

A survey of the distribution and relative prevalence of *Aedes aegypti* in Sabah, Brunei, and Sarawak

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Although dengue haemorrhagic fever is widely established in South-East Asia, no cases have been reported from Borneo. In order to help to assess whether the infection could become established in Borneo, a survey was made, using the single-larva collection method, of the distribution and prevalence of the principal vector, Aedes aegypti, in Sabah and in a few towns and villages of Brunei and Sarawak. In addition, the prevalence of Ae. aegypti was compared with that of certain other species of Aedes.

Ae. aegypti was found to be well established in the north, east, and south-west of Sabah but to be absent from almost all of the west coast. It was either uncommon in, or absent from, several small coastal villages; in others, very high Breteau indices were recorded. No reasonable explanation for this discontinuous distribution can be suggested. Large numbers of potential larval habitats were found, giving reason to believe that Ae. aegypti will spread further within these territories.

Although dengue haemorrhagic fever is now widely established in South-East Asia, no cases have yet been reported from Borneo. In the Philippines, the infection was first recognized in 1954 in Manila, and since then there have been frequent outbreaks (Dizon et al., 1968). Epidemics and local outbreaks were also described in Viet-Nam (Halstead et al., 1965), Thailand (Halstead & Yamarat, 1965), West Malaysia (Rudnick et al., 1965), and Singapore (Lim et al., 1961). In all these areas, *Aedes aegypti* has been the principal and usually the only vector, although *Ae. albopictus* has occasionally been involved (Rudnick & Chan, 1965; Gould et al., 1968). Although dengue haemorrhagic fever has not become established anywhere on the island of Borneo, the proximity of, and regular traffic with, the Philippines, Singapore, and West Malaysia suggest that the risk of its introduction is high. In order to help to assess whether the infection could become established, a survey was made between July and October 1970 of the distribution and relative prevalence of *Ae. aegypti* in Sabah. During July several towns and villages were also surveyed in Brunei and Sarawak.

Ae. aegypti has seldom been recorded in Sabah; although Stanton (1920) reported its presence in Jesselton (now Kota Kinabalu), it has since appeared to be absent from the state. In a recent survey that included all the main towns, Ramalingam (1970) reported the presence of *Ae. aegypti* only in Semporna, on the east coast. In Brunei, also, the presence of *Ae. aegypti* has rarely been recorded; only recently has it been identified in the town of Brunei (Zachariah, personal communication). In Sarawak, it has been recorded in and around Kuching by Macdonald et al. (1967) and Surtees (1970), and in Sibuluan by Macdonald et al. (1965). In Kalimantan, which makes up the remainder of the island of Borneo, there are no recent records; the presence of *Ae. aegypti* was reported there by Bonne-Wepster & Brug (1932) and Brug & Bonne-Wepster (1947).

DESCRIPTION OF THE AREA

Sabah

Sabah has an area of about 76 000 km² and forms the northern tip of the island of Borneo. To the south it borders on Kalimantan and Sarawak (Fig. 1). The climate is equatorial and the monthly temperatures vary little throughout the year. In the lowlands, the average temperature in the shade is about 27°C, the daily range being 24–30°C. The four main seasons are

