RESEARCH NOTE

AEDES MOSQUITO LARVAE COLLECTED FROM ISHIGAKI-JIMA AND TAKETOMI-JIMA ISLANDS IN SOUTHERN JAPAN

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Abstract. An investigation of habitat preference for larval breeding sites by *Aedes* (Diptera: Culicidae) mosquitoes which occur around human dwellings in Ishigaki-jima and Taketomi-jima Islands revealed that *Ae. albopictus* Skuse 1894 preferred pools in tires and boats and was distributed widely from the coast, inland. Although *Ae. riversi* Bohart & Ingram, 1946 and *Ae. flavopictus miyarai* (Tanaka *et al*, 1979) shared tree holes as larval breeding sites, *Ae. riversi* was collected near the ocean whereas *Ae. flavopictus miyarai* was collected inland. *Ae. togoi* Theobald, 1907 was collected near the coast and strongly preferred boats. Our study showed that habitat preference was different between four species of *Aedes* mosquito in Ishigaki-jima and Taketomi-jima Islands.

Keywords: *Aedes albopictus*, distance, ocean, microhabitat, Japan

INTRODUCTION

The Asian tiger mosquito, *Aedes* (Stegomyia) *albopictus* Skuse, 1894, has spread from its native range, Southeast Asia and East Asia (Tanaka *et al*, 1979), to at least 28 other countries, largely through the international trade in used tires (Reiter and Sprenger, 1987; Benedict *et al*, 2007). On establishment, *Ae. albopictus* may become merely a pest, but it is a potential vector for a wide range of human pathogens such as dengue fever and chikungunya fever (Gratz, 2004), posing serious public health risks.

Invading species interact with resident species and with local abiotic environments, and these interactions determine the eventual range and abundance of the invader, and in some cases, the fates of resident species and communities (Williamson, 1996; Lounibos, 2002). *Ae. albopictus* oviposits relatively cold-hardy and long-lived eggs and is found in close proximity to humans (Hawley, 1988). This species has negatively affected population growth of North American container-dwelling *Aedes* mosquitoes (Livdahl and Willey, 1991; Juliano, 1998).

Many *Stegomyia* species in the *scutel-*

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laris group are locally distributed in Asia (Huang, 1979). Comparative studies of the behavior, ecology, and physiology of *Ae. albopictus* and sympatric species of *Stegomyia* provide useful information for predicting the distribution and abundance of *Ae. albopictus* in countries where it is introduced.

MATERIALS AND METHODS

The Ryukyu Archipelago is subtropical and is a transitional zone between the Oriental and the Palaearctic regions from a zoogeographical point of view. The mosquito fauna of the Ryukyu Archipelago is very rich and unique, especially in Ishigaki-jima and Iriomote-jima Islands (Toma and Miyagi, 1990). Fifteen species of five genera have been collected from the habitats around human dwellings on Ishigaki-jima and Iriomote-jima Islands including the medically important species (Toma *et al*, 1983). Habitat preference, such as for forests and coastal of endemic *Aedes* species in the Ryukyu Archipelago have been investigated (Miyagi and Toma, 1978); therefore, we studied the preferences for an oviposition site of *Aedes* mosquitoes occurring around human dwellings in Ishigaki-jima and Taketomi-jima Islands.

The third and fourth stages of mosquito larvae and pupae were collected from pools in tires, boats, and tree holes on Ishigaki-jima and Taketomi-jima, islands in the Ryukyu Archipelago in late January, 2007, by a small metal net or a pippet. Emerging adults were identified by species under a binocular microscope with reference to Tanaka *et al* (1979) and Toma and Miyagi (1986). All sampling sites were marked by a GPS receiver (GPSMAP® 60CSx, Garmin International, Olathe, KS) and a site's distance to the ocean was calculated using Google Earth (http://earth.google.com/). Manly's α was used to test for habitat preference (Krebs, 1999), with the following equation:

$$\alpha_i = \frac{\log p_i}{\sum p_j}$$

where α_i = Manly's α for habitat type i, p_i, $p_j = e_i/n_i$ ($i = 1, 2, 3, \ldots, m$) ($j = 1, 2, 3, \ldots,$ m), e_i = number of habitat types i unused, n_i = total number of habitat types i, and m = number of habitat types.

One-way ANOVA and Tukey's multiple comparison tests were used for comparisons of each site distances from the ocean.

RESULTS

Eighty-seven discarded tires, 17 boats, and 7 tree holes were examined in Ishigaki-jima and Taketomi-jima Islands. Larvae of four species of *Aedes*, one species each of *Culex*, and *Tripteroides* were collected (Table 1). *Ae. albopictus* was the dominant species collected from all collection sites. *Ae. albopictus* was frequently collected from tires and boats, but was infrequently collected from tree holes (Table 2). *Ae. riversi* Bohart and Ingram 1946 and *Ae. flavopictus miyarai* (Tanaka *et al*, 1979) were collected more frequently from tree holes, while *Ae. togoi* Theobald 1907 was collected more frequently from pools of water in boats.

