Bull. Org. mond. Santé } 1969, 40, 819-829
Bull. Wld Hlth Org.

Replicate Surveys of Larval Habitats of *Aedes aegypti* in Relation to Dengue Haemorrhagic Fever in Bangkok, Thailand *

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Dengue haemorrhagic fever in Bangkok and Thonburi occurs principally during the wet season. The mosquito vector is Aedes aegypti. *A study was made of the larval habitats of* A. aegypti *in 14 localities, at three different times of the year, to determine whether there were fluctuations in the* A. aegypti *population, as measured by the number of occupied habitats, which could be correlated with the incidence of the infection.*

The habitats were classified into 6 categories and a single larva was collected for identification from each one that was occupied. The number and percentage of occupied habitats of each category per 100 houses were analysed to determine whether there were differences between localities and between times of the year. Almost all the comparisons between localities were highly significant. There was evidence of slight changes in the number of occupied habitats from time to time, the chief increase being between the cool and the warm seasons and the chief decrease from the wet to the cool season, but it seems unlikely that outbreaks of dengue haemorrhagic fever can be explained by increases in A. aegypti *densities during the wet season.*

Since 1958, biennial epidemics of dengue haemorrhagic fever have been occcuring in Bangkok, Thailand. The etiology of the disease is not fully understood, but several types of dengue virus have been isolated from patients with or without haemorrhagic manifestations and the same types have also been isolated from the mosquito *Aedes aegypti* (Johnston, Halstead & Cohen, 1967). Furthermore, antibodies against some of the viruses are frequently found in individuals who have had haemorrhagic symptoms. Thus it seemed likely that *A. aegypti* is an important vector and that changes in its numbers were responsible for changes in the incidence of the disease. This view gained support from 2 observations: firstly, the disease is strongly associated with the wet season when it was presumed that mosquito populations would be particularly dense; and, secondly, the observations of Scanlon (1966), who found that the number of mosquitos caught in Bangkok in 1962 was correlated with the incidence of the disease. However, it must always be remembered that such a correlation, even if it exists, does not necessarily imply a causal relationship between *A. aegypti* and the incidence of disease.

In view of the probable relationship between this vector and the disease and the paucity of data on the dynamics of *A. aegypti* populations, the World Health Organization established an *Aedes* Research Unit in Bangkok in 1966. As part of its programme the dynamics of an adult population of the mosquito were studied from July 1966 to July 1967 using a mark–release–recapture procedure (Sheppard et al., 1969). Also as part of the unit's general programme of research and as a check on the results which might come from the mark–release–recapture experiment, larval habitats in the urban area of Bangkok and Thonburi, a city just across the river Chao Phraya from Bangkok, were surveyed on a number of occasions between October 1966 and June 1967. This paper reports the results of these surveys.

* From the WHO *Aedes* Research Unit, Bangkok, Thailand. The study was supported jointly by a United States Public Health Service research grant, No. CC 00174, from the National Communicable Diseases Center, Atlanta, Ga., USA, and by the World Health Organization.

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LOCAL CONDITIONS AND SURVEY METHODS USED

Classification of larval habitats

Because the numbers of miscellaneous containers, which are difficult to classify, are relatively few in Bangkok, it has been possible to produce a simple classification of habitats. These are water jars, miscellaneous containers, and " natural containers " outdoors, and jars, ant-traps, and miscellaneous containers indoors. For the purposes of the present investigation it is important to note that larvae are very rarely found in tree-holes, coconut shells and other " natural " containers of water in urban areas. The vast majority of larval habitats are man-made containers in which the water is relatively clean.

Throughout Thailand people store water. The primary storage places are large water-jars (generally 100–200-litre capacity). These jars are made of cement, ceramic earthenware or unglazed earthenware. Regardless of the income and education of the householder, one or more are found in almost every house. Ant-traps are also very common. These traps, in which the legs of cupboards and tables often stand, are usually of glazed earthenware, but tin cans, water glasses, plastic cups, or any small vessel holding water may be used. The miscellaneous containers consist of a multitude of receptacles found in households: plates on which flower-pots stand, flower-vases, cement baths, foot-baths, wooden and metal barrels, metal cisterns, tires, bottles, tin cans, discarded wet-cell batteries, glass containers associated with " spirit houses " (shrines) and drainpipes are a few examples. Natural containers include treeholes, leaf axils and coconut shells; they are the least common of the larval habitats.

Description of the area and housing conditions

A general description of the area and the conditions under which *A. aegypti* is found breeding has been given by Sheppard et al. (1969). Housing in Bangkok is very varied and zoning ordinances for the most part do not exist. Consequently, for simplicity, areas were classified as shop-house, slum, low-income, middle-income or high-income, according to the most prevalent type of housing, even though the dwellings in any one area were not exclusively of one kind.

Shop-houses line many of the main streets of Bangkok; they are the family home and business premises combined under one roof. Typically they consist of a shop in front, on the ground floor, and a kitchen at the back. There is usually a bathroom which may be within the building or in a shed attached to it. The kitchen and bathroom usually have at least one water tap each. The bathroom will house either a cement bath or water-jars and there will be one or more jars in the kitchen, and ant-traps at the base of the cupboards. The upper one or two storeys include bedrooms and store rooms. The newer shop-houses are brick or cement, but many of the older ones are wooden. Each house is usually a single family dwelling; however, many of the family groups are very large.

Slum houses may be made of various materials. For the most part, they are wooden with galvanized metal roofs. In areas such as Khlong Toei, the houses are raised several feet above the ground since the water table is high and a pool of water lies under the house during most of the year. In areas with less permanent standing water, the occupants may construct a wooden or cement floor on the ground. Home industries, such as dressmaking, may be found in some of these houses, and others may be used as cafés and small community markets. Water-jars are usually found outside the house and in the bathroom. Ant-traps may or may not be present. Some householders have a private water supply; others obtain their water from one of the communal standpipes in the area, either carrying it or bringing it by hose to their jars.

Housing in low-income areas is often not very different from the slum housing, but the houses are considered to be more permanent, and their construction is better. Housing in middle-income areas is more spacious, better constructed and usually includes gardens. The government has created some very good housing areas for low- and middle-income groups; the streets and houses are well planned and well built, and they make very convenient survey and study areas.

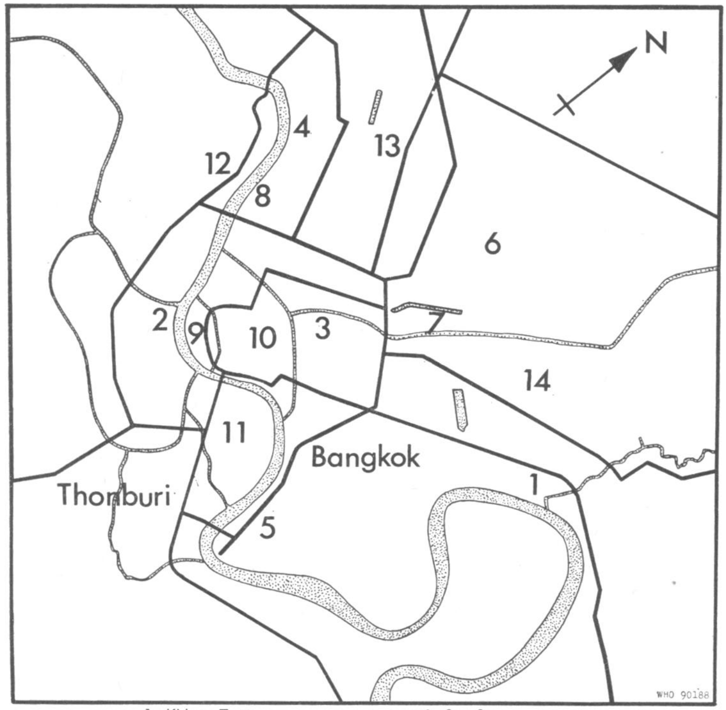
The housing in the high-income areas usually consists of large compounds each with one or more main houses, servants' quarters, and a large garden area. The main houses are modern with running water, electricity, screened windows, and other conveniences. The servants' quarters often constitute the main breeding areas of *Aedes aegypti.*

The study sites

Fourteen study sites were selected in Bangkok and Thonburi. Fig. 1 shows the location of the following numbered sites:

(1) *Khlong Toei.* This is a large slum area between the abattoir and the Port Authority Administration

FIG. 1
LOCATION OF THE STUDY SITES IN BANGKOK AND THONBURI



1. Khlong Toei
2. Phran Nok
3. Soi King Phet
4. Bang Pho
5. Krung Thep Bridge Area
6. Huay Kwang
7. Makkasan
8. Sam Sen
9. Tha Tian Market
10. The 22nd July Circle
11. Mae Klong
12. Bang Plat
13. Soi Aree
14. Soi 49-55

Building, The section studied was near the Chao Phraya river. The houses fit the general description given above; most of them are raised above ground-level and board walks join the houses one with the other.

(2) *Phran Nok*. This is a slum area in Thonburi. The houses are wooden and most of them are raised several feet above the ground. Water lies under many of the houses except during the dry season.

(3) *Soi King Phet*. This is a large lower-class housing area near Wat Boromnivas and a few minutes walk from the unit laboratory. Housing is similar to Khlong Toei, but is more permanent with fewer areas of standing water.

(4) *Bang Pho*. This area is a low- to middle-class housing district. Many houses are fairly new 2-storey wooden structures. For the most part the area is dry, but there are some sections with standing water.

