Journal of the American Mosquito Control Association, 11(2):230–234, 1995

OPERATIONAL AND SCIENTIFIC NOTES

AEDES ALBOPICTUS AND OTHER *AEDES* (*STEGOMYIA*) SPECIES IN FIJI

B. H. KAY,[1] G. PRAKASH[2] AND R. G. ANDRE[3]

ABSTRACT. During an assessment of the dengue situation in Fiji in early 1992, a house-to-house survey of container-breeding *Aedes* was made. Discarded tires and water drums were identified as key breeding sites for the 4 potential dengue vectors: *Aedes aegypti, Aedes albopictus, Aedes pseudoscutellaris,* and *Aedes polynesiensis. Aedes albopictus* were detected on Viti Levu, Vanua Levu, and on Taveuni. Examination of early records and of used tire importation suggests entry into Fiji after July 1985 but well before July 1988 when the species was first detected. It is also possible the *Ae. albopictus* was introduced via aircraft from Hawaii. In Suva, the 4 *Stegomyia* species coexist, but in Lautoka, it appears that *Ae. albopictus* may be displacing *Ae. pseudoscutellaris.*

The expansion of *Aedes albopictus* (Skuse) in the Western Pacific region was first noted for northern New Guinea in 1972 (Schoenig 1972) and the Solomon and Santa Cruz islands by 1978 (Elliott 1980). Following surveys in 1992, *Ae. albopictus* was also detected in the port of Kiunga and on Daru Island in the Western Province of New Guinea (regularly linked by sea or air respectively to northern Australia) (Cooper et al. 1994). In 1988 and 1989, respectively, *Ae. albopictus* was intercepted in Brisbane and Darwin, Australia (Kay et al. 1990), and in 1993 in Auckland, New Zealand (Laird et al. 1994).

The Fiji Islands are located in the southwest Pacific Ocean approximately 3,000 km northeast of Sydney, Australia. One-third of the more than 300 islands of Fiji are inhabited, but most of the population lives on the 3 largest islands: Viti Levu, Vanua Levu, and Taveuni. Suva is the largest city, main port, and capital. Travel among these islands the capital is frequent and rapid, facilitating movement of humans and perhaps mosquitoes infected with dengue or other arboviruses. The most recent outbreak of dengue hemorrhagic fever occurred in 1989–90 with more than 3,600 confirmed cases and 30 deaths (Ministry of Health, Suva, unpublished data).

In Fiji, Laille et al. (1990) detected *Ae. albopictus* in ovitraps, a mango tree hole, and in a tire in the Nadi area but not in Suva or its airport, Nausori. During February 1992, while on a USAID funded mission (Andre et al. 1992[4]) on the surveillance and control of dengue and its vectors, we extended these findings by surveying 3 of the major islands, Viti Levu (7 sites), Vanua Levu (6 sites), and Taveuni (9 sites). Both wet and dry containers were recorded and any immatures therein collected with a 10 × 20-cm net (Tun-Lin et al. 1994), counted, and aliquots identified. This enabled us to examine the prevalence of *Aedes* (*Stegomyia*) spp. in key centers in Fiji and to estimate the relative importance of each container type in terms of the numbers of immatures being produced. On this basis, we then were able to recommend some prioritization of the limited resources for vector control.

The following localities were surveyed: Burata St. settlement, Nanuka St. settlement, Nadera, Suva port, Samabula and Edinburgh Drive (Suva area), Nagali village (Nausori area), all on Viti Levu; Nagigi village, Vaivita and St. Bedes College, Savarekareka (all grouped as rural in Table 1), Labasa, and Savu Savu, all on Vanua Levu; Somo Somo, Lamini and Lovonivonu villages, Government Station, Baculevu Government School, Vuniuto settlement and 3 resorts, Garden Island, Bibi's Hideaway, and Matei Lagoon, all on Taveuni.

A total of 1,371 containers was inspected from 198 premises (Table 1) and 132 of them were found positive for *Ae.* (*Stegomyia*) species. Discarded tires comprised 16.4% of containers inspected but of these 47% were wet and over half (53%) of these were positive for larvae. Allowing for mixed infestations, the following were iden-

[1] Mosquito Control Laboratory, Queensland Institute of Medical Research, P. O. Royal Brisbane Hospital, Brisbane 4029 Australia.

