OBSERVATIONS ON THE BREEDING HABITATS OF *AEDES AEGYPTI* (L.) IN JAKARTA, INDONESIA

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INTRODUCTION

Aedes aegypti (L.) is the major vector of dengue and dengue haemorrhagic fever in Southeast Asia. Studies of the immature mosquito populations in Thailand (Tonn *et al.*, 1969), Singapore (Chan *et al.*, 1971) and Borneo (MacDonald and Rajapaksa, 1972) have shown that *Ae. aegypti* is a peridomestic mosquito in this region. The breeding places are usually in or near houses in the relatively clean water stored in containers and used for drinking and bathing. The purpose of this study reported herein was to determine which of the many types of water storage receptacles used in Jakarta were the most productive of mosquitoes, what factors contributed to certain containers being favored over others, and to consider ways that this information might be used to advantage in control campaigns of larviciding or sanitation.

MATERIALS AND METHODS

Larval Surveys : The four study localities, in the districts of Tanah Tinggi, Karang Anyar, Grogol and Pasar Manggis in Jakarta, were typical crowded urban areas with very little space between houses for vegetation or for refuse with potential breeding sources. A full description of the study areas is given in a separate paper dealing with the seasonal abundance of *Aedes aegypti* in Jakarta where the adult landing rate (1.2 females per man-hour) and the larval indices (House Index = 47%, Container Index = 32%, Breteau Index = 58) remained relatively constant throughout the year (Nelson *et al.*, 1976). Twice per month from May, 1973 until June, 1974 two to four field workers checked all potential breeding sources in 100 houses in each study locality. During initial surveys 2289 larvae were identified from 323 positive containers, of which 320 (99%) contained *Aedes aegypti*, 3 (1%) contained *Aedes albopictus* and 2 (1%) contained *Culex fatigans*. As virtually all positive containers were infested with *Aedes aegypti*, in subsequent surveys larvae were not identified, all positive containers being considered to harbor *Ae. aegypti*. Presence or absence of larvae was recorded by container type, and the number of pupae, as seen by visual inspection of the container, was recorded.

Description of breeding sites : The breeding habitats were classified into nine categories as follows :

1 & 2 : Water jars (indoor and outdoor) were small earthen or ceramic containers found in the kitchen of virtually every house for storage of clean water used for drinking and cooking. The jars were usually almost cylindrical and approximately 50 cm high (range 28 cm to 79 cm). The wide mouth of the jars was usually covered with a metal or woven bamboo lid. Indoor water jars were the most common containers in houses, the most frequently positive, and the greatest producers of *Aedes* pupae.

3 & 4 : Bak mandi (indoor and outdoor) were large cubiform or oblong concrete reservoirs found in most bathrooms for storage of water for bathing and laundering. They were usually uncovered. On the average, only one in every two houses had bak mandi because frequently several households shared the same bathing facility. More water was stored in bak mandi than all other containers combined, and these reservoirs were the second greatest producer of *Aedes* pupae.

5 & 6 : Drums (indoor and outdoor) were large, cylindrical, metal containers usually of 200 liter capacity. Other smaller cylindrical metal containers were also included in this category. Drums were frequently covered with a circular wooden or metal lid. This type of container was uncommon in our study localities, but in other parts of Jakarta, especially where well water is very saline near the sea, drums are commonly used for long-term storage of rain water or puchased water.

7 & 8 : Miscellaneous containers (indoor and outdoor) included plastic pails, flower vases and flower plates indoors and discarded tires, tin cans, bottles and any other object capable of holding water outdoors. The outdoor containers were not of great importance in our study because the lack of adequate space between houses did not permit the collection of very much refuse. Ant traps, an *Aedes* source of considerable importance in other parts of South Asia were of little importance in our study. The few ant traps that were found, employed kerosene instead of water as the ant barrier.

9 : Natural containers (outdoor only) such as tree holes, broken bamboo stems and leaf axils were present only in Pasar Manggis, but none contained larvae of *Aedes aegypti.* Bamboo fence posts were positive and were recorded as "natural" containers, but should have been categorized as "miscellaneous" because they were non-living and man-made.

Analysis of larval indices : The larval data, segregated by container type, were averaged for the four localities, and the indices were calculated from these means. In Table 1 the index W is the per cent of all water-filled containers represented by the container type in question; e.g. for indoor drums W = (8.2/185.2) × 100 = 4.4. C is the per cent of water-filled containers of the type in question that were positive for *Ae. aegypti.* This is the same as the Container Index but specific for each container type; e.g. for indoor drums C = (2.4/8.2) × 100 = 29.3. L is the relative contribution of each container type to the total number of positive containers, i.e. the per cent of all larvae-positive containers represented by this container type; e.g. for indoor drums L = (2.4/60.1) × 100 = 4.0. P is the per cent of total pupal production represented by the container type; e.g. for indoor drums P = (6.8/93.1) × 100 = 7.3.

RESULTS

Water storage habits: The physical measurements were taken of 203 containers with water. Containers in the "miscellaneous" and "natural" categories were not measured because they were relatively scarce and always much smaller than the others. As seen in Table 2 the mean capacity for water storage in the four localities was 173 liters per house, but on the average only 92 liters were actually being stored at any one time. Total water storage per house in bak mandi was twice that of water jars and ten times that of drums, the latter containers being large but uncommon in our study localities.

Water in bak mandi came from wells that were either indoors or near the home (for 92% of the bak mandi sampled) and was used for bathing and laundering (89%). Water in water jars was usually purchased from a house-to-house water vendor (74%) and was used for drinking and cooking (99%). Drums were used to store well water (57%), purchased water (38%), and occasionally, rain water (7%). Only 2 containers (one drum

Table 1

Immature indices in four localities in Jakarta segregated by container-type to show relative abundance of each type (W), relative container Index (C), relative contribution to all positive containers (L), and relative pupal production. Averages of 266 surveys from May 1973 until June 1974.

Container type		Containers with water: Mean no. per 100 houses	W	Containers with larvae: Mean no. per 100 houses	C	L	Containers with pupae: Mean no. pupae per larval positive container	Mean no. pupae per 100 houses	P
Indoor :	Drum	8.2	4.4	2.4	29.3	4.0	2.3	6.8	7.3
	Bak mandi	38.6	20.8	8.9	23.1	14.8	4.4	29.1	31.3
	Water jar	93.7	50.6	43.1	46.0	71.7	1.5	48.2	51.8
	Miscellaneous	22.4	12.1	1.4	6.2	2.3	0.8	1.0	1.1
	Subtotal	162.9	88.0	55.8	34.3	92.8	1.8	85.1	91.4
Outdoor :	Drum	4.3	2.3	1.1	25.6	1.8	1.9	3.4	3.7
	Bak mandi	7.3	3.9	1.1	15.1	1.8	3.2	3.0	3.2
	Water jar	2.9	1.6	0.8	27.6	1.3	0.7	0.4	0.4
	Miscellaneous	6.8	3.7	1.2	17.6	2.0	1.0	1.1	1.2
	Natural	1.0	0.5	0.1	10.0	0.2	1.2	0.1	0.1
	Subtotal	22.3	12.0	4.3	19.3	7.2	2.1	8.0	8.6
Total		185.2	100.0	60.1	32.5	100.0	1.9	93.1	100.0

W = Per cent of all water-filled containers represented by this container type.
C = Per cent of water-filled containers of this type that were positive (= container specific Container Index).
L = Per cent of all larvae-positive containers represented by this container type.
P = Per cent of total pupal production per 100 houses represented by this container type.

and one bak mandi) had water that had been piped directly to the house. One to two days was the usual interval between additions of water to the containers.

Habitat of immatures : The four localities were quite similar in composition of container types present and breeding indices among the container types. As seen in Table 1, of a mean of 185 water-filled containers per 100 houses in the four localities, on the average 60 were positive, resulting in a Container Index (C) of 32%. If all the container types were infested equally, the Container Index would be the same for each container type, and the relative contribution to larval infestation by each container type (L) would be the same as the per cent of that container type found (W). Such was not the case. By far the greatest infestation (L) was in indoor water jars (72%), nearly 3 times that of all other containers

Table 2

Potential and actual volume of water stored in houses in four localities in Jakarta.

Type of container	Water jar	Bak mandi	Drum	Total
No. containers with water examined	108	65	30	203
Mean capacity per container (liters)	53	205	95	118
Mean actual water volume per container (liters)	31	109	38	59
Mean no. containers per 100 houses	93	52	15	160
Mean capacity of water per house (liters)	50	107	16	173
Mean actual volume of water per house (liters)	29	57	6	92

combined. Indoor water jars were not only the most common containers with water (51%), but also had the highest rate of infestation (C), 46% of indoor water jars being positive. Indoor bak mandi ranked second for larval infestation (L = 15%). No other container type accounted for more than 4%.

Production of pupae : The standing crop of pupae in the four areas was nearly one pupa per house. By far the greatest production of pupae came from inside houses. More than 10 X as many pupae were found indoors as outdoors. This difference was caused primarily by the greater frequency of water-filled containers found indoors (6.8X) and secondly by the higher Container Index indoors (1.9 X). The number of pupae per positive container indoors was nearly the same as outdoors, but each of the top three pupae-producing container types yielded more per container indoors than outdoors (water jars 2.1 X, bak mandi 1.4 X, and drums 1.2 X).