(5) *Krung Thep Bridge area*. This is a low- to middle-class housing area in the southern part of Bangkok. It is very similar to the Bang Pho area, but most of the residents are Moslem rather than Buddhist.

(6) *Huay Kwang*. The area surveyed is low-class housing adjacent to a government study area where *A. aegypti* was being controlled by DDT.

(7) *Makkasan*. This is a well planned housing area built by the railway authorities, consisting of long 2-storey 8-unit apartments. The first or ground floor is usually a cooking and bathing area and the second floor has living rooms and bedrooms. Almost every house has running-water indoors or on the outside patio.

(8) *Sam Sen*. This is a shop-house area between the Chao Phraya river and Sukhothai Palace. The main street has a number of 2-storey brick and

cement shop-houses. Behind these houses are single-storey wooden shop-houses, some slum houses, and a shipyard. Most of the houses have running water; there are communal stand-pipes near the docks.

(9) *Tha Tian Market.* This is another riverside shop-house area. It is near Wat Phra Chetupon (Temple of the Reclining Buddha). The inhabitants are mostly Chinese, and many of their shops are wholesale warehouses. The blocks along the periphery of the study area consist of 2- or 3-storey shop-houses. Only the ground floor of these houses was examined because of reluctance on the part of the owners to allow the mosquito scouts upstairs. In the rear of the houses it was possible to see flower-pots and water taps upstairs, suggesting that larvae probably could have been collected from sources on the upper floors. Directly behind the shop-houses, in many blocks, were slum houses, and towards the centre of the blocks were markets or warehouses. Very few water-jars were found outside because the area was heavily congested.

(10) *The 22nd July Circle.* This is a Chinese shop-house section on Maitrichit Road near the Plabplachai police station. The shop-houses fit the general description given above. A large proportion are tire and battery shops. At the back of the houses, in the centre of the block, are 1-storey wooden houses, many of which are inhabited by workers making fish-balls, an industry carried out on the pavement. The residents of other houses are engaged in a variety of home industries. For the most part, the area is devoid of open spaces. Narrow, cement-paved alleys honeycomb the congested area; few jars are found outside.

(11) *Mae Klong.* This is an area of middle-class housing in the central section of Thonburi. The majority of the houses are 2-storey wooden structures; a few are made of brick. The compounds are small, and many of the patios are completely cemented.

(12) *Bang Plat.* This is a northern rural or suburban residential area in Thonburi. Both residential houses and shop-houses were surveyed. The area is surrounded by fruit gardens. mostly coconut and betel-nut trees. These is a municipal water-supply. Many houses are on stilts and board walks serve as paths.

(13) *Soi Aree.* This is a rather large high-income residential area located in the northern section of Bangkok. Many foreigners live in the area. The compounds are large and dry. The area fits the general description of high-income housing.

(14) *Soi 49-55.* This is a high-income residential area in the southern part of Bangkok. Its residents are mostly foreigners. It is very similar to the Soi Aree study area.

Seasons of the year

Bangkok and the surrounding areas have 3 main seasons in the year: a wet season which begins in May and lasts until October, a cool season from November until the end of February, and a hot, dry season during March and April until the beginning of the rains. There is usually a gradual transition between the seasons. Fig. 2 shows the mean daily rainfall by months plotted against the mean daily temperature from July 1966 to July 1967 and also the averages for the period from 1958 to 1967, inclusive. As the figure shows, the year 1966–67 differed in some respects from the average. In view of the distinct seasons it was decided to make surveys in each of the study areas at least once during each season. In this way any effect of climate on the larval populations might be measured.

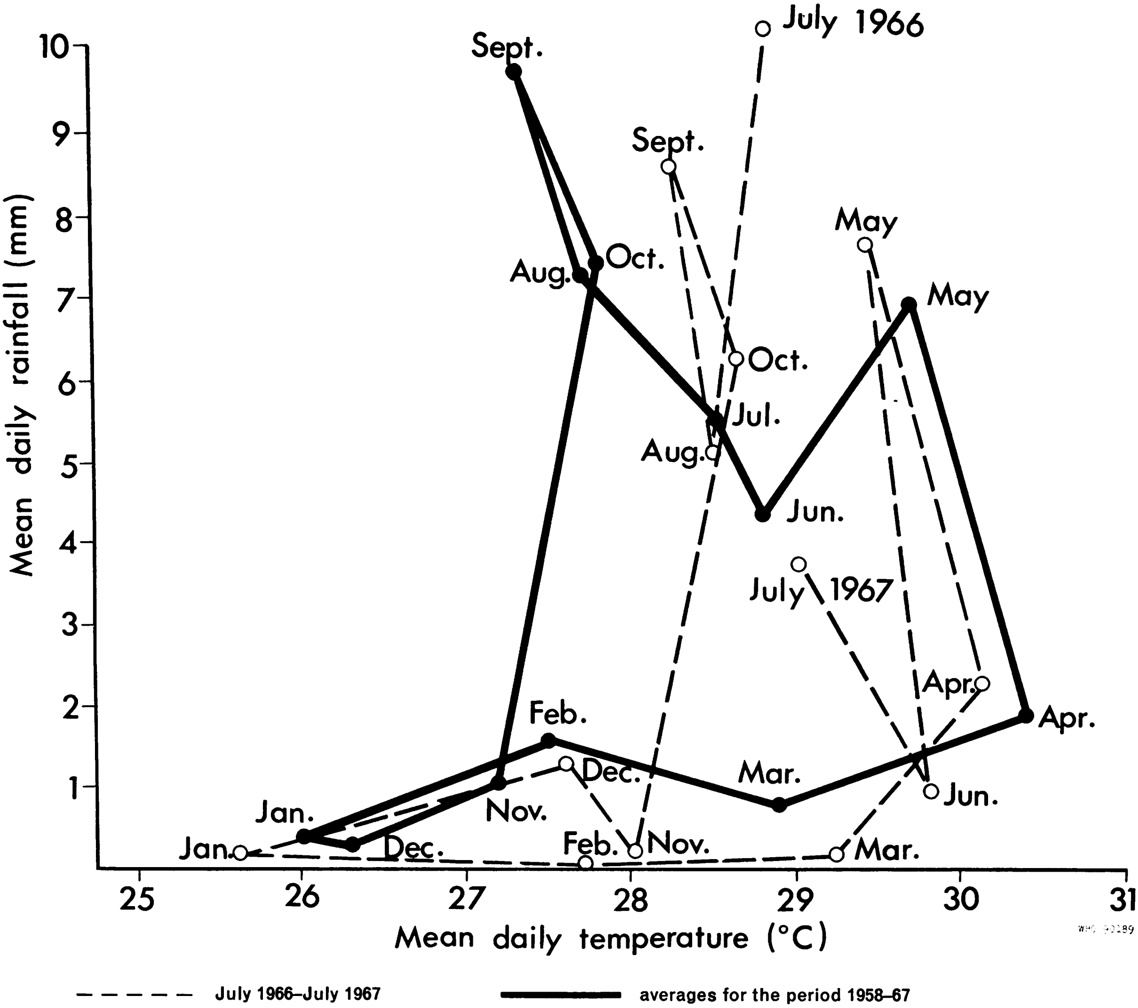
Method of collecting larvae

Teams of mosquito scouts, a collector and a recorder, were assigned sectors in the area being surveyed. Their collecting kit consisted of the usual equipment for collecting mosquito larvae (electric torches, pipettes, etc.) and 6 plastic bottles each labelled to correspond with one of the 6 categories of larval habitats (for further details see Sheppard, Macdonald & Tonn, 1969). Usually 100 houses in each area were surveyed on each occasion; sometimes a larger sample was taken but only twice were fewer than 100 houses examined (see Table 1). 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 brought to the laboratory at the end of the survey. After identification, they were either destroyed or used for insecticide tests.

Sometimes difficulties arose as to what constituted a house and whether containers were indoors or outdoors. For the purpose of the surveys, 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. Indoors was taken to be

FIG. 2

RELATION BETWEEN MEAN DAILY TEMPERATURE AND MEAN DAILY RAINFALL BY MONTHS



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 mosquito scouts.

RESULTS

A summary of the results of the surveys in the 14 localities is given in Table 1. Both the potential larval habitats (apparently suitable containers with water) and those in which larvae were actually present, are shown. A premise index is also given for each survey, that is to say, the percentage of houses in or around which mosquito larvae were found. The premise index includes all species but in the remainder of the table larvae other than *A. aegypti* have been excluded. Since very few other species were in fact collected, the premise index is almost equivalent to the classical *A. aegypti* index. In Table 2, the data have been averaged over all localities for each season of the year but, before averaging, the individual survey results were adjusted where necessary so that they corresponded to collections from 100 houses.

TABLE 1
THE RESULTS OF THE LARVAL SURVEYS IN 14 LOCALITIES OF BANGKOK AND THONBURI

Locality	Dates of collections	Number of premises examined	Premise index	Outdoor containers: Jars, Number examined	Outdoor containers: Jars, Number positive	Outdoor containers: Miscellaneous, Number examined	Outdoor containers: Miscellaneous, Number positive	Outdoor containers: Natural, Number examined	Outdoor containers: Natural, Number positive	Indoor containers: Jars, Number examined	Indoor containers: Jars, Number positive	Indoor containers: Ant-traps, Number examined	Indoor containers: Ant-traps, Number positive	Indoor containers: Miscellaneous, Number examined	Indoor containers: Miscellaneous, Number positive
Khlong Toei	30.1.67	100	95	298	199	4	2	0	0	97	66	81	52	4	2
	5.4.67	100	88	242	154	1	0	0	0	116	90	83	50	0	0
	21.6.67	100	84	265	130	5	1	0	0	116	66	46	33	9	6
Phran Nok Road	12.12.66	101	91	390	97	12	6	0	0	232	81	183	116	18	7
	6.3.67	100	92	287	109	19	2	0	0	176	101	154	93	9	3
	7.6.67	100	93	311	115	32	17	2	0	290	136	170	120	34	22
Soi King Phet	2.2.67	100	73	215	93	1	1	0	0	138	69	52	28	1	1
	10.4.67	100	92	217	105	0	0	0	0	198	110	110	93	4	2
	25.5.67	100	91	256	112	12	10	8	7	198	103	133	89	14	8
Bang Pho	6.2.67	100	85	204	18	57	8	0	0	204	53	209	165	16	10
	17.5.67	100	76	188	58	17	9	5	4	151	54	218	174	13	5
	31.10.66	160	77	338	79	24	9	0	0	292	70	352	257	30	13
Krung Thep Bridge Area	7.11.66	93	93	501	168	3	1	0	0	283	87	135	79	28	12
	19.4.67	100	89	395	161	1	0	0	0	214	121	157	93	10	3
	21.6.67	100	96	356	159	23	13	0	0	256	157	150	91	23	14
Makkasan Area	16.1.67	100	63	231	39	5	3	0	0	239	31	148	87	14	1
	29.4.67	100	70	218	50	2	1	0	0	235	59	125	102	27	4
	5.10.66	191	65	463	65	27	15	0	0	458	66	296	146	18	3
Huay Kwang	14.12.66	85	80	101	49	1	0	0	0	164	71	132	65	3	2
	8.5.67	100	97	183	124	0	0	0	0	206	145	215	168	1	1
	5.6.67	100	87	204	111	7	2	3	2	172	105	172	117	7	1
Sam Sen	4.1.67	100	64	50	21	15	6	0	0	206	98	162	89	23	13
	20.3.67	100	71	66	36	2	1	0	0	215	75	131	85	10	2
	7.6.67	100	56	43	18	3	2	0	0	183	44	164	123	44	18
Tha Tian	9.1.67	100	45	8	2	0	0	0	0	133	30	43	20	64	23
	27.3.67	100	59	22	7	1	0	0	0	160	82	64	34	65	18
	14.6.67	100	60	20	13	6	2	0	0	129	50	65	42	79	22
22nd July Circle	23.1.67	100	63	12	2	0	0	0	0	165	59	81	39	58	18
	3.4.67	100	57	60	23	0	0	0	0	162	51	73	38	41	12
	14.6.67	100	69	24	14	0	0	0	0	185	81	115	57	42	14
Mae Klong	7.12.66	108	79	587	57	25	6	0	0	295	80	311	193	64	34
	1.5.67	100	88	313	113	9	1	0	0	223	113	156	97	26	11
	5.6.67	100	93	540	141	42	7	0	0	245	90	233	154	50	35
Bang Plat	21.11.66	136	77	275	42	9	3	0	0	248	96	263	169	6	3
	26.4.67	100	84	164	57	6	3	0	0	196	121	161	94	6	2
	12.6.67	100	85	180	59	15	3	3	0	235	103	228	176	31	10
Soi Aree	2.11.66	102	77	279	81	72	13	0	0	207	86	280	148	72	19
	17.4.67	100	82	255	99	10	5	0	0	117	53	148	89	47	24
	26.6.67	100	82	189	76	41	20	0	0	208	90	131	87	72	38
Soi 49-55	9.11.66	142	53	269	31	71	11	0	0	232	47	242	96	37	5
	24.4.67	100	39	154	24	24	4	0	0	136	21	103	43	73	9
	19.6.67	100	42	114	13	36	3	0	0	148	26	102	48	39	10

TABLE 2

RESULTS OF THE SEASONAL SURVEYS AVERAGED OVER LOCALITIES

	Premise index	Outdoor containers (no. positive/no. examined)				Indoor containers (no. positive/no. examined)				Grand total
		Jars	Miscellaneous	Natural	Total	Jars	Miscellaneous	Ant-traps	Total	
November–February (cool)	74	67/234	4/15	0/0	71/249	66/195	10/28	91/156	167/379	238/628
March–mid-May (warm)	77	80/197	2/7	0/0	82/204	85/179	7/24	90/136	182/339	264/543
Late May–October (wet)	77	75/211	7/18	1/1	83/230	81/199	15/34	98/149	194/382	277/612

Since collections were made in each of the localities on 3 separate occasions, well separated in time, it is possible to use the analysis of variance to study the difference between the localities and between times of the year. Thus there are 41 degrees of freedom available, 13 for differences between localities, 2 for differences between collecting times and 26 for the interaction between localities and collecting times. The interaction variance has been used as an error variance since consecutive collections were so spaced apart that larvae present on one occasion would not be present on the next. The chief difficulty with such an analysis is that it was impossible to study a random sample of houses in each locality on each visit since a relatively homogeneous area of sufficient size was not available. Consequently, many of the houses were sampled on 2 or 3 occasions. This could affect the error variance and must be borne in mind when the significance of the results is considered. A summary of the probabilities for the various comparisons is given in Tables 3 and 4.

DISCUSSION

The collecting method

The policy of collecting only a single larva from each positive container was adopted as this method has a number of advantages over the more orthodox procedure in which a number of larvae are taken from each habitat. Ideally, one would like to be able to identify all the larvae in all occupied containers but this is quite impossible in practice, since in a survey of a useful size (100 houses or more) the time required to collect larvae would be prohibitive. Furthermore, one would require some hundreds of bottles in order to keep each larval collection separate, and the identification of the larvae would

TABLE 3

SIGNIFICANCE OF COMPARISONS OF NUMBERS OF CONTAINERS BETWEEN LOCALITIES AND BETWEEN SEASONS

Comparison	Probability		Season with highest number
	Between localities	Between times	
Premise index	<0.001	NS	
Total outdoor jars	<0.001	NS	
Outdoor jars occupied	<0.001	NS	
Total outdoor miscellaneous containers	<0.001	<0.05	Wet
Outdoor miscellaneous containers occupied	<0.02	<0.01	Wet
Total natural containers	NS	NS	
Natural containers occupied	NS	NS	
Total indoor jars	<0.001	NS	
Indoor jars occupied	<0.001	<0.05	Warm
Total ant-traps	<0.001	NS	
Ant-traps occupied	<0.001	NS	
Total indoor miscellaneous containers	<0.001	NS	
Indoor miscellaneous containers occupied	<0.001	<0.01	Wet
Total outdoor containers	<0.001	NS	
Total outdoor containers occupied	<0.001	NS	
Total indoor containers	<0.001	NS	
Total indoor containers occupied	<0.001	NS	
Total containers outdoor and indoor	<0.001	NS	
Total containers outdoor and indoor occupied	<0.001	NS	

TABLE 4

SIGNIFICANCE OF COMPARISONS OF PERCENTAGE CONTAINERS OCCUPIED BETWEEN LOCALITIES AND BETWEEN SEASONS

Comparison	Probability		Season with highest per-cent-age
	Between localities	Between times	
Outdoor jars	<0.001	<0.01	Warm
Outdoor miscellaneous	NS	NS	
Indoor jars	<0.001	<0.01	Warm
Ant-traps	<0.05	<0.05	Wet
Indoor miscellaneous	NS	NS	
Total outdoors	<0.001	<0.01	Warm
Total indoors	<0.001	<0.01	Warm
Total outdoors and indoors	<0.001	<0.001	Warm

be exceedingly time-consuming. Consequently, 2 alternatives are available to the investigator. Either a few habitats can be exhaustively examined or a number of larvae can be taken from all positive containers. The former procedure gives a sample too small to be useful for survey purposes, the latter provides no estimate of the density of larvae since an unknown proportion is collected. It may be claimed that by taking a sample of larvae, a good estimate of the number of habitats in which more than one species is present can be obtained. This is untrue, since such an estimate will be highly biased with respect to the proportion of containers with more than one species and the estimate will be of unknown precision unless all larvae are taken and identified. Finally, this incomplete sampling method in which a small sample of larvae is collected from each container is also unsatisfactory when an estimate is required of the relative frequency of different container-breeding species or when a random sample of a population is required for insecticide resistance or genetic studies. Any estimate obtained from such a sample will be biased by a correlation between the individuals within a container as it is probable, for example, that they would have the same parentage.

It was because of the serious theoretical shortcomings of this incomplete sampling method, particularly for collecting larvae for insecticide work, that the single-larva-per-container collection-method was devised (Sheppard, Macdonald & Tonn, 1969). It became obvious that this method had advantages also in survey work, especially when large surveys were made in a city such as Bangkok, where only 1 species is common in containers, or when surveys were made up-country, where the collectors could not be supervised and the relative frequencies of domestic and peri-domestic species were required. The single-larva collection-method provided not only a satisfactory sampling technique, but also a check on the accuracy of the results since the number of larvae in each collection-bottle should correspond exactly with the number of positive habitats recorded by the collector. Thus if larvae were recorded in 37 ant-traps then there should be 37 larvae in the corresponding collection-bottle.