[2] National Vector Control Unit, Ministry of Health, P. O. Box 30, Suva, Fijian Islands.

[3] Formerly with the Henry M. Jackson Foundation and the Vector Biology and Control Project; now with the Department of Preventive Medicine/Biometrics, Uniformed Services University of the Health Sciences, Bethesda, MD 20814.

[4] Andre, R. G., B. H. Kay, E. Kikau and S. H. Waterman. 1992. Assessment of the epidemiology of dengue and its past, present and future control in Fiji. Vector Biology and Control Project Report no. 81269. Arlington, VA.

tified from tires: *Aedes aegypti* (Linn.) (39), *Ae. albopictus* (28), *Aedes pseudoscutellaris* (Theobald) (4), *Aedes polynesiensis* Marks (1), *Culex quinquefasciatus* Say (4), *Culex annulirostris* Skuse (1), and *Toxorhynchites splendens* (Wied.) (1). There were 10,667 *Aedes* (*Stegomyia*) immatures in 68 tires counted (mean 157, range 3–596), which comprised 65.2% of all *Stegomyia* collected.

Drums comprised 4.2% of containers examined and 63% of these contained water. More than 61% of wet drums were positive, mainly for *Ae. aegypti* but also infrequently for *Ae. albopictus, Ae. pseudoscutellaris,* and *Ae. polynesiensis.* Some 3,624 immatures were collected from 22 positive drums (mean 164.7, range 3–909) and this comprised 22.1% of the total immatures collected.

In contrast, tins and bottles were numerous, comprising 48% of total containers examined. Although 40.1% of these contained water, only 5.7% of these were positive. Overall, their contribution to total *Aedes* (*Stegomyia*) collected was 2.3%, with these containers averaging 28.2 (1–66) immatures. Because many bottles in particular were exposed to full sunlight, by mid-afternoon the glass and contents often became warm. This was thought to be a factor mitigating colonization. All 4 species of *Aedes* were found in bottles and tins.

Of the other biotopes, *Ae. albopictus* was also found in plant pot bases, shells, iron parts, a tree hole, and in a *Pandanus* axil with *Aedes fijiensis* Marks. The biotopes occupied by these *Aedes* spp. are well known, as are the susceptibilities of *Ae. polynesiensis, Ae. pseudoscutellaris,* and *Ae. fijiensis* to *Wuchereria bancrofti* (Lee et al. 1982, 1987).

With respect to transmission of dengue, this study clearly indicates that discarded tires and 200-liter drums should receive priority attention in view of their relative contribution to the total numbers of immatures collected. Collectively, therefore, 82.7, 99.7, and 99.1% of *Stegomyia* at the key population centers of Suva, Labasa, and Savu Savu were being produced by 36.3, 47.1, and 20.4% of potential breeding sites inspected. In rural Vanua Levu and on Taveuni, tires and drums comprised 10.6 and 6.9% of inspected containers and produced 42.8 and 37.5%, respectively, of total *Stegomyia* found. Focusing on the principle of key containers (Tun-Lin et al., in press) would ensure that limited personnel could be used most cost effectively to reduce *Aedes* numbers.

Aedes albopictus was found on all 3 islands surveyed, that is, Viti Levu (Suva, Nadera, Nanuka St. settlement), Vanua Lavu (Labasa, Naigigi), and Taveuni (Somo Somo, Lovonivonu, Government Station), suggesting that it is well established. Although introduction of exotic mosquitoes is well documented throughout the Pacific region (Pillai and Ramalingan 1985), it is interesting to speculate on how and where this species was introduced and its consequence.

Fortunately, the National Vector Control Unit has records of house-to-house surveillance for 1981 and for 1982 and from 1988 to 1991 for Suva and Lautoka. Isolated records indicate *Ae. albopictus* was already well established in the western division around Ba (Tavua rural) and at Sigatoka town and rural areas by October 1988. It was common in Lautoka in November 1988 and in industrial, residential, and outlying rural areas of Suva in 1989. Its widespread distribution throughout Viti Levu by 1989 suggests introduction somewhat earlier than its initial discovery in July 1988.