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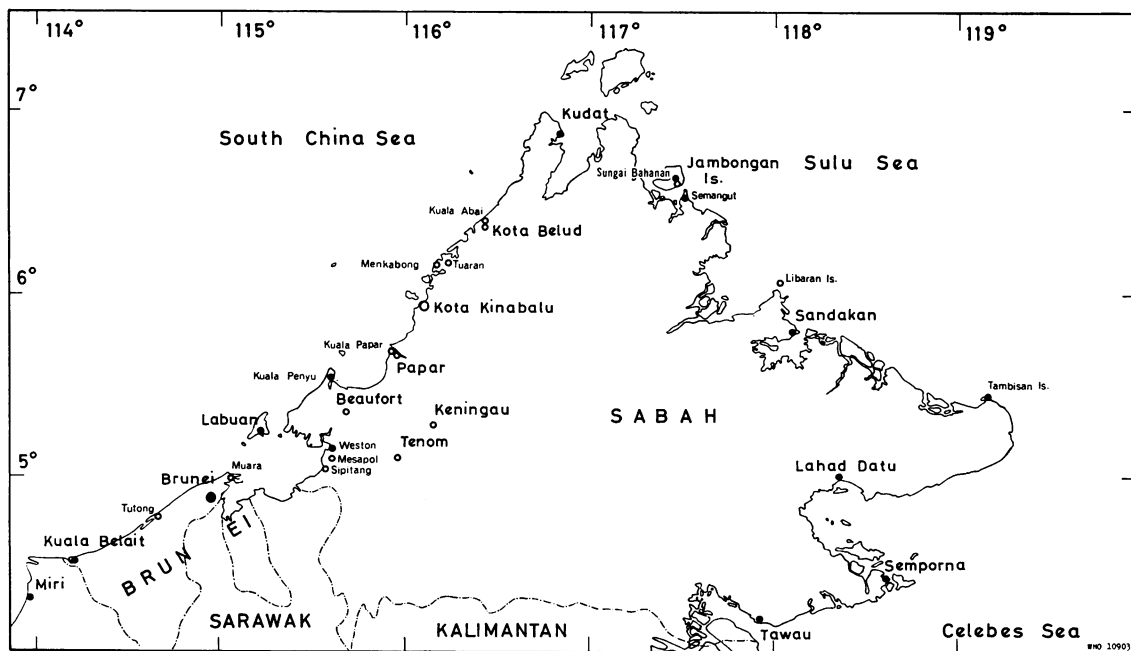


Fig. 1. Distribution of *Aedes aegypti* in Sabah and Brunei (solid circles, *Ae. aegypti* present; open circles, *Ae. aegypti* absent).

the north-east monsoon (from December to February), the south-west monsoon (from June to August), and two inter-monsoon periods. These seasons differ in different parts of the state; the annual rainfall may vary from 150 cm to 400 cm according to locality, the highest figures being recorded in the north-east coastal area and in the Brunei Bay area.

The population of Sabah, estimated at about 640 000, is concentrated mainly along the west coast. There are a few moderate-sized towns on the east coast, but in the interior the population is sparse. Shipping facilities around the coast are good and most of the traffic between the west and east coasts is by sea. Road transport facilities are limited, particularly in the interior and on the east coast; however, most of the towns are linked by air services.

Brunei

Brunei has an area of some 5 700 km². It is divided by Sarawak into two separate parts (see figure). The population, largely concentrated in the town of Brunei and a few small towns along the coast, totals

only about 150 000. The climate is similar to that of Sabah in its general features.

Sarawak

Sarawak, with an area of 125 000 km², is larger than either Sabah or Brunei. The population, numbering about 1 million, is concentrated mainly in the south-west in and around the capital town of Kuching, but there are several quite large towns, notably Sibu and Miri, situated centrally and in the north. In its general features the climate resembles that of Sabah.

METHODS

In each town and village covered by the survey, shop-houses were usually examined and also, whenever possible, low- or medium-class residential housing. Shop-houses typically contain a shop on the ground floor, in front, with washing and toilet facilities at the rear; the kitchen may be downstairs at the back of the house or upstairs with the bedrooms.

Nearly every shop has a piped water supply. The residential houses selected were usually of the *kampong*¹ type, built of wood and raised several feet above ground level. In the areas visited, the homes were often built over a river or the sea and connected to the land and to one another by narrow bridges. Most of the districts had a piped water supply, but as a rule a standpipe was shared by several houses.

The method chosen for the *Ae. aegypti* survey was the single-larva collection method (Sheppard et al., 1969). The larval habitats were grouped into six categories—indoor and outdoor jars, drums, and miscellaneous containers. A different collection bottle was used for each category of container in each locality. A record was kept of all occupied and unoccupied larval habitats and a single larva from each occupied container was transferred to the appropriate collection bottle. The larvae were identified on the day of collection. When only pupae were present in a container, one was removed and identification was made when the adult emerged. When larvae were being identified, care was taken to avoid overlooking *Ae. seatoi*, a recently described species from Thailand that resembles *Ae. aegypti* in several characteristics (Huang, 1969).

