Tropical Biomedicine 27(1): 33–40 (2010)

Categorization of potential breeding sites of dengue vectors in Johor, Malaysia

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Received 10 July 2009; received in revised form 3 December 2009; accepted 5 December 2009

Abstract. This crosssectional study was to compare and categorize potential breeding sites of dengue vectors, *Aedes aegypti* and *Aedes albopictus* at three different places, namely, an urban (Taman Permas Jaya, Johor Bahru, Johor), a suburban (Kg. Melayu Gelang Patah, Johor Bahru, Johor) and a rural (Felda Simpang Waha, Kota Tinggi, Johor) habitats in Malaysia. Larval surveys were conