

Review

**Mosquito Fauna in the Federated States of Micronesia:
A Discussion of the Vector Species of the Dengue Virus**

NODA Shinichi

*Research Center for the Pacific Islands, Kagoshima University
Korimoto 1-21-24, Kagoshima, 890-8580 Japan
E-mail: snoda@cpi.kagoshima-u.ac.jp*

Abstract

Several investigations of mosquito fauna in the Federated States of Micronesia (FSM) have been conducted, but there is currently little information on the mosquito species, which may be the vector to dengue fever. This review is a summary of the geographical distribution and breeding sites of the mosquito species on four states: Yap, Chuuk, Pohnpei and Kosrae, the FSM. Major vectors for dengue fever and dengue hemorrhagic fever are *Aedes aegypti* and *Ae. albopictus* in urban areas of Southeast Asia and in the Western Pacific Resion. *Aedes aegypti* was collected on Pingelap Island (Pohnpei State) and on Kosrae Island (Kosrae State), and it was the predominant species on Pingelap Island. *Aedes albopictus* was collected on Weno Island (Chuuk State), Pohnpei Island and Kahlap Island (Mokil Atoll) (Pohnpei State), and on Kosrae Island (Kosrae State), and it was the predominant species on Kahlap Island and Kosrae Island. Entomological investigations designated the native mosquito species, *Ae. hensilli*, as a vector of the dengue virus on Yap Proper. *Aedes hensilli* was the predominant species on Yap Proper, Ulithi Atoll (Mogmog, Falarop, Asor and Fassarai Island) and Fais Island (Yap State) and Weno Island (Chuuk State), and it was also distributed on Romanum Island and Piis-Paneu Island (Chuuk State). Therefore, four states of the FSM seems to be highly dengue-sensitive. Environmental management programs are necessary to prevent or minimize vector propagation and human contact.

Key words: *Aedes aegypti*, *Aedes albopictus*, *Aedes hensilli*, dengue fever, Federated States of Micronesia, mosquito fauna

Introduction

Dengue fever is closely associated with poor environmental sanitation, inferior housing and inadequate water supplies. Major vectors for dengue fever are *Aedes aegypti* and *Ae. albopictus*. In the Pacific islands, *Ae. polynesiensis*, a member of the

Ae. scutellaris complex, has also been designated as a vector, along with several other minor species (WHO 2003). The dengue fever outbreak in Yap State, the Federated States of Micronesia (FSM), was reported between June and July 1995 (SAVAGE *et al.* 1998). Entomological investigations designated the native mosquito species, *Ae. hensilli*, as a vector of dengue virus (SAVAGE *et al.* 1998, NODA *et al.* 2005). Another dengue fever outbreak occurred in Yap State from May 2004 to January 2005 after Typhoon Sudal, when six cases were transmitted to Japan via a visiting group of school children; however, there was no known secondary spread from this case (MARTIN 2005, NUKUI *et al.* 2006). Dengue fever cases have reliably occurred in Yap State every year since 2007 (WHO 2010). In 2001, dengue infections were identified on three of the six islands of Hawai'i. During the investigation, 1,644 persons with locally acquired dengue-like illness were evaluated, and 122 (7%) laboratory-positive dengue infections were identified. *Aedes albopictus* was present in all communities surveyed on these three islands, but unexpectedly, no *Ae. aegypti* were found (EFFLER *et al.* 2005).

The FSM includes four states: Yap, Chuuk, Pohnpei and Kosrae. These areas form the Caroline Island chain together with Palau. Kosrae State is the easternmost island of the FSM and adjoins the Marshall Islands. An outbreak of dengue fever in the Marshall Islands was confirmed in October 2011 (MINISTRY OF FOREIGN AFFAIRS OF JAPAN 2011). It was feared that the dengue virus might be carried into Kosrae State, and unfortunately it was transmitted there in September 2012, and among 230 patients with suspected dengue infections, 85 were confirmed positive between 26 September and 11 November. The infection rate was extremely high within the total population of Kosrae (MINISTRY OF FOREIGN AFFAIRS OF JAPAN 2012).

