ON PHILIPPINE MOSQUITOES, VIII. THE DISTRIBUTION OF AEDES AEGYPTI LINN. (DIPTERA: CULICIDAE) AND ITS RELATIONSHIP TO THE SPREAD OF DENGUE HAEMORRHAGIC FEVER[1]

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Initial surveys conducted in 21 provinces and 6 selected areas from the Greater Manila between the period August and November 1969, to determine the prevalence of Aedes aegypti **(Linn.) and the relationship of its distribution to the spread of dengue haemorrhagic fever showed that the mosquito vector was present in all areas surveyed and was found predominantly in domestic containers such as water jars, drums, and various artificial containers in both indoors and outdoors. In the Greater Manila area,** Aedes aegypti **was the most dominant mosquito species found in these receptacles, while the indigenous** Aedes albopictus **Skuse, a typical host of other forms of dengue infection in rural areas of Southeast Asia, was totally absent.**

The increase in the population of Aedes aegypti **is correlated with the increasing size of human population, thus, the incidence of the disease.**

With the present distribution and prevalence of Aedes aegypti **in the Philippines, only effective control measures, increased vigilance and expansion of more surveilance program can eliminate large population of the vector to reduce the incidence of more epidemics of the disease. But complete eradication of other forms of dengue remains an impossibility with the presence of** Aedes albopictus.

In recent years, a series of epidemics of haemorrhagic fever transmitted by *Aedes aegypti* have occurred in the Southwest Pacific and Southeast Asian countries. The infection was first reported and recognized in Manila in 1956 (Hammon *et al* 1960). Since then, epidemics have spread and occurred in Thailand in 1958, 1960, 1962 and 1964; in Hanoi in 1958; in South Vietnam in 1960 and 1963; in Singapore in 1960; in Penang between 1962 and 1964; in Calcutta in 1963; and in Visakhapatnam, southern India in 1964 (Halstead 1965; Halstead *et al* 1965; Rao 1966; and Macdonald *et al* 1967).

In the Philippines, the biggest epidemic outbreak of this unusual disease occurred in 1966, when a total of 7,794 cases (hospitalized) and 63 deaths

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were reported for Manila alone during a period covering from January to November 5. During the same period 336 cases and 41 deaths were reported from various provinces (Quarterman 1967).

The distribution of *Aedes aegypti* have, in recent years, been the subject of concern to entomologists, epidemiologists and other health authorities in most Southeast Asian countries (James 1913; Stanton 1920; Barraud 1928; Reid 1954; Macdonald 1956; Scanlon 1965, 1966 a and b; Halstead 1965; Tonn *et al* 1969; and Sheppard *et al* 1969). In the Philippines, however, information on the distribution, relative prevalence and habits of this mosquito species is still insufficient and incomplete. Large scale surveys were non-existent, although some small scale surveys were conducted in the Greater Manila area sometime in 1966 and 1967 by the Health Department.

In view of the outgrowth of more epidemics of haemorrhagic fever, the World Health Organization and the Bureau of Quarantine, Department of Health, initiated a joint program of mapping this mosquito vector throughout its range, using standard survey method. The objectives of this study are as follows: (1) To determine the relative prevalence of the vector, *Aedes aegypti;* and (2) to show the relationship of its distribution to spread of dengue haemorrhagic fever, hence, the control.

This paper presents the results of the nation-wide initial surveys conducted between the period of August and November 1969 in 21 selected provinces and 6 areas of the Greater Manila.

MATERIALS AND METHODS

A simple method, called the "single-larva" collection method was recommended (Sheppard *et al* 1969). Teams of mosquito personnel, a collector and a recorder, were assigned sectors in the area surveyed. Collection of larvae was in two parts, indoor and outdoor. The indoor habitats were classified as jars, drums and miscellaneous water-holding containers; the outdoor habitats were jars, drums and miscellaneous artificial and various natural containers (e.g. tree holes, plant axils etc.). A collecting kit consisted of medicine droppers, flashlight, and 6 prescription bottles each labeled to correspond with one of the 6 categories of larval habitats, was used. Except for the Greater Manila area, 100 houses per district per

province (or 200 houses per province) were surveyed. For each house, a record was kept of the total number of potential larval habitats in each of the categories given above, together with the number of these habitats in which larvae were present. A single larva was collected from each occupied habitat, transferred into the appropriate bottle and recorded.. The larval specimens were killed and preserved in 75 percent alcohol and shipped to Manila for identification and processing of data. In the Greater Manila area, surveys were conducted in Malate, Paco, Sampaloc, Quiapo, Tondo, and Quezon City. All specimens from these areas were brought back alive to the laboratory. After each identification, the larvae were reared for various insecticide-resistance studies.

Sometimes, difficulties arose as to what constituted a house and whether containers were indoors or outdoors (Tonn *et al* 1969). For the purpose of these survey, a house was defined as a single isolated structure or, in the case of a row of adjoining dwellings, an area occupied by a single family group. Indoor was taken to be any area covered by a roof, but sometimes a jar would be partly indoors and partly outdoors. In such cases, a decision based on the amount of covering was left to the collectors.

RESULTS

THE DISTRIBUTION: *Aedes aegypti* was found to be present in all areas surveyed (Fig. 1). The indices of *Ae. aegypti* and *Ae. albopictus* in relation to the number of houses examined per province are shown in Table. 1. In provincial surveys, it was found that some areas were "dominated" by *Ae. aegypti* alone; no other related species was collected. These provinces are as follows: Ilocos Norte, La Union, Zambales, Camarines Sur, Cebu, Negros Oriental, Negros Occidental, Leyte, Samar, Iloilo, Misamis Oriental, Davao, Zamboanga and Sulu. The 6 areas surveyed in the Greater Manila were all *"Aedes aegypti* territories"; *Aedes albopictus* was totally absent (Table 1).

The ratio of *Ae. albopictus* to *Ae. aegypti* (Table 2) in all areas surveyed, showed that the latter species was the dominant mosquito even in areas where the former species was present in significant numbers. The only areas where *Ae. albopictus* was more abundant than *Ae. aegypti,* were the districts of Maagod and Bagumbayan, in Legaspi City, Albay province, and the districts of Palneb and Santo Niño, in Virac, Catanduaness province, respectively.

TABLE 1. **Indices of** Aedes **mosquitoes in relation to the number of houses examined in 22 provinces (including Greater Manila Area) between August and November 1969.**

CITIES/TOWNS	EXAMINED No. HOUSES	*AEDES* *aegypti*	AVE.	*albopictus*	AVE.
Laoag City, Ilocos Norte	200	86	0.43	0	0.000
Ilagan, Isabela	200	155	0.75	1	0.005
San Fernando, La Union	200	105	0.53	0	0.000
Dagupan City, Pangasinan	200	102	0.51	1	0.005
Olongapo City, Zambales	200	37	0.19	0	0.000
Legaspi City, Albay	200	19	0.10	149	0.750
Naga City, Camarines Sur	200	412	2.00	0	0.000
Virac, Catanduanes	200	117	0.59	129	0.640
Cebu City, Cebu	200	203	1.00	0	0.000
Dumaguete City, Negros Or.	200	204	1.00	0	0.000
Tacloban City, Leyte	200	126	0.63	0	0.000
Calbayog, Samar	200	165	0.83	0	0.000
Iloilo City, Iloilo	200	126	0.63	0	0.000
Bacolod City, Negros Occ.	200	120	0.60	0	0.000
Puerto Princesa, Palawan	200	305	2.00	1	0.005
Cagayan de Oro City, Misamis Or.	200	248	2.00	0	0.000
Iligan City, Lanao del Norte	200	258	2.00	2	0.020
Davao City, Davao	200	1,001	5.00	0	0.000
Koronadal, Cotabato	200	183	0.92	1	0.005
Zamboanga City, Zamboanga	200	14	0.07	0	0.000
Jolo, Sulu	200	25	0.12	0	0.000
Greater Manila area					
Malate	101	114	1.13	0	0.00
Paco	100	86	0.86	0	0.00
Tondo	110	75	0.68	0	0.00
Sampaloc	100	65	0.65	0	0.00
Quiapo-Sta. Cruz	108	50	0.46	0	0.00
Quezon City	105	79	0.75	0	0.00
TOTALS	4,824	4,480		280	