A disadvantage of the method is that it yields no information on the association of 2 or more species in a single habitat nor on the density of larvae. However, as shown above, no other method except complete sampling will do this satisfactorily.

In the present investigation, we have assumed that any changes in the population size of *A. aegypti* would be reflected in the number of containers positive for the larvae. This seemed a reasonable assumption since in Bangkok there are marked differences between localities in the number of containers and there are always many apparently suitable habitats unoccupied. Hence any increase in population size should result in an increased number of positive habitats and not just an increase in the density of larvae in the habitats already occupied.

Differences between localities

The analyses of collections from the 14 localities reveal a highly significant difference between localities for most comparisons (Tables 3 and 4). Of the 27 comparisons (not all of which are independent), 23 are significant. Only the 2 concerned with natural containers, of which there were very few (Table 1), and the 2 concerned with the percentage of indoor and outdoor miscellaneous containers positive for larvae are not significant, at least at the 5% level of probability.

There seems little doubt that there are quite marked differences in the populations of larvae per house in different areas of Bangkok and Thonburi. Nevertheless, it might be argued that the significance of the results was derived from the spuriously small error variances which were due to repeated sampling of the same houses. However, such an argument is difficult to sustain since not only are there always a large number of unoccupied but apparently suitable habitats, but it is known from studies in other areas of Bangkok that the containers available in any one house frequently change. This is particularly true of ant-traps and miscellaneous containers, which may dry up frequently and are not regularly replenished with water, but to a lesser extent the same is also true of the much larger water-jars.

The differences between localities did not seem closely related to the type of environment as defined by our classification of housing conditions. This classification is therefore unsatisfactory as a guide to the density of *A. aegypti* in different localities and would not help in mapping approximate densities when planning control measures.

Differences between seasons

The identification of all the major environmental factors affecting the distribution of positive larval habitats is important when control measures are planned. On the other hand it is the possibility that there are changes in population density due to seasonal factors such as rainfall, humidity or temperature that is important when studying seasonal changes in the incidence of dengue haemorrhagic fever.

An examination of Tables 2 and 3 reveals little effect of season on the number of containers available for *A. aegypti* or on the number positive. The miscellaneous containers outdoors show significant variation, the greatest number occuring in the wet season as might be expected. The number of these which are positive is also significantly higher in the wet season. The only other significant comparisons are those for the number of positive indoor jars and the number of positive indoor miscellaneous containers, the former being highest in the warm season, the latter in the wet. Thus there is evidence of small adjustments in the numbers of positive containers but no large effects or consistent trends embracing all larval habitats. The lack of any marked effect of season may be partly due to the relatively dry month of June 1967 when many of the " wet season " samples had to be taken (see Fig. 2).

Again it might be argued that the significance of the absolute changes was underestimated because of the nature of the error variance. However, a comparison which is not subject to this criticism can be drawn. If there were no difference in the number of positive habitats per 100 houses between any 2 times of the year, then the mean of the differences between the same 2 times for all localities should not differ significantly from zero. The comparisons for the most important types of habitat are given in Table 5 with their significance and 95% confidence limits. Most of the comparisons are non-significant. It is difficult to judge how much reliance can be placed on the probabilities when so many comparisons are made, but in view of the data on the percentage of positive containers (Table 4) it is probable that at least some of the differences are real. The percentage change in the total number of positive containers between the cool and wet seasons amounts to about 15.8% with 95% confidence limits of -1.4 to $+33.0$. Thus the change was not significant and any change that did occur could lie between an increase of 33% and a decrease of 1.4% between these 2 seasons.

A comparison of the percentages of apparently suitable larval habitats which are positive (Table 4) shows an interesting contrast to the results showing the numbers of positive habitats (Table 3). The comparisons between times of the year are significant for all types of container except for the miscellaneous containers. The reason for the significance of the percentage values becomes apparent when the number of habitats available and the number positive are compared. There was a non-significant drop in the number of habitats available in the warm season coupled with a non-significant increase in the number positive at that time (and sometimes in the wet season as well). Thus the difference (the percentage positive) is significant. This negative correlation is just what would be expected if the population density were nearly but not quite constant from season to season, showing a slight increase at times of the year when suitable habitats were scarce. Hence a container index (the percentage of positive containers) would overestimate the change in population size and could be significant in the absence of a change in larval population if the number of available habitats were much reduced.