Surveys of mosquitoes in Micronesia were carried out by BOHART and INGRAM (1946) and BOHART (1957). However, a few investigations of mosquito fauna in the FSM were conducted after their surveys, and there is currently little information on the mosquito species that may be the vector to the dengue fever. Recently, investigations of mosquito fauna were carried out in four states of the FMS (NODA *et al.* 2005, 2013a, 2013b, 2014). This review is a summary of the geographical distribution and breeding sites of mosquito species on four states of the FSM.

Distribution of Mosquitoes on the Federated States of Micronesia

The FSM has 607 islands sprinkled across more than 2.6 million km² of the Pacific, and extends 2,900 km from east to west. About 65 islands are inhabited. The total land area is 705 km². The average annual temperature is 27 °C (GALBRAITH *et al.* 2000).

1. Mosquitoes on Yap State

Yap Proper consists of the four tightly clustered islands of Yap, Tomil-Gagil, Map and Rumung. Yap Proper has 100 km² of land. The interior regions have gentle

rolling hills, and the highest point is 174 m. The average annual rainfall is 3,100 mm. The population is approximately 7,800. Ulithi Atoll is composed of 49 islands with a total landmass of 4.6 km². They are mere strands of coral and sand rising precariously above the water. Ulithi's inhabited islands, Mogmog, Falarop, Asor and Fassarai Island, have a total population of just over 1,000. Fais Island is a single island of raised limestone with just over 2.6 km². It has a partial fringing reef, sandy beaches, cliffs and sea caves. With an elevation of 18 m, Fais Island is the highest of Yap's outer islands. The population of Fais Island is approximately 200. Surveys of larval mosquitoes on nine municipalities of Yap Proper, except Rumung, were carried out in October and November 1999. Surveys on Ulithi Atoll were carried out in October 2001 and November 2008. Surveys on Fais Island were carried out in November 2008.

A total of 1,683 larvae belonging to 12 species, including two unidentified species, were collected at 155 natural and artificial habitats (Table 1) (NODA *et al.* 2005, unpublished data).

On Yap Proper, a total of 723 larval mosquitoes belonging to 10 species were collected at 60 habitats. They are identified as *Aedes hensilli*, *Ae. lamelliferus*, *Ae.*

Table 1. The number of mosquitoes and their habitat types collected on Yap State, Federated States of Micronesia.

Island	Species	Number of individuals	Number of habitats*	Habitat types
Yap Proper	<i>Aedes hensilli</i>	506	42	Coconut shell, Tin, Plastic container, Tire, Tree hole, Canoe, Metal drum
	<i>Aedes lamelliferus</i>	61	8	Coconut shell, Tire, Tree hole, Canoe, Metal drum
	<i>Aedes maehleri</i>	97	15	Coconut shell, Tire, Tree hole, Canoe
	<i>Aedes</i> sp. 1	5	2	Small water pool, Metal drum
	<i>Aedeomyia actasticta</i>	7	2	Small water pool, Dam
	<i>Culex quinquefasciatus</i>	35	2	Tin, Tire
	<i>Culex annulirostris</i>	3	2	Coconut shell, Small water pool
	<i>Culex sitiens</i>	5	1	Small water pool
	<i>Culex</i> sp.	1	1	Tire
	<i>Lutzia fuscana</i>	3	2	Tire
Ulithi Atoll				
Falalop	<i>Aedes hensilli</i>	158	25	Coconut shell, Tin, Plastic container, Autoparts, Plastic water barrel, Metal drum
	<i>Culex quinquefasciatus</i>	170	9	Plastic container, Sewage, Plastic water barrel, Metal drum
	<i>Culex gossi</i>	1	1	Autoparts
Mogmog	<i>Aedes hensilli</i>	98	13	Coconut shell, Tin, Plastic container, Plastic water barrel, Metal drum
	<i>Culex quinquefasciatus</i>	10	2	Plastic water barrel
Asor	<i>Aedes hensilli</i>	96	13	Coconut shell, Plastic container, Metal drum
	<i>Culex quinquefasciatus</i>	49	2	Plastic container, Metal drum
Fassarai	<i>Aedes hensilli</i>	192	16	Coconut shell, Tin, Plastic container, Plastic water barrel, Metal drum
	<i>Culex quinquefasciatus</i>	19	1	Concrete water tank
Fais	<i>Aedes hensilli</i>	103	14	Coconut shell, Plastic container
	<i>Culex quinquefasciatus</i>	42	4	Coconut shell, Pipe
	<i>Culex nigropunctatus</i>	22	1	Coconut shell