Indoor water jars produced 1.1 X as many pupae per 100 houses than all other containers combined and 1.7 X the production of indoor bak mandi, the second most productive container type. Although twice as much water was stored in bak mandi as water jars, and although more pupae per container were found in bak mandi, water jars produced more pupae overall because of their much greater abundance.

The pupal index (P) correlated well with the relative larval index (L) for each container type, except for indoor bak mandi and indoor water jar. The number of positive indoor water jars was 4.8 X that of bak mandi, but the pupal production was only 1.3 X because indoor bak mandi produced 2.9 X as many pupae per larval positive container as indoor water jars.

Effect of covering containers : As shown in Table 3 approximately half of 194 containers inspected had covers and also approximately half were infested with immatures. However, 65% (71/109) of the covered containers and only 36% (31/85) of the uncovered containers were positive. This difference was highly significant (chi-squared = 14.6, $p < 0.001$). It has been observed that covers, usually consisting of loose-fitting metal or straw lids on water jars and wooden discs on drums, often are not placed squarely on top of the container, so that there is enough space between the edge of the cover and the lip of the container for entrance and exit of mosquitoes. Also, the covers of water jars are removed many times during the day for use of the water for cooking and drinking. Not only is there ample opportunity for gravid females to enter covered containers to oviposit, but

Table 3

Presence or absence of *Aedes* immatures and cover in 194 containers of four localities in Jakarta.

Category	Immatures present	Immatures absent	Total	Per cent
Cover present :				
Observed	71	38	109	56.2
Expected	57.3	51.6		
Cover absent :				
Observed	31	54		
Expected	44.7	40.3	85	43.8
Total	102	92	194	-
Per cent	52.6	47.4	-	100.0

apparently, either the covered containers are *preferred* over uncovered ones for oviposition, or larval survival is better. The relatively dark interior of the covered container may very well be more attractive to the gravid female.

DISCUSSION

The immature habitats of *Aedes aegypti* in the study areas in Jakarta were similar to those studied in other countries of Southeast Asia, in that positive containers usually contained relatively clean water and occurred in or near human habitation. Unlike Singapore (Chan *et al.*, 1971) and Bangkok (Tonn *et al.*, 1969) ant traps were not an important breeding source, and outdoor containers were much more common in the Bangkok and Singapore studies than in this study. Our study localities, being representative of usual living conditions of perhaps the majority of the inhabitants of Jakarta, were quite crowded and had very small gardens with few outdoor containers. In other less crowded areas of Jakarta, especially near the periphery of the city, there are many more outdoor containers, both man-made and natural, infested with both *Ae. aegypti* and *Ae. albopictus*.

Aedes albopictus does not flourish in crowded urban situations, hence its virtual absence from our study localities. In Bangkok *Ae. albopictus* is also absent from the crowded city, occurring only at the outskirts where vegetation and fruit gardens are plentiful (Tonn *et al.*, 1969; Yasuno *et al.*, 1969).

An *Aedes* sanitation control program involving destruction or removal of outdoor breeding sources would have little effect in urban Jakarta, because the most important sources are indoor water jars and bak mandi. These containers are found even in homes with piped water supply. Larvicides of very low mammalian toxicity are quite effective in these kinds of containers (Bang and Pant, 1972) but the cost of chemicals may be prohibitive for a country-wide control program. The containers can be cleaned periodically by the homeowner or by health workers, or they can be replaced by mosquito-proofed containers or otherwise be made unsuitable for breeding. One recommendation commonly made by health officials is that the homeowners should cover their water jars to prevent *Aedes* infestation. However, as normally used, the loose-fitting lids appear to enhance infestation, rather than to inhibit it.

SUMMARY

A one-year study was done of the breeding habitats of *Aedes aegypti* (L.) and of the water storage habits of the inhabitants in four crowded districts of urban Jakarta. Immature mosquitoes were found in or near houses in containers of relatively clean water used for drinking or bathing purposes. An average of 185 containers were found per 100 houses, of which 60 were positive for *Aedes* immatures, resulting in a Container Index of 32%. The mean potential water storage capacity per house was 173 liters, of which only 92 liters of water was actually being stored at any one time. Water jars were the most common containers found, but bak mandi (cuboidal or oblong concrete reservoirs) held more water per container. Total water storage per house in bak mandi was twice that of water jars and ten times that of drums, which were uncommon. Ant traps and other miscellaneous containers were unimportant for either water storage or mosquito production. A mean of 0.93 pupae per house was found, pupal production indoors being ten times than outdoors. Indoor water jars produced more pupae per house than all other containers combined. The infestation rate of covered containers was significantly higher than that of uncovered containers, perhaps because loose-fitting lids allowed entrance of gravid females to the attractive darkened interior of the container.

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