Analysis of the relative proportions of *Ae. aegypti* : *Ae. albopictus* in tires for both Suva and Lautoka for each year between 1989 and 1991 (Table 2 gives totals only) indicated no significant differences for locality ($F = 3.74$, $df = 1, 4$, $P = 0.13$) and for years for Suva ($\chi^2 = 2.88$, $P = 0.24$) and Lautoka ($\chi^2 = 0.04$, $P = 0.98$ and for 1988–91, $\chi^2 = 0.27$, $P = 0.98$), perhaps indicating some degree of equilibrium and/or stability.

One possible source, used vehicle tires were first imported into Suva from Asia in July 1985 and currently at least 8 importers operate through this port. There are no official records of such importations but by far the greatest volume is landed at Suva docks. Between July 1985 and 1988, 2 smaller importers commenced operations through the secondary ports of Nadi and Lautoka. Tires landed at Suva currently are redistributed to 12 businesses throughout the Fijian islands, principally via the ferry service linked to Suva but not to Nadi. Tires are mainly redistributed prior to any retreading process, thus ensuring rapid potential transfer of *Ae. albopictus* within the casings. It is thought that most of these imports are from Japan and therefore would involve a cold-hardy strain. The other option is associated with the possible breakdown of disinsection procedures, following the military coup of 1987, at Nadi airport, which is well connected with direct flights from Hawaii. A tropical strain of *Ae. albopictus* is well established there. During our 1992 survey, there did not seem to be clear responsibility and adequate liaison between those concerned with agricultural and medical quarantine duties.

The prognosis (Table 2), based only on local authority surveillance data, suggests that the wetter capital of Suva (3,841 mm rainfall annually) will be at risk of dengue transmission by all 4

Table 1. Premise inspection for immature *Aedes* (*Stegomyia*) mosquitoes in Fiji, January 31–February 7, 1992.

Container category		Viti Levu			Vanua Levu									Taveuni		
		Suva/Nagali[1]			Labasa			Savusavu			Rural			All sites		
		Total	Wet	Positive	Total	Wet	Positive	Total	Wet	Positive	Total	Wet	Positive	Total	Wet	Positive
Water storage	Drums	35	17	12	5	5	3	9	7	4	3	3	1	5	4	2
	Tanks							4	1	0	1	1	0	2	1	0
	Wells	2	2	0				2	2	0						
	Others	2	2	1				2	2	2						
Trash	Tires	47	32	20	95	35	29	36	14	8	14	8	5	33	17	7
	Bottles, tins	66	14	3	108	32	1	118	33	0	69	10	5	297	175	6
	Coconut shells	12	0	0				27	0	0	26	—	1	34	2	0
Disused household/ industrial	Sinks, baths, dishes	17	12	4	1	0	0	22	6	1	4	1	0	9	3	2
	Iron parts	9	5	1	2	1	1							1	1	1
Garden receptacles	Flower pots	26	1	1	1	1	1	1	0	0	4	3	1	6	2	2
	Ornamental tire/shell	3	1	0							10	—	0	54	1	0
	Vases													10	7	2
Natural	Tree holes	3	3	3							1	1	0	2	1	1
	Crab holes[2]	4	—	—							28	—	—	88	—	—
	Axils													10	10	1
	Recreational										1	1	1			
	No. premises		52			17			17			37			75	

[1] Thirteen premises in the village contained 6 drums (3 positive), 1 small water storage container (wet but negative), and 1 positive tire.
[2] Crab holes not sampled (—).

Table 2. Summarized *Aedes* (*Stegomyia*) surveillance data for 1981–82 and 1988–91, Suva and Lautoka, Fiji Islands.

			Number of positive containers detected with *Aedes*			
Locality	Biotope	Year	*aegypti*	*albopictus*	*pseudoscutellaris*	*polynesiensis*
Suva	Tires	1981–82	222	0	68	1
		1989–91	165	97	39	0
	Drums	1981–82	44	0	17	0
		1989–91	17	11	8	0
	Plant containers	1981–82	89	0	96	0
		1989–91	21	39	27	0
	Tins, bottles, shells	1981–82	79	0	78	2
		1989–91	12	13	13	0
Lautoka	Tires	1982	45	0	19	0
		1989–91	116	101	0	0
	Plant containers	1982	14	0	24	0
		1989–91	22	35	1	0