Boats were found 0.84 km from the ocean. However, tires and tree holes were widely distributed from the coast to relatively far inland (tires, 0.1-4.0 km; tree holes, 0.2-2.9 km). One-way ANOVA showed that the distance from the coast at which species were collected varied significantly between species (F=4.58, df=3, p<0.01) with *Ae. togoi* and *Ae. riversi* being collected 0.1-0.2 km from the ocean (Fig 1)

Table 1
Numbers of individuals and sites collected in Ishigaki-jima Island and Taketomi-jima Island from January 22-25, 2007.

Species	No of individuals	No of sites where collected
Aedes albopictus Skuse 1894	40	24
Ae. flavopictus miyarai	10	3
Ae. riversi Bohart & Ingram, 1946	8	3
Ae. togoi Theobald, 1907	5	3
Culex fuscanus Wiedemann 1820	4	4
Tripteroides bambusa Yamada 1917	3	1

Table 2
Manly's α for habitat preference of four *Aedes* species in Ishigaki-jima and Taketomi-jima Islands.

Species	Tire	Boat	Tree hole
Ae. albopictus	0.58	0.42	0.00
Ae. flavopictus miyarai	0.04	0.00	0.96
Ae. riversi	0.14	0.00	0.86
Ae. togoi	0.09	0.91	0.00

Values greater than 0.33 (=1/3) indicate preference. Values less than 0.33 indicate avoidance.

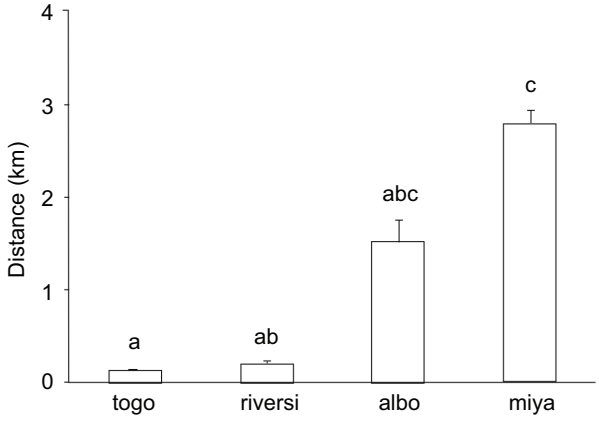

Fig 1–Mean distance from the coast to the collecting site for four species of *Aedes* mosquitoes (togo, *Ae. togoi*; riversi, *Ae. riversi*; albo, *Ae. albopictus*; miya, *Ae. flavopictus miyarai*). The data are means±SE. The same letters are not significantly different (p>0.05), by Tukey's test.

while *Ae. flavopictus miyarai* collected 2.5-3.0 km (mean 2.8 km) from the ocean. *Ae. albopictus* was distributed widely from the coast to far inland.

DISCUSSION

Our study showed the preference for an oviposition site of four species of *Aedes* female mosquito in Ishigaki-jima and Taketomi-jima Islands. Although *Ae. togoi* and *Ae. riversi* were both collected near the ocean, *Ae. togoi* preferred pools of water in boats sampled near the ocean, while *Ae. riversi* preferred tree holes. *Ae. togoi* larvae have a high tolerance for salinity and are able to develop in containers of water having a higher salinity than sea water, similar to conditions in boat pools (Matsumoto and Matutani, 1976; Matsu-

moto *et al*, 1976). *Ae. riversi* is confined to natural forests of evergreen broad-leaf trees of the satellite Islands of Kyushu and Ryukyu islands (Mogi, 1976, 1990). The results of Eshita and Kurihara (1979) are consistent with our findings in that the authors collected *Ae. riversi* from tree holes with adults inhabiting forested habitats. Therefore, *Ae. togoi* and *Ae. riversi* apparently coexist by inhabiting different microhabitats.

Like *Ae. riversi*, *Ae. flavopictus miyarai* and *Ae. riversi* preferred tree holes on the Ishigaki-jima and Taketomi-jima Islands. However, *Ae. flavopictus miyarai* was found at greater distances inland, while *Ae. riversi* was found closer to the ocean. These species may coexist by limiting their distribution according to a pool's distance from the coast in spite of preferring a similar microhabitat.

Ae. albopictus was distributed widely from the coast to far inland and had a wide habitat preference. Our study supports the observations of Sota *et al* (1992) that larval *Ae. albopictus* can be found in tree holes less frequently than *Ae. riversi*, and that *Ae. albopictus* more frequently exploits artificial containers found outside forests on small islands and in the coastal area of northern Kyushu, Japan. Furthermore, our results showed a similar tendency in the relationship between *Ae. albopictus* and *Ae. flavopictus miyarai*.

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