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Oviposition behaviour and parity rates of *Aedes aegypti* collected in sticky traps in Trinidad, West Indies

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ABSTRACT

The oviposition behaviour of *Aedes aegypti* was studied using sticky traps (ST), double sticky traps (DST) and standard ovitrap traps in urban St. Augustine and rural Tamana, Trinidad, West Indies. In St. Augustine three traps were deployed in 10 houses for 10 weeks while in Tamana traps were similarly deployed (10 houses for 10 weeks). At each house one ovitrap, one ST and one DST were placed using the criteria established for ovitrap placement. The results showed large numbers of adults collected, 3602 collected in DSTs and 1,670 adults collected in STs. In addition, >9000 immatures were collected in the DST vs >7000 in the STs. Over the 10 weeks 517 *Ae. aegypti* eggs were collected from ovitraps from Tamana and 3252 eggs from St. Augustine. Most of the females collected were parous (99%) with many older females collected e.g. 7 pars collected in both Tamana and St. Augustine. A major finding of the study was the observation of the "death stress oviposition" behaviour displayed among *Ae. aegypti* females captures in the sticky traps. This is the first report of this behaviour in the field and may well explain the collection of large numbers of immatures found in the ST and DSTs. The results of this study are discussed in the context of developing surveillance and control strategies, especially for reducing man–vector contact.

1. Introduction

Dengue Fever and its haemorrhagic manifestations have re-emerged as a major public health problem, with high morbidity and mortality rates, because of the failure of conventional vector control programs (Gubler and Kuno, 1997) and the failure to develop appropriate vaccines which can target all four dengue serotypes (Halstead, 2008). Consequently 2.5 billion people live at risk of contracting dengue with an estimated 50–100 million cases occurring annually (Gubler, 1998; Farrar et al., 2007).

In response to the global challenge of dengue transmission many have re-examined old approaches and have refined or refashioned them. Numerous workers have examined oviposition attractants of *Aedes aegypti* L. (Buxton and Hopkins, 1927; Manefield, 1951; O'Gower, 1963) with Gjullin et al. (1965) reporting that grass infusion and log pond water enhancing oviposition by *Ae. aegypti* and *Culex pipiens quinquefasciatus* Say. However, Hazard et al. (1967) showed *Ae. aegypti* were not attracted to the odour of hay infusion in an olfactomoter.

With the emergence of insecticide resistance among the various disease vectors, a concerted effort was made to re-visit the use of botanicals and their integration into conventional ovitraps made from black jars containing tap water which were found to be attractive to gravid female mosquitoes (Fay and Eliason, 1966). The combined effect/attraction of black ovitraps and hay infusion was reported to remove large sectors of the mosquito population (Reiter et al., 1991; Trexler et al., 1998) but Chadee et al. (1993) reported the failure of this combination to elicit increased oviposition and this was later supported by other studies (Santanna et al., 2006; Gama et al., 2007). The failure to observe an increase in oviposition was subsequently found to result from changes in bacterial activity especially fermentation (Santanna et al., 2006).

The incorporation of various attractants and sticky glue components has further modified ovitraps to "lure and kill" devices. For example, ovitraps containing plain tap water were attractive to gravid females (Fay and Eliason, 1966) but now collect mosquitoes when they alight on the sticky substance during, before or after oviposition (Muir and Kay, 1998; Ordonez et al., 1997). Modifications have emerged with the addition of mouse odour (McCall et al., 1996), infusion filled ovitraps with either velour paper (Zeichner and Perich, 1999) or flannel cloth (Williams et al., 2007) ovistrips treated with synthetic pyrethroids, filled with hay infusion, using sticky traps with synthetic oviposition attractants (Santanna et al., 2006) and the use of lucerne to attract gravid females to standard ovitraps (Ritchie, 2001) and sticky ovitraps (Ritchie et al., 2003, 2004).

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Table 1
Aedes aegypti collected using sticky traps, double sticky trap and standard ovitraps over 10 weeks in Trinidad, West Indies (2008).

Locations	Sticky trap		Double sticky trap		Ovitrap	
	Adults	Immatures	Adults	Immatures	Eggs	Larvae
Tamana	220	1592	316	1652	517	180
St. Augustine	1480	5900	2286	7777	2735	13
Total	1700	7492	2602	9429	3252	193

Recently, Chadee and Ritchie (in press) described the new double sticky trap and compared the efficiency of sticky, double sticky and conventional ovitraps. The results indicated that the double sticky traps were more efficient in collecting adult *Ae. aegypti* than standard sticky traps (Ritchie et al., 2003, 2004). The collection of large numbers of adults from sticky traps was far superior to human bait collections in Tanzania (Corbet and Smith, 1974), in Arizona, USA (Hoeck et al., 2003) and in Trinidad (Chadee and Martinez, 2000) and provided an opportunity to study urban and rural populations of *Ae. aegypti* in Trinidad (Chadee and Ritchie, in press).