*Number of larval mosquito habitats: Yap Island: 60; Falalop Island: 33; Mogmog Island: 14; Asor Island: 14; Fassarai Island: 17; Fais Island: 17.

maehleri, *Aedes* sp. 1, *Aedeomyia catasticta*, *Culex quinquefasciatus*, *Cx. annulirostris*, *Cx. sitiens*, *Culex* sp. and *Lutzia fuscana*. Among them, *Ae. hensilli* was the predominant species collected (506 larvae, 42 habitats) followed by *Ae. maehleri* (97 larvae, 15 habitats), *Ae. lamelliferus* (61 larvae, 8 habitats) and *Cx. quinquefasciatus* (35 larvae, 2 habitats).

On four islands of Ulithi Atoll, a total of 793 larval mosquitoes belonging to three species were collected at 78 habitats. They are identified as *Ae. hensilli*, *Cx. quinquefasciatus* and *Cx. gossi*. The larvae of *Ae. hensilli* were collected at 67 habitats and *Cx. quinquefasciatus* were collected at 14 habitats.

On Fais Island, a total of 167 larval mosquitoes belonging to three species were collected at 17 habitats. They are identified as *Ae. hensilli*, *Cx. quinquefasciatus* and *Cx. nigropunctatus*. The larvae of *Ae. hensilli* were collected at 14 habitats, and *Cx. quinquefasciatus* were collected at four habitats.

2. Mosquitoes on Chuuk State

Chuuk State is composed of 192 outer islands, which include 15 main islets and more than 80 smaller islets that make up Chuuk Lagoon. The average annual rainfall is 3,600 mm in Chuuk Lagoon. About 40 of the state's islands are inhabited. Chuuk is

Table 2. The number of mosquitoes and their habitat types collected on Chuuk State, Federated States of Micronesia.

Island	Species	Number of individuals	Number of habitats*	Habitat types
Weno	<i>Aedes hensilli</i>	318	44	Coconut shell, Tin, Glass container, Plastic bag, Plastic container, Metal container, Bucket, Tire, Freezer, Plastic water barrel
	<i>Aedes albopictus</i>	41	10	Coconut shell, Tin, Plastic container, Rubber container, Tire
	<i>Aedes lamelliferus</i>	11	1	Coconut shell
	<i>Aedes</i> sp. 2	1	1	Coconut shell
	<i>Culex quinquefasciatus</i>	72	6	Coconut shell, Pan, Tire, Washing machine
	<i>Culex carolinensis</i>	656	41	Coconut shell, Tin, Plastic container, Rubber container, Bucket, Tire
	<i>Culex annulirostris</i>	80	6	Tin, Glass container, Bucket, Concrete puddle, Track loading platform, Taro field
	<i>Lutzia vorax</i>	1	1	Tin
Romanum	<i>Aedes hensilli</i>	23	4	Coconut shell, Tin, Rock pit
	<i>Aedes scutscriptus</i>	99	11	Coconut shell, Banana stump, Tin, Glass container, Rock pit, Plastic container
	<i>Culex quinquefasciatus</i>	16	3	Coconut shell, Glass container, Well
	<i>Culex carolinensis</i>	66	4	Coconut shell, Glass container, Pan, Plastic water barrel
Piis-Paneu	<i>Aedes hensilli</i>	82	8	Coconut shell, Tin, Pan
	<i>Aedes scutscriptus</i>	65	10	Coconut shell, Tin, Banana stump, Tree hole, Plastic container
	<i>Aedes</i> sp. 3	17	2	Well, Taro patch
	<i>Culex quinquefasciatus</i>	59	3	Tree hole, Concrete puddle, Puddle
	<i>Culex carolinensis</i>	105	7	Coconut shell, Tin, Taro patch
	<i>Culex annulirostris</i>	49	3	Puddle, Taro patch