Sometimes there was difficulty in deciding whether or not to include in the records a jar or drum containing fresh water; where the water was clearly very fresh and was being used and replenished during the day, the container was omitted from the records.

RESULTS AND DISCUSSION

Tables 1 and 2 summarize the results. Since the single-larva collection method measures the relative prevalence of mosquitos in containers in and around houses, and not the absolute prevalence of any one species, both *Ae. aegypti* and *Ae. albopictus* were almost certainly more common than the data might suggest. The number of containers with *Ae. aegypti* per 100 houses (the "Breteau index") gives a measure for comparison of one locality with another. It is thought that when this index is below 5 there is no serious risk of an outbreak of a disease transmitted by *Ae. aegypti*.

¹ There is no precise translation for the Malay word *kampong*. Any small or large collection of houses may be called a *kampong*, but the area covered by the houses varies widely; some *kampongs* extend several kilometres along a river bank and others consist of a few houses clustered together. A *kampong* house may be built of wood, split bamboo, or palm thatch, and it is raised above ground level. Each house stands in its own compound, usually surrounded by fruit trees, coconut palms, and shrubs.

In planning control measures against *Ae. aegypti* it is helpful to know the location of the larval habitats. As Table 2 shows, most of these were indoors. This was particularly true of shop-houses, which almost always had a piped water supply and few outdoor water-storage drums. In *kampong*-type residential houses, on the other hand, outdoor drums provided the most common source of *Ae. aegypti*.

In Sabah, Brunei, and Sarawak *Ae. albopictus* was both widespread and common. Since *Ae. albopictus* larvae, unlike those of *Ae. aegypti*, are not found solely in and around houses, those recorded in Tables 1 and 2 reflect the choice of habitat of only part of the *Ae. albopictus* population.

Sabah

Although, as Table 1 and Fig. 1 show, *Ae. aegypti* was far from rare in Sabah, it showed an unexpected type of distribution. Whereas high Breteau indices were recorded in Kudat (in the north), in a few coastal areas in the south-west (e.g., Labuan and Weston), and in most of the towns and villages on the east coast, no *Ae. aegypti* were found in the main towns on the west coast. There was no apparent reason for this. Types of housing and the customs of the people were similar throughout the area of the survey, and potential larval habitats were available in all the localities visited.

In those communities where *Ae. aegypti* was present, its local distribution and prevalence were not uniform. On Labuan Island, for example, it has not as yet spread outside the town of Victoria; elsewhere on this island, *Ae. albopictus* was found to be highly prevalent in place of *Ae. aegypti*. In Tawau, no *Ae. aegypti* foci were detected in the large, low-income Ice-box² district, despite the large number of suitable habitats and the presence nearby of a small population of the species in the town centre. In general, the towns on the east coast showed a lower prevalence, in relation to the available habitats, than might have been expected.

The very high Breteau indices were all found in small coastal villages, e.g., Weston, Sungai Bahanan, and Tambisan. There may be a correlation between high Breteau indices and a large amount of small-boat traffic, particularly if mosquitos are regularly introduced from different sources, e.g., the Philippines and Kalimantan. However, *Ae. aegypti* was found to be absent from, or uncommon in, some

² This is the official name of the district.

Table 1. (continued)