In the Greater Manila area, *Ae. aegypti* accounted for .91% of the total collection, followed by *Culex fatigans* Wiedemann, .09%

HABITAT PREFERENCES: *Aedes aegypti* was shown to occupy the same types of habitats in all areas surveyed. The container indices found in various habitats (6 classified categories) in the Greater Manila area are shown in Table 3. For indoor habitats, *Ae. aegypti had* a marked preference for drums, followed by jars and miscellaneous receptacles. However, for outdoors, the principal habitats of this mosquito were jars, drums and miscellaneous containers, in that order. *Culex fatigans* was collected mostly from indoor and outdoor jars.

In the provinces, both *Ae. aegypti* and *Ae. albopictus* were frequently collected (Table 4) from indoor drums and outdoor jars, while *C. fatigans* generally preferred indoor miscellaneous receptacles and outdoor drums and jars.

COMPARISON OF SURVEYS: A general comparison of the survey conducted in the 6 areas of the Greater Manila and those in the 21 provinces is given in Table 5. Although the total number of houses examined in the Greater Manila area was lesser in comparison with that in the provinces (1,224 vs. 4,200), it is worth noting that there were more containers positive for *Ae. aegypti* per house or greater in total positive container for *Ae. aegypti* in the 6 areas of the Greater Manila area surveyed than in the 21 provinces combined. These findings fully support the theory, that any increase in human population size should result in an increased number of positive habitats for *Ae. aegypti,* and not just an increase in the density of larvae in the habitats already occupied. In terms of human population size, the Greater Manila area is bigger than the 21 provinces combined.

DISCUSSION

THE "SINGLE-LARVA" COLLECTION METHOD: This method was used because it has more advantages over other methods being used in various various rural areas of Southeast Asia (Smith 1956; Rudnick 1967).[1] Firstly, since this study was conducted on a large scale basis, the time required to collect larvae was prohibitive. If all larvae would be collected from each positive habitat, one would required several hundreds of bottles just to keep each larval collection, hence, more time would be needed in the identification

TABLE 2. **Ratio of** Aedes aegypti **to** Ae. albopictus **in various provinces surveyed (August-November 1969).**

Province City/Town	Districts	Total Aedes	Total Aegypti	%	Total Albo-pictus	%	No. Con-tainers Ex-amined	Con-tainer Index
ILOCOS NORTE	A	43	43	1.00	0	0.00	380	0.10
Laoag City	B	43	43	1.00	0	0.00	366	0.10
ISABELA	San Vicente	76	75	0.98	1	0.02	295	0.26
Ilagan	Sta. Barbara	80	80	1.00	0	0.00	268	0.36
LA UNION	A	61	61	1.00	0	0.00	223	0.27
San Fernando	B	84	84	1.00	0	0.00	183	0.45
PANGASINAN	Bonuan	49	48	1.00	0	0.00	332	0.14
Dagupan City	Malued	55	54	0.98	1	0.02	253	0.21
ZAMBALES	Sta. Rita	17	17	1.00	0	0.00	26	0.65
Olongapo City	Pag-asa	20	20	1.00	0	0.00	21	0.90
ALBAY	Maagod	70	9	0.01	61	0.99	148	0.47
Legaspi City	Magumbayan	98	10	0.01	88	0.99	168	0.58
CAMARINES SUR	Bayawas	240	240	1.00	0	0.00	100	2.40
Naga City	Triangulo	172	172	1.00	0	0.00	83	2.07
CATANDUANES	Palneb	123	60	0.49	63	0.51	86	1.50
Virac	Sto. Niño	121	57	046	63	0.52	44	2.70
CEBU	San Nicolas	107	107	1.00	0	0.00	319	0.34
City City	Sanciangko	96	96	1.00	0	0.00	304	0.32
NEGROS ORIENTAL	Taft	89	89	1.00	0	0.00	188	0.49
Dumaguete City	Look	115	115	1.00	0	0.00	192	0.60
LEYTE	Burgos	74	74	1.00	0	0.00	396	0.19
Tacloban City	Pericohon	52	52	1.00	0	0.00	209	0.25
SAMAR	Matobato	96	96	1.00	0	0.00	195	0.50
Calbayog	Ague-etan	69	69	1.00	0	0.00	198	0.30
ILOILO	Molo	49	49	1.00	0	0.00	207	0.24
Iloilo City	Tanza	77	77	1.00	0	0.00	137	0.56
NEGROS OCC.	Malusan	66	66	1.00	0	0.00	203	0.33
	Villa	54	54	1.00	0	0.00	165	0.33
PALAWAN	Puerto	140	139	0.99	1	0.01	1,373	0.10
Puerto Princesa	Quezon	166	166	1.00	0	0.00	815	0.20
MISAMIS OR.	Bonbon	165	165	1.00	0	0.00	204	0.80
Cagayan de Oro City	Nazareth	79	79	1.00	0	0.00	215	0.37
LANAO DEL NORTE	Kuwalan	78	78	1.00	0	0.00	323	0.24
Iligan City	Matabang	193	190	0.98	3	0.02	258	0.75
DAVAO	Bolton	574	574	1.00	0	0.00	1,046	0.55
Davao City	Quezon	427	427	1.00	0	0.00	850	0.50
COTABATO	1	91	90	0.99	1	0.01	185	0.45
Koronadal	2	93	93	1.00	0	0.00	264	0.35
ZAMBOANGA	1	8	8	1.00	0	0.00	933	0.85
Zamboanga City	2	6	6	1.00	0	0.00	691	0.81
SULU	Marina	15	15	1.00	0	0.00	481	0.03
Jolo	Scott	10	10	1.00	0	0.00	731	0.01

TABLE 3. **Container indices of the various habitats examined in the 6 areas of the Greater Manila (August-November 1969).**

Districts	Species	INDOORS Jars %	INDOORS Drums %	INDOORS Misc %	OUTDOORS Jars %	OUTDOORS Drums %	OUTDOORS Misc. %	Containers Total No. Examined
TONDO	*Aedes aegypti*	0.00	0.20	0.16	0.42	0.26	0.31	319
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.15	0.01	0.02	0.26	0.18	0.07	
QUIAPO-STA. CRUZ	*Aedes aegypti*	0.29	0.26	0.06	0.00	0.18	0.05	550
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.21	0.04	0.02	0.33	0.06	0.02	
PACO	*Aedes aegypti*	0.00	0.25	0.08	0.17	0.36	0.14	534
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.00	0.00	0.00	0.00	0.00	0.00	
SAMPALOC	Aedes aegypti	0.27	0.18	0.08	0.70	0.24	0.10	420
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.00	0.00	0.00	0.00	0.03	0.08	
MALATE	*Aedes aegypti*	0.10	0.31	0.21	0.26	0.24	0.11	578
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.00	0.02	0.00	0.00	0.00	0.03	
QUEZON CITY	*Aedes aegypti*	0.15	0.18	0.14	0.19	0.35	0.12	567
	Ae. albopictus	0.00	0.00	0.00	0.00	0.00	0.00	
	Culex fatigans	0.00	0.00	0.00	0.00	0.00	0.00	

TABLE 4. **Container indices of the 6 classified habitats in the 21 provinces surveyed (August-November 1969).**

SPECIES	INDOORS Jars %	INDOORS Drums %	INDOORS Misc. %	OUTDOORS Jars %	OUTDOORS Drums %	OUTDOORS Misc. %
Aedes aegypti	4.47	6.23	4.81	7.52	7.14	5.41
Aedes albopictus	0.02	0.39	0.23	1.09	0.26	0.91
Culex fatigans	0.42	0.49	0.54	1.43	1.75	1.14

of the specimens. In this method, all areas were sized and the habitats were categorized into 6, so that one would only need 6 bottles for every area being surveyed. Secondly, this method checks the accuracy of the results, since the total number of larvae in each bottle should exacly correspond

TABLE 5. **Comparison of surveys conducted in the Greater Manila Area and the provinces (August-November 1969).**

COMPARED DATA	RESULTS Manila	Provinces
Number of surveys	12	42
Total number of houses examined	1,224	4,200
Total number of containers examined	2,362	14,216
Total number of containers positive	413	6,469
Number of containers per house	1.93	3.38
Number of positive containers per house	0.34	0.29
Percentage of containers positive	0.18	0.65
Outside jars per house	0.07	0.75
Outside jars positive per house	0.03	0.25
Percentage of positive outside jars	0.65	0.51
Indoor jars per house	0.08	1.24
Indoor jars positive per house	0.02	0.02
Percentage of indoor jars positive	0.24	0.20
Total jars per house	0.15	0.97
Total jars positive per house	0.04	0.43
Percentage of jars positive	0.41	0.30
Drums per house	0.48	1.79
Drums positive per house	0.01	0.49
Percentage of drums positive	0.24	0.37
Miscellaneous containers per house	0.30	2.54
Miscellaneous containers positive per house	0.05	0.69
Percentage of miscellaneous containers positive	0.13	0.35
Percentage of total containers	2.29	6.33
Percentage of total positive containers	0.38	0.35

with the number of positive habitats being recorded. So, if say, the larvae were recorded from 50 jars, then there should be 50 larvae in the corresponding bottle. And finally, this method is simple enough, anyone can repeat the procedure at any given time at appropriate intervals, giving more or less comparable information.

On the other hand, one main disadvantage of this method is that, it does not give any information on the association of two or more species

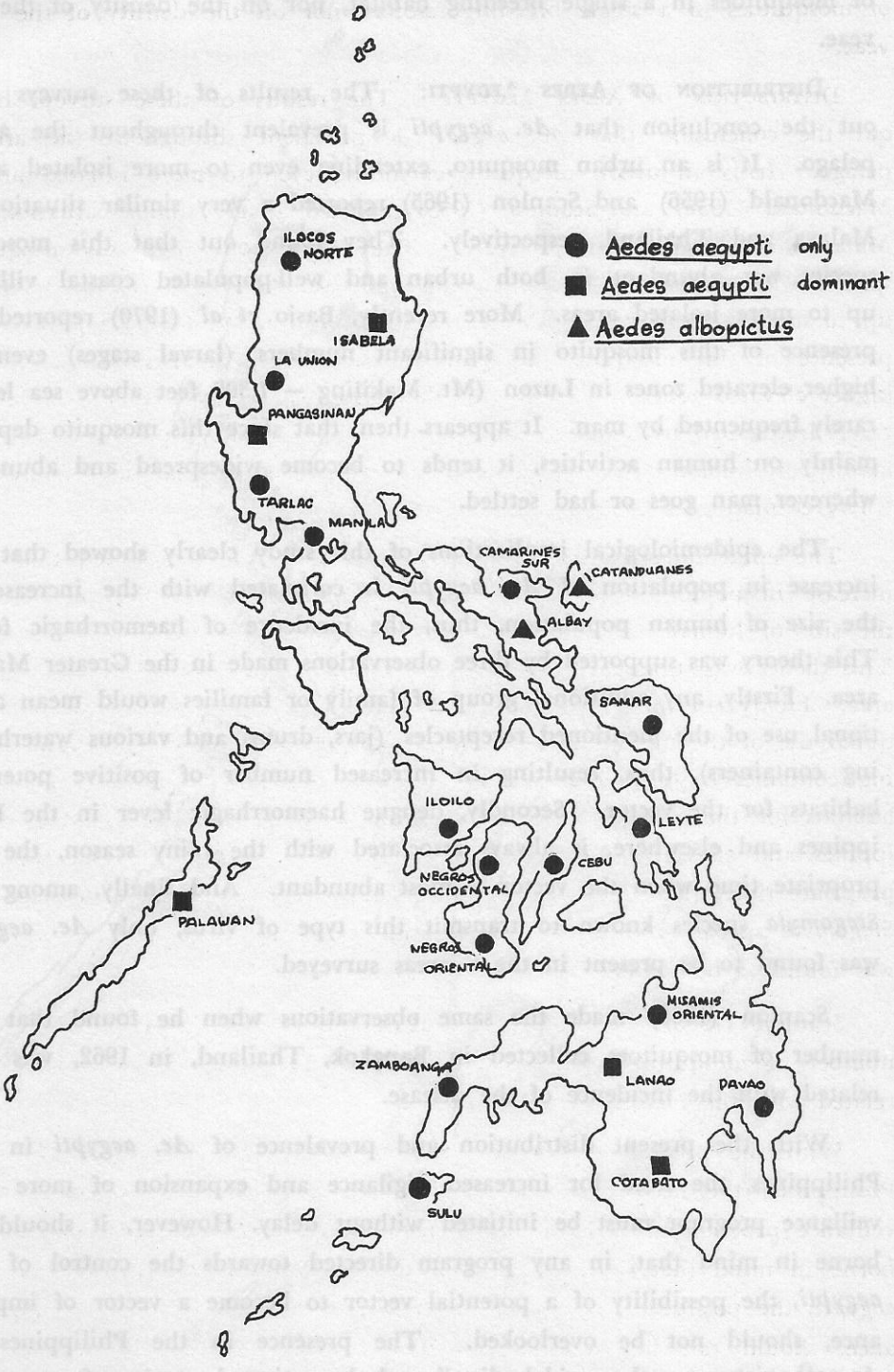

Fig. 1. Distribution of *Aedes aegypti* and *Aedes albopictus*.

of mosquitoes in a single breeding habitat, nor on the density of the larveae.

DISTRIBUTION OF AEDES AEGYPTI: The results of these surveys bear out the conclusion that *Ae. aegypti* is prevalent throughout the archipelago. It is an urban mosquito, extending even to more isolated areas. Macdonald (1956) and Scanlon (1965) reported a very similar situation in Malaya and Thailand, respectively. They found out that this mosquito species was abundant in both urban and well-populated coastal villages, up to more isolated areas. More recently, Basio *et al* (1970) reported the presence of this mosquito in significant numbers (larval stages) even on higher elevated zones in Luzon (Mt. Makiling — 1,300 feet above sea level), rarely frequented by man. It appears then, that since this mosquito depends mainly on human activities, it tends to become widespread and abundant wherever man goes or had settled.

The epidemiological implications of this study clearly showed that the increase in population of *Ae. aegypti* is correlated with the increase in the size of human population, thus, the incidence of haemorrhagic fever. This theory was supported by three observations made in the Greater Manila area. Firstly, any additional group of family or families would mean additional use of the mentioned receptacles (jars, drums and various waterholding containers), thus, resulting in increased number of positive potential habitats for the vector. Secondly, dengue haemorrhagic fever in the Philippines and elsewhere, is always associated with the rainy season, the appropriate time when the vector is most abundant. And finally, among the *Stegomyia* species known to transmit this type of virus, only *Ae. aegypti* was found to be present in the 6 areas surveyed.

Scanlon (1966) made the same observations when he found that the number of mosquitoes collected in Bangkok, Thailand, in 1962, was correlated with the incidence of the disease.

With the present distribution and prevalence of *Ae. aegypti* in the Philippines, the need for increased vigilance and expansion of more surveillance program must be initiated without delay. However, it should be borne in mind that, in any program directed towards the control of *Ae. aegypti,* the possibility of a potential vector to become a vector of importance, should not be overlooked. The presence in the Philippines of *Ae. albopictus,* another widely-distributed domesticated species of mosquito, particularly in forested areas, should give us a pause. What seems likely

to occur in this receptive country is the existence of the sylvan form of dengue. That is, involving *Ae. albopictus* and forest animals, then finally man in the cycle. This mosquito species is worth noting, because it has been considered a typical mosquito host of other forms of dengue infection in various rural areas of Southeast Asia (Smith 1956, Rudnick 1967). Only effective control measures can eliminate large population of *Ae. aegypti*, to reduce incidence of more epidemics of dengue haemorrhagic fever, but complete eradication of other forms of dengue infection remains an impossibility with the presence of *Ae. albopictus*.

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