If the changes in larval population size are linearly related to the number of positive containers over the range of changes observed in this study, then it is clear that there has been very little change in population size between the sampling times. The only significant change concerns the positive jars, which are the most productive larval habitat and in which there was an increase in the numbers positive between the cool and warm seasons. This change contrasts with the remainder of the positive containers, which showed a non-significant drop between the cool and warm seasons and an almost

TABLE 5

THE MEAN CHANGES BETWEEN SEASONS IN THE NUMBERS OF OCCUPIED LARVAL HABITATS PER 100 HOUSES OVER 14 LOCALITIES

Habitat	Seasonal comparison	Mean change and 95 % confidence limits	t	P	Percentage mean change and 95 % confidence limits
Indoor jars	Cool to warm	19.3 ± 16.9	2.46	<0.05	29.2 ± 25.6
	Cool to wet	14.6 ± 16.8	1.87	>0.05	22.0 ± 25.4
	Warm to wet	− 4.7 ± 16.2	0.63	>0.5	−5.5 ± 19.0
Outdoor jars	Cool to warm	13.4 ± 16.1	1.79	>0.05	20.0 ± 24.1
	Cool to wet	7.9 ± 20.8	0.82	>0.4	11.9 ± 31.2
	Warm to wet	—5.4 ± 8.2	1.43	>0.1	−6.8 ± 10.3
Total jars	Cool to warm	32.6 ± 26.0	2.71	<0.02	24.6 ± 19.6
	Cool to wet	22.5 ± 29.3	1.66	>0.1	16.9 ± 22.1
	Warm to wet	−10.1 ± 17.9	1.22	>0.2	−6.1 ± 10.8
Habitats other than jars	Cool to warm	−6.8 ± 27.7	0.53	>0.6	−6.4 ± 26.3
	Cool to wet	15.1 ± 19.6	1.66	>0.1	14.3 ± 18.6
	Warm to wet	21.9 ± 23.2	2.03	>0.05	22.2 ± 23.6
Total habitats	Cool to warm	25.9 ± 42.2	1.32	>0.2	10.9 ± 17.7
	Cool to wet	37.6 ± 40.9	1.99	>0.05	15.8 ± 17.2
	Warm to wet	11.7 ± 35.1	0.72	>0.4	4.4 ± 13.3

significant increase between the warm and wet seasons. Thus there is an indication that the type of larval habitat may shift with seasons, more jars being occupied in the hot season (when many other habitats may be dry) but a reverse tendency in the wet season when the number of occupied jars tends to decline and the number of other occupied containers increases. The fluctuations in population size would appear to be not much greater than 15% and the main change, if any, occurs between the cool and the warm seasons rather than the warm and the wet seasons.

The results therefore fully support the conclusions reached by Sheppard et al. (1969) that the adult population size fluctuates very little during the year and that the increase in haemorrhagic fever in Bangkok in the wet season cannot reasonably be attributed to an increase in numbers of the vector *A. aegypti.* It is still possible that the change in the incidence of the infection is attributable to some other aspect of the dynamics of the adult mosquito population such as a change in biting rates. This possibility is being investigated in another study.

ACKNOWLEDGEMENTS

We are most grateful to Dr Sujarti Jatanasen for his great assistance in solving many local problems during the surveys, and we should like to thank the Thai staff of the *Aedes* Research Unit for their technical assistance.

RÉSUMÉ

INSPECTIONS RÉPÉTÉES DES GÎTES LARVAIRES D'*AEDES AEGYPTI* DANS LE CADRE DES RECHERCHES SUR LA DENGUE À MANIFESTATIONS HÉMORRAGIQUES À BANGKOK, THAÏLANDE

Afin d'établir une éventuelle relation de cause à effet entre les fluctuations des populations d'*Aedes aegypti* et les variations de l'incidence du syndrome dengue-fièvre hémorragique, on a mené une enquête sur les gîtes larvaires du moustique en 14 endroits de Bangkok et de Thonburi. De nombreux types d'habitations étaient représentés dans ces secteurs: magasins, taudis, logements destinés à des personnes disposant de revenus faibles, moyens ou élevés. Les gîtes, répartis en six catégories, ont été contrôlés à trois reprises au cours de l'année, à des époques correspondant autant que possible aux trois saisons. Lors de ces inspections, une seule larve a été recueillie dans chaque gîte occupé.

Le nombre et le pourcentage (par 100 habitations) de gîtes occupés de chaque catégorie ont été analysés. La comparaison entre secteurs a mis en évidence de fortes différences de la densité des habitats d'*A. aegypti*, mais le manque d'uniformité des superficies bâties et non bâties a rendu impossible toute évaluation de l'infestation par unité de surface. On a noté de légères variations dans le nombre des gîtes occupés suivant l'époque des différents contrôles. Ce nombre augmentait principalement entre la saison froide (novembre à février) et la saison sèche (mars à mai) et s'abaissait surtout entre la saison des pluies (mai à octobre) et la saison froide. La variation maximale ne paraît pas avoir été très supérieure à 16%.

Il semble que la densité des populations d'*A. aegypti* varie assez peu au cours de l'année et que l'accroissement de l'incidence de la fièvre hémorragique, maximal pendant la saison des pluies, ne puisse pas raisonnablement être attribué à une augmentation du nombre des vecteurs.

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