*Number of larval mosquito habitats: Weno Island: 86; Romanum Island: 21; Piis-Paneu Island: 26.

one of Micronesia's most populous islands, with a population of approximately 48,000 people, of which approximately one-third live on Weno Island. Weno Island is the main island, and the district center of Chuuk State. At just over 18km², it is the second largest island in the lagoon. Tropical forests make up much of the interior, with the highest point being Mt. Tonoken (370m), which is located in the center of the island. Romanum Island is also located in the lagoon, and is less than 1 km². This island is hilly and the highest point is only 54 m above sea level. Houses are scattered throughout the island, and the population is approximately 300. Piis-Paneu Island is located on the atoll ring reef; it is also less than 1 km². The elevation is consistently near sea level, houses are scattered throughout the island, and the population is approximately 250. Surveys of larval mosquitoes on Weno, Romanum and Piis-Paneu Island were carried out in August 2011.

A total of 1,761 larvae belonging to nine species, including one unidentified species, were collected at 133 natural and artificial habitats (Table 2) (NODA *et al.* 2014). In Weno Island, a total of 1,180 larvae belonging to eight species, including one unidentified species were collected at 86 habitats. As the area and population of Weno Island is large, there were many kinds of sources of mosquito larvae. They were identified as *Ae. hensilli*, *Ae. albopictus*, *Ae. lamelliferus*, *Aedes* sp. 2, *Cx. quinquefasciatus*, *Cx. carolinensis*, *Cx. annulirostris* and *Lt. vorax*. *Culex carolinensis* and *Ae. hensilli* were the predominant species, and were collected at 41 and 44 habitats, respectively. *Aedes albopictus* was collected from discarded containers along the main road in northwest side of Weno Island.

On Romanum Island, a total of 204 larvae belonging to four species were collected at 21 habitats. They were identified as *Ae. hensilli*, *Ae. scutoscriptus*, *Cx. quinquefasciatus* and *Cx. carolinensis*. *Aedes scutoscriptus* was the predominant species, and was collected at 11 habitats.

On Piis-Paneu Island, a total of 377 larvae belonging to six species, including one unidentified species, were collected at 26 habitats. They were identified as *Ae. hensilli*, *Ae. scutoscriptus*, *Aedes* sp. 3, *Cx. quinquefasciatus*, *Cx. carolinensis* and *Cx. annulirostris*. *Culex carolinensis* was the predominant species collected (7 habitats) followed by *Ae. hensilli* (8 habitats).

3. Mosquitoes on Pohnpei State

Pohnpei Island is high, volcanic, roughly circular, and its coast is lined with coves and jutting peninsulas and it is covered with a thick jungle. The interior contains rugged mountain ridges and deep valleys. It has an average diameter of 21 km and a land area of 334 km². Pohnpei Island is the largest island in the FSM. The highest peak is Ngihneni at 791m. The coastline is mainly composed of tidal flats and mangrove swamps. The town of Kolonia has an average annual rainfall of 4,800 mm. The population of Pohnpei State is approximately 34,900, and 90% of the population lives on Pohnpei Island. Pohnpei State includes eight outlying atolls, each covering an area of less than 2.6 km². To the southeast, almost like stepping stones down to Kosrae, are

Table 3. The number of mosquitoes and their habitat types collected on Pohnpei State, the Federated States of Micronesia.

