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ORIGINAL PAPER

The effects of simulated rainfall on immature population dynamics of *Aedes albopictus* and female oviposition

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Abstract Larvae of *Aedes albopictus* Skuse typically inhabit natural and artificial containers. Since these larval habitats are replenished by rainfall, *Ae. albopictus* may experience increased loss of immature stages in areas with high levels of rainfall. In this study, we investigated the effects of rainfall and container water level on habitat quality, population density, and oviposition activity of *Ae. albopictus*. In field and laboratory experiments, we found that rainfall resulted in the flushing of breeding habitats. Excess rain negatively impacted larval and pupal retention, especially in small habitats. When filled with water to overflowing, container habitats were significantly repellent to ovipositing females. Taken together, these data suggest that rainfall triggers population loss of *Ae. albopictus* and related species through a direct detrimental effect (flushing out) and an indirect effect (habitat unsuitability and ovipositional repellency).

Keywords *Aedes albopictus* · Container · Rainfall · Population loss · Repellency

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Introduction

A special characteristic of *Aedes* mosquitoes is that their eggs require the retention of enough moisture for successful embryonation (Strickman 1980; Hill et al. 2006). This is typical of *Ae. albopictus*, a species that is increasingly attracting major public health attention. The species has the innate ability to transmit dengue viruses (Shroyer 1986; Mitchell 1991; Gratz 2004; Malavige et al. 2004) which infect up to 50 million people every year, causing more than 20,000 deaths globally (Burke and Monath 2001; WHO http://www.who.int/topics/dengue/en/). Several other pathogens (Konishi 1989; Mitchell et al. 1998) including Chikungunya virus (Roiz et al. 2009; Delatte et al. 2010) are also transmitted by this vector, which has been proven to be a particularly invasive species (Hawley 1988).

Due to the importance of *Ae. albopictus* in public health, a substantial body of works has been directed towards understanding its population dynamics. The larvae of this mosquito typically develop in various aquatic habitats, including phytotelmata and artificial containers (Hawley 1988; Sota et al. 1992; Madon et al. 2003; Simard et al. 2005). The prevalence of the larvae in these habitats depends largely on rainfall, which is therefore the major water source (Fish and Carpenter 1982). Although evidence exists that rainfall is responsible for the abundance of *Ae. albopictus* (Lo and Narimah 1984), heavy rains have negative effects on the egg population (Hornby et al. 1994). It seems likely that there is a trade-off between sufficient rainfall and habitat population. This is because heavy rainfall could create new habitats and the overflowing of existing ones, which may wash out the larvae, thus off-setting their quality in older habitats.

In spite of previous suggestions addressing the negative impacts of rainfall on the eggs (Rozilawati et al. 2007) and