Ae. (*Stegomyia*) spp. but on the drier western side of Viti Levu (e.g., Lautoka [1,844 mm, Fijian Meterological Service]), *Ae. albopictus* may be displacing *Ae. pseudoscutellaris.* Chi-square analysis of proportions of *Ae. aegypti* to *Ae. pseudoscutellaris* for 4 container types for Suva, listed in Table 2, indicated no significant changes in the distributions from 1981–82 to 1989–91, as follows: tires ($\chi^2 = 1.08$, $P = 0.29$), drums ($\chi^2 = 0.02$, $P = 0.90$), plant containers ($\chi^2 = 0.14$, $P = 0.71$), and tins, bottles, shells ($\chi^2 = 0$, $P > 0.99$). For Lautoka, however, the relative proportions altered significantly for tires ($\chi^2 = 35.4$, $P < 0.001$) and for plant containers ($\chi^2 = 18.1$, $P < 0.001$) after *Ae. albopictus* was known to be present. Formal study of possible competitive interactions, photoperiod sensitivity, cold hardiness, and genetic characterization presents a fertile field of study and the opportunity to identify the possible geographic source of *Ae. albopictus.*

We thank S. Ritchie, C. Jennings, and Marshall Laird for manuscript review and statistical assistance and fellow members of the survey team: J. U. Mataika, M. Bale, S. H. Waterman, and S. Landry. Dr. D. Calder, USAID/Suva, coordinated the visit, which was funded by the Vector Biology and Control Project, Contract No. DPE-5948-C-00-5044-00 to Medical Service Corporation International, Arlington, VA, for the Agency for International Development, Office of Health, Bureau for Research and Development, Washington, DC.

REFERENCES CITED

Cooper, R. D., D. G. E. Waterson, M. Kupo and A. W. Sweeney. 1994. *Aedes albopictus* (Skuse) (Diptera: Culicidae) in the Western Province of Papua New Guinea and the threat of its introduction to Australia. J. Aust. Entomol. Soc. 33:115–116.

Elliot, S. 1980. *Aedes albopictus* in the Solomon and Santa Cruz islands, South Pacific. Trans. R. Soc. Trop. Med. Hyg. 74:747–748.

Kay, B. H., W. A. Ives, P. I. Whelan, P. Barker-Hudson, I. D. Fanning and E. N. Marks. 1990. Is *Aedes albopictus* in Australia? Med. J. Aust. 153:31–34.

Laille, M., P. Fauran and F. Rodhain. 1990. Note sur la présence d'*Aedes* (*Stegomyia*) *albopictus* dans les isles Fidji. Bull. Soc. Pathol. Exot. 83:394–398.

Laird, M., L. Calder, R. C. Thornton, R. Syme, P. W. Holder and M. Mogi. 1994. Japanese *Aedes albopictus* among four mosquito species reaching New Zealand in used tires. J. Am. Mosq. Control Assoc. 10:14–23.

Lee, D. J., M. M. Hicks, M. Griffiths, M. Geary and E. N. Marks. 1987. The Culicidae of the Australasian region, Volume 4. Aust. Govt. Publ. Serv., Canberra.

Lee, D. J., M. M. Hicks, M. Griffiths, R. C. Russell and E. N. Marks. 1982. The Culicidae of the Australasian region, Volume 2. Aust. Govt. Publ. Serv., Canberra.

Pillai, J. S. and S. Ramalingan. 1985. Recent introductions of some medically important Diptera in the Northwest, Central and South Pacific (including New Zealand), pp. 81–101. *In:* M. Laird (ed.). Commerce and the spread of pests and disease vectors. Praeger, New York.

Schoenig, E. 1972. Distribution of three species of *Aedes* (*Stegomyia*) carriers of virus diseases on the main island of Papua New Guinea. Philipp. Sci. 9:61–82.

Tun-Lin, W., B. H. Kay and A. Barnes. Understanding productivity, a key to *Aedes aegypti* surveillance. Am. J. Trop. Med. Hyg. (in press).

Tun-Lin, W., B. H. Kay and T. R. Burkot. 1994. Quantitative sampling of immature *Aedes aegypti* in metal drums using sweep net and dipping methods. J. Am. Mosq. Control Assoc. 10:390–396.