Locality	Type of housing	Number of houses examined	Number of houses with mosquito larvae	Total number of containers				Relative prevalence			Number of containers per 100 houses			
				With water	With mosquito larvae	With <i>Ae. aegypti</i>	With <i>Ae. albopictus</i>	With other species	<i>Ae. aegypti</i>	<i>Ae. albopictus</i>	Other species	With mosquito larvae	With <i>Ae. aegypti</i> (Breteau index)	With <i>Ae. albopictus</i>
SABAH (cont.)														
Semangut	Kampong	13	11	76	52	35	1	16	0.67	0.02	0.31	400	269	8
Libaran Island	Kampong	15	2	35	3	0	0	3	0	0	1.0	20	0	0
Sandakan	Shop	20	2	41	4	4	0	0	1.0	0	0	20	20	0
town centre	Kampong	20	5	49	9	9	0	0	1.0	0	0	45	45	0
Sim Sim	—	—	—	20	7	6	1	0	0.86	0.14	0	—	—	—
port area	—	—	—	161	129	124	1	4	0.96	0.01	0.03	614	590	5
Tamblian Island	Mixed	21	15	76	21	7	10	4	0.33	0.48	0.19	66	22	31
Lehad Datu	Mixed	32	7	76	19	12	3	4	0.63	0.16	0.21	37	24	6
Semporna	Mixed	51	8	143	19	12	3	4	0.63	0.16	0.21	37	24	6
Tawau	Mixed	51	8	143	19	12	3	4	0.63	0.16	0.21	37	24	6
town centre	Shop	15	2	67	3	2	0	1	0.67	0	0.33	20	13	0
ice-box district	Kampong	28	11	168	38	0	36	3	0	0.92	0.08	136	0	125
port area	—	—	—	27	1	1	0	0	1.0	0	0	—	—	—
military camp	Barracks	—	—	36	1	0	1	0	0	1.0	0	—	—	—
BRUNEI														
Town of Brunei	Shop	15	1	78	1	0	0	1	0	0	1.0	7	0	0
town centre	Kampong	14	5	75	10	7	1	2	0.7	0.1	0.2	71	50	7
Kampong Ayer	Shop	12	0	84	0	0	0	0	0	0	0	0	0	0
Muara	Shop	13	4	57	7	0	5	2	0	0.71	0.29	54	0	38
Tutong	Shop	15	11	73	21	14	6	1	0.67	0.29	0.05	140	93	40
Kuala Belait	Shop	15	11	73	21	14	6	1	0.67	0.29	0.05	140	93	40
SARAWAK														
Miri	Shop	25	15	136	53	32	13	8	0.60	0.25	0.15	212	128	52
town centre	Kampong	20	11	82	21	3	17	1	0.14	0.81	0.05	105	15	85
Kampong Degang	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kuching	Shop	20	13	60	33	31	1	1	0.94	0.03	0.03	165	155	5
town centre	Kampong	5	5	63	37	30	7	0	0.81	0.19	0	740	600	140

Table 2. Relative distribution of larval habitats of *Ae. aegypti* and *Ae. albopictus*

Species and housing	Total number of collections	Relative distribution					
		indoors			outdoors		
		Jars	Drums	Miscellaneous	Jars	Drums	Miscellaneous
<i>Ae. aegypti</i>							
shop	209	0.12	0.19	0.40	0.09	0.09	0.11
kampong	195	0.18	0.25	0.13	0.12	0.30	0.03
<i>Ae. albopictus</i>							
shop	103	0.20	0.16	0.26	0.09	0.06	0.23
kampong	98	0.06	0.09	0.13	0.11	0.34	0.27

places that receive frequent visits from Philippine and Indonesian trading craft. Although there is thus no plausible explanation for the discontinuous distribution of *Ae. aegypti*, it is reasonable to conclude that, in the absence of control measures, this mosquito will become more widespread in Sabah.

Brunei

In Brunei, only a few localities were sampled for *Ae. aegypti*. The results (Table 1) show that the species is established in the coastal town of Kuala Belait and in Kampong Ayer in the town of Brunei, a very large and scattered kampong whose houses are built on piles on mud flats in the river. It is not unlikely, however, that there were undetected foci in the town of Brunei itself.

Sarawak

In a survey of *Ae. aegypti* made in Kuching in 1964, 17 of 57 shop-houses and residential houses examined were positive (Macdonald et al., 1967); in 1968,

Surtees (1970) found foci in villages 11 km and 16 km south of Kuching, while 11 of 74 houses in the town itself were positive. In the present survey, approximately 12 of 20 shop-houses were positive (Table 1). Owing to the good piped water supply in Kuching, there were virtually no storage jars or drums and almost all the larvae were in small containers, such as ant-guards. On the outskirts of the town, *Ae. aegypti* showed a high prevalence in a fishing kampong, Kampong Petanak. Although only 5 houses were examined in this kampong, 3 of these were large and complex structures in which 5–10 related family groups were living. The very high Breteau index found for Kampong Petanak is therefore not comparable with that found for other localities.

