1]. One model has estimated that there are 390 million dengue cases annually, with 70% of them in Asia [2]. *Aedes aegypti*, an anthropophagic daytime-biting mosquito, is the principal vector