In Tanzania, Corbet and Smith (1974) dissections provided information on the age structure of host-seeking *Ae. aegypti* females and showed 28.4% of the population was parous, while in Tucson, Arizona the host-seeking females parous rates were 44.0% (Hoeck et al., 2003). To date no studies have been conducted on the physiological age of *Ae. aegypti* mosquitoes collected at oviposition sites.

Several methods have been used to determine the physiological age of mosquitoes including the use of dilatations on the ovarioles (Detinova, 1962), the use of oil injections to ovarioles (Hoc and Charlwood, 1990) and by gas chromatography analysis of whole-body cuticular hydrocarbons (Desena et al., 1999). In the Caribbean region the physiology of the *Ae. aegypti* mosquitoes, their population dynamics and various risk factors for dengue transmission have never been conducted but rather most studies have been confined to surveillance, based primarily on house-to-house larval inspections (PAHO, 1994), on the use of modified ovitraps (Fay and Eliason, 1966), population molecular genetics (Apostal et al., 1994; Colton et al., 2003) and more recently, on the pupal surveys (Focks and Chadee, 1997; Chadee, 2004). The large number of adults collected during the Chadee and Ritchie (in press) study afforded the opportunity to age grade the females collected and to determine the age structure of populations seeking oviposition sites.

The objectives of this study were to determine the age structure of *Ae. aegypti* populations seeking oviposition sites and to determine the suitability of sticky traps for monitoring adult mosquito populations in the urban centre St. Augustine and in the rural village of Tamana, Trinidad, West Indies.

2. Materials and methods

2.1. Study sites

This study was conducted for 10 weeks at two sites, one urban housing centre located along the east-west-corridor (Chadee et al., 1995; Chadee, 2004) in north Trinidad: St. Augustine (10°38′N; 60°23′W) an urban university town with 3000 houses and approximately 15,000 people; and in a rural community of Tamana (10°49′N; 61°19′W), nestle in the forested foothills of the Central Range located in east-central Trinidad with 80 houses and 300 people. Details of the topography, vegetation and meteorology of the study sites have been described by Chadee and Ritchie (in press).

2.2. General

A total of 20 houses were selected for ovitrapping study, ten (10) different houses in Tamana and ten in St. Augustine. At each house in both areas ovitraps (Fay and Eliason, 1966), sticky traps (Ritchie et al., 2003) and double sticky (Chadee and Ritchie, in press) traps were placed at ground level in the enclosed porch area to protect them from animals, wind, rain and direct sunlight.

All sticky traps and ovitraps were serviced weekly, as described by Chadee and Ritchie (in press). These traps were exposed for 1 week for each of 10 weeks. The ovitraps (Fay and Eliason, 1966), sticky traps (Ritchie et al., 2003) and double sticky traps (Fig. 1) were serviced in accordance with the methods described by Chadee and Ritchie (in press). All adult mosquitoes and immatures collected in the two types of sticky traps were counted and all live adults collected using fine tip forceps and placed into labeled (trap types and house number) tubes. All immatures were also collected and placed into labeled tubes and transported to the Parasitology Laboratory, Department of Life Sciences, University of the West Indies, St. Augustine, Trinidad. At the laboratory, immatures and adults were identified according to species using standard keys for container breeding mosquitoes (Darsie and Ward, 1981).

The ovaries of a subsample of the mosquitoes were examined and scored as nulliparous or parous by Detinova's method, according to the presence or absence of tracheolar skeins. In addition, both ovaries of all parous females were scored for parity by Polovodova's method of counting the number of dilatations on varioles and the presence of retained eggs (Detinova, 1962). Mosquitoes with ovaries in Sella's stages 4–7 were not age-graded because large quantities of yolk obscured the follicular relics and made examination difficult.

3. Results

3.1. Trapping

Large numbers of *Ae. aegypti* females were collected in sticky traps in Tamana and St. Augustine (Table 1) but with more females collected in St. Augustine than in Tamana.

A total of 220 females were collected in the sticky traps from Tamana while 1480 females were captured in St. Augustine. The number of immature stages (larvae) collected in the sticky traps also reflected a similar pattern with more immatures, 5900 collected in St. Augustine vs 1592 collected in Tamana (Table 1).

The double sticky traps employed in Tamana and St. Augustine collected a total of 316 females and 2286 females, respectively while 1652 and 7777 immatures were collected from Tamana and St. Augustine, respectively (Table 1).

Over the 10 weeks, ovitraps collected 517 *Ae. aegypti* eggs from Tamana and 3252 eggs from St. Augustine (Table 1).

3.2. Age composition of Ae. aegypti

The age composition of *Ae. aegypti* females collected at oviposition sites is shown in Table 2. As expected the parous rate of ovipositing females was high (99%) and the number of nulliparous was small (1%). Of the parous females age-graded over 78% were one parous, 13% were two parous, 5% were three parous and 3% four parous, with four, seven-parous females occurring at Tamana and nine, seven-parous females at St. Augustine (Table 2).