In the north of Sarawak, *Ae. aegypti* was well established in the town of Miri and its outskirts. However, apart from a single record of its occurrence in Sibul (Macdonald et al., 1965), no data are available from elsewhere in Sarawak.

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RÉSUMÉ

ENQUÊTE SUR LA RÉPARTITION ET LA PRÉVALENCE RELATIVE D'*Aedes aegypti* À SABAH, BRUNEI ET SARAWAK

Bien qu'actuellement très répandu en Asie du Sud-Est, le syndrome dengue/fièvre hémorragique n'a jamais été signalé à Borneo. Afin d'évaluer les risques de propa-

gation de la maladie à ce territoire, on y a procédé, de juillet à octobre 1970, à une enquête sur la répartition et la prévalence du principal vecteur, *Aedes aegypti*. Au

cours de ces investigations, qui se sont déroulées à Sabah ainsi que dans quelques villes et villages de Brunei et de Sarawak, on a utilisé la méthode consistant à prélever une seule larve par récipient.

A Sabah, on a mesuré des indices de Breteau (nombre de récipients contenant des larves d'*Ae. aegypti* par 100 habitations) élevés dans le nord, l'est et le sud-ouest du territoire, mais on n'a découvert aucun *Ae. aegypti* dans les principales villes de la côte ouest. Rien à l'heure

actuelle ne permet d'expliquer cette répartition très inégale du vecteur. Etant donné l'existence de nombreux gîtes potentiels, on peut raisonnablement s'attendre à une extension de son aire de distribution.

A Brunei, où seules quelques localités ont été prospectées, la présence d'*Ae. aegypti* a été décelée dans la ville côtière de Kuala Belait et à Brunei. A Sarawak, elle a été constatée à Kuching et à Miri.

REFERENCES

- Bonne-Wepster, J. & Brug, S. L. (1932) *Geneesk. T. Ned.-Ind.*, **72**, suppl. 2, 1-85
- Brug, S. L. & Bonne-Wepster, J. (1947) *Chronica Nat.*, **103**, 179-197
- Dizon, J. J., Mendoza, J. B. & Gomez, F. M. (1968) *J. Philipp. med. Ass.*, **44**, 597-609
- Gould, D. J., Yuill, T. M., Moussa, M. A., Phinit Simasathien & Rutledge, L. C. (1968) *Amer. J. trop. Med. Hyg.*, **17**, 609-618
- Halstead, S. B. & Charas Yamarat (1965) *Amer. J. publ. Hlth*, **55**, 1386-1395
- Halstead, S. B., Voulgaropoulos, E., Tien, N. H. & Suchinda Udomsakdi (1965) *Amer. J. trop. Med. Hyg.*, **14**, 819-830
- Huang, Y. M. (1969) *Proc. ent. Soc. Wash.*, **71**, 234-239
- Lim, K. A., Rudnick, A. & Chan, Y. C. (1961) *Singapore med. J.*, **2**, 158-161
- Macdonald, W. W., Smith, C. E. G., Dawson, P. S., Ganapathipillai, A. & Mahadevan, S. (1967) *J. med. Ent.*, **4**, 146-157
- Macdonald, W. W., Smith, C. E. G. & Webb, H. E. (1965) *J. med. Ent.*, **1**, 335-347
- Ramalingam, S. (1970) *Med. J. Malaya*, **25**, 73-74
- Rudnick, A. & Chan, Y. C. (1965) *Science, N. Y.*, **149**, 638-639
- Rudnick, A., Tan, E. E., Lucas, J. K. & Mohamed bin Omar (1965) *Brit. med. J.*, **1**, 1269-1272
- Sheppard, P. M., Macdonald, W. W. & Tonn, R. J. (1969) *Bull. Wld Hlth Org.*, **40**, 467-468
- Stanton, A. T. (1920) *Bull. ent. Res.*, **10**, 333-344
- Surtees, G. (1970) *J. med. Ent.*, **7**, 273-276