Island	Species	Number of individuals	Number of habitats*	Habitat types
Pohnpei	<i>Aedes albopictus</i>	8	2	Plastic container, Tire
	<i>Aedes hakansoni</i>	366	34	Coconut shell, Tin, Tire, Plastic container, Rock pit, Metal container
	<i>Aedes oakleyi</i>	132	7	Well, Water pool, Metal drum, Concrete water pool
	<i>Culex quinquefasciatus</i>	118	6	Coconut shell, Tin, Plastic container, Concrete water pool
	<i>Culex maplei</i>	534	25	Coconut shell, Tin, Plastic container, Metal container, Coconut casing, Rock pit, Tire, Metal drum, Concrete water pool
	<i>Culex annulirostris</i>	3	1	Rock pit
Mokil Atoll				
Kahlap	<i>Aedes albopictus</i>	166	20	Coconut shell, Tin, Ceramic cup, Bottle, Metal container
	<i>Aedes marshallensis</i>	172	22	Coconut shell, Tin, Ceramic cup, Plastic container, Coconut casing
	<i>Culex quinquefasciatus</i>	344	12	Plastic container, Metal container, Metal drum, Concrete water tank, Well
Pingelap Atoll				
Pingelap	<i>Aedes aegypti</i>	304	21	Stump of banana, Plastic container, Metal container, Discarded refrigerator, Plastic water barrel, Concrete water tank, Metal drum,
	<i>Aedes marshallensis</i>	240	16	Coconut shell, Stump of banana, Plastic container, Tree hole, Metal drum
	<i>Aedes vexans noctanus</i>	20	1	Taro patch
	<i>Culex quinquefasciatus</i>	336	15	Plastic container, Plastic water barrel, Concrete water tank, Well, Taro patch, Metal container, Metal drum, Concrete frame

*Number of larval mosquito habitats: Pohnpei Island: 59; Kahlap Island: 49; Pingelap Island: 46.

Mokil Atoll and Pingelap Atoll. Mokil Atoll's three islets total approximately 1.3 km² of land. Approximately 100 people live on Kahlap Island, the largest and only inhabited islet. Pingelap Atoll also has three islets. Approximately 300 people live on Pingelap Island. Surveys of larval mosquitoes on Pohnpei Island, Mokil Atoll and Pingelap Atoll were carried out in November 2007 and August 2010.

A total of 2,713 larval mosquitoes belonging to nine species were collected at 154 natural and artificial habitats (Table 3) (NODA *et al.* 2013a). On Pohnpei Island, a total of 1,161 larval mosquitoes belonging to six species were collected at 59 habitats. They were identified as *Ae. albopictus*, *Ae. hakansoni*, *Ae. oakleyi*, *Cx. quinquefasciatus*, *Cx. maplei* and *Cx. annulirostris*. *Aedes albopictus* was only collected at two habitats: a small plastic container and a tire. *Aedes hakansoni* was the predominant species being collected at 34 habitats. *Culex maplei* was collected at 25 habitats. The other three species were collected at a relatively small number of habitats (1 to 7 habitats).

On Mokil Atoll, a total of 682 larval mosquitoes belonging to three species were collected at 49 habitats. They were identified as *Ae. albopictus*, *Ae. marshallensis* and *Cx. quinquefasciatus*. *Aedes albopictus* was collected at 20 habitats. *Aedes marshallensis* was also collected at 22 habitats. *Culex quinquefasciatus* was collected at 12 habitats.

On Pingelap Atoll, a total of 870 larval mosquitoes belonging to four species were collected at 46 habitats. They were identified as *Ae. aegypti*, *Ae. marshallensis*, *Ae. vexans noctunus* and *Cx. quiquefasciatus*. Among them, *Ae. aegypti* was the predominant species and was collected at 21 habitats. *Aedes marshallensis* was collected at 16 habitats. *Aedes vexans noctunus* was only collected from a taro patch. *Culex quiquefasciatus* was collected at 15 habitats.

4. Mosquitoes in Kosrae State

Kosrae Island is roughly triangular, covering an area of 109 km². The island interior is composed of rugged mountains and river valleys. About 70% of the island is mountainous, and another 15% is mangrove swamp. Mt. Finkol, the highest peak, rising to a height of 629 m. The average annual rainfall is 5,500 mm. Approximately 7,700 people live on Kosrae Island. Surveys of larval mosquitoes on Kosrae Island were carried out in three areas, Tafunsak, Tofol, and Utwe, in December 2009, and six areas, Tafunsak, Lelu, Tofol, Malem, Utwe, and Walung, in June 2012.

A total of 962 larvae belonging to six species were collected at 106 natural and artificial habitats (Table 4) (NODA *et al.* 2013b). They were identified as *Ae. aegypti*, *Ae. albopictus*, *Ae. marshallensis*, *Cx. quinquefasciatus*, *Cx. annulirostris*, and *Cx. kusaiensis*. *Aedes albopictus* was the predominant species (59 habitats) followed by *Ae. marshallensis* (35 habitats), and these species were distributed in all areas. The number of *Cx. quinquefasciatus* and *Cx. kusaiensis* was relatively large, and they were collected at 15 and 19 habitats in five areas, respectively. The number of *Cx. annulirostris* was relatively small, and it was collected at four habitats in three areas. *Aedes aegypti* larvae were collected at only one habitat (a tire) in Tafunsak in 2009, and it was not collected in 2012.

Table 4. The number of mosquitoes and their habitat types collected on Kosrae State, the Federated States of Micronesia.

Island	Species	Number of individuals	Number of habitats*	Habitat types
Kosrae	<i>Aedes aegypti</i>	2	1	Tire
	<i>Aedes albopictus</i>	412	59	Coconut shell, Tin, Banana stump, Bamboo stump, Plastic container, Ceramic cup, Pot, Autoparts, Tire, Boat
	<i>Aedes marshallensis</i>	182	35	Coconut shell, Tin, Banana stump, Tree hole, Plastic container, Paper container, Tire, Pot
	<i>Culex quinquefasciatus</i>	154	15	Coconut shell, Metal container, Tin, Plastic container, Pot, Boat
	<i>Culex annulirostris</i>	84	4	Metal container, Puddle, Puddle of fountain, Concreat tank
	<i>Culex kusaiensis</i>	126	19	Coconut shell, Bamboo stump, Tin, Ceramic cup, Tire, Plastic container

*Total number of habitat is 106.

Vector Mosquitoes for the Dengue Fever

The distribution of vector mosquito species in the FSM is summarized in Table 5. It is a well-known fact that major vectors for dengue fever are *Ae. aegypti* and *Ae. albopictus* in urban areas of Southeast Asia and in the Western Pacific Region (WHO 2003). *Aedes aegypti* was collected on Pingelap Island (Pohnpei State) and on Kosrae Island (Kosrae State), and it was the predominant species on Pingelap Island. *Aedes albopictus* was collected on Weno Island of Chuuk State, Pohnpei Island and Kahlap Island (Mokil Atoll) of Pohnpei State, and on Kosrae Island. It was the predominant species on Kahlap Island and Kosrae Island. Entomological investigations designated the native mosquito species, *Ae. hensilli*, as a vector of dengue virus (SAVAGE *et al.* 1998, NODA *et al.* 2005). *Aedes hensilli* was the predominant species on Yap State (Yap Proper, Ulithi Atoll and Fais Island) and Weno Island of Chuuk State, and it was also distributed on Romanum and Piis-Paneu Island of Chuuk State. *Aedes* species lay eggs in practically all types of artificial containers, and also in some natural containers. In the FSM, artificial habitats (e.g., tins, plastic containers, plastic bottles, noodle containers, tires) were seen more frequently than natural habitats (e.g., tree holes, coconut shells, banana stumps, bamboo stumps). The distribution of vector mosquito species and habitats for larvae showed that four states of the FSM are highly dengue-sensitive.

The distribution of *Aedes* mosquitoes was different from state to state. *Aedes hensilli* was distributed on the western area of the FSM. On the other hand, *Ae. albopictus* and *Ae. aegypti* were mainly distributed on the eastern area of the FSM. The distribution of *Ae. aegypti* was recorded on Yap Proper (SAVAGE *et al.* 1998), and infestations of *Ae. albopictus* were discovered on Yap Proper in 1995 (CDC information on *Ae. albopictus*, http://www.cdc.gov/ncidod/dvbid/arbor/albopic_new.htm). The effects of competition can be important because they can impact on native species. On Yap Proper, both species were not collected by NODA *et al.* (2005) or in 2008 during a further survey, and *Ae. hensilli* was the predominant species. *Aedes aegypti* and *Ae. albopictus* may not be effective competitors against *Ae. hensilli* on Yap Proper. *Aedes hensilli* and *Ae. albopictus* were collected on Weno Island, but the distribution of *Ae. albopictus* was limited along the main road in the northwest. In Pohnpei and Kosrae State, *Ae. aegypti* and *Ae. albopictus* were collected, but *Ae. hensilli* was not collected (NODA *et al.* 2013a, 2013b). In Kosrae, *Ae. aegypti* and *Ae. albopictus* were collected, and *Ae. albopictus* was the predominant species. *Aedes albopictus* larvae were collected at 59 habitats, and *Ae. aegypti* larvae were collected at only one habitat (NODA *et al.* 2013b). *Aedes albopictus* seems to be superior to *Ae. aegypti*. In general, there is seasonality in the occurrence of mosquitoes. However, there would be no need in the FSM to consider the seasonality because the maximum and minimum temperatures do not change throughout the year and there is no dry season.

Table 5. Distribution list of mosquitoes in the Federated States of Micronesia.

	Yap State					Chuuk State	Pohnpei State			Kosrae State	
	Ulithi Atoll					Weno	Pis-Panenu	Pohnpei	Kahlap	Pingelap	Kosrae
	Yap Proper	Falalop	Mognog	Asor	Fassarai						
<i>Aedes hensilli</i>	◎*	◎	◎	◎	◎	◎	○	◎			
<i>Aedes albopictus</i>						○		○	◎		◎
<i>Aedes aegypti</i>									◎		△
<i>Aedes lamelliferus</i>	○**					△					
<i>Aedes maehleri</i>	○										
<i>Aedes scutoscriptus</i>							◎	◎			
<i>Aedes hakanssoni</i>								◎			
<i>Aedes oakleyi</i>								○			
<i>Aedes marshallensis</i>									◎	◎	◎
<i>Aedes vexans noctanus</i>										△	
<i>Aedeomyia actasticta</i>	△***										
<i>Culex quinquefasciatus</i>	△	○	○	○	△	○	○	○	○	○	○
<i>Culex annulirostris</i>	△					△	○	△			△
<i>Culex sitiens</i>	△										
<i>Culex gossi</i>		△									
<i>Culex nigropunctatus</i>					△						
<i>Culex carolinensis</i>						◎	○	○			
<i>Culex maplei</i>								◎			
<i>Culex kusaiensis</i>											○
<i>Lutzia fuscana</i>	△										
<i>Lutzia vorax</i>						△					

* ◎ : Larvae were collected at more than 30% habitats.

** ○ : Larvae were collected at between 10 and 30% habitats.

*** △ : Larvae were collected at less than 10% habitats.

Mosquito Control

Diet has changed significantly since World War II in the FSM. Imported rice, flour, sweet and refined foods, and fatty meats have increasingly replaced local food. As a result of increased trash produced by the use of artificial containers (e.g., tins, plastic containers, plastic bottles, noodle containers), they have become habitats for *Aedes* mosquito larvae. Coconut shell is also a major habitat for mosquito larvae. The vectors of dengue fever breed around houses, and can be controlled by appropriate personal and community action. Destruction or elimination of unwanted natural and artificial containers around human living premises definitely contributes to an overall

reduction of the *Aedes* population (WHO 2003).

In 2007, the Zika virus, a relatively mild disease similar to dengue fever and characterized by rash, joint pain, and conjunctives, was reported on Yap Proper. This was the first report of the Zika virus outside of Africa and Asia (DUFFY *et al.* 2009, HAYES 2009). *Aedes hensilli* seemed to be a vector of the Zika virus on Yap Proper. The Chikungunya virus is also transmitted to humans by virus-carrying *Aedes* mosquitoes. Chikungunya has been identified in nearly 40 countries of Africa and Asia. The Chikungunya virus was brought in to Yap State, and 640 patients were reported until 22 October, 2013 (MINISTRY OF FOREIGN AFFAIRS OF JAPAN 2013). Community education, which raise the level of awareness of the dengue fever, is necessary, and the cooperation and participation of the community is vital for the control of dengue fever and other vector-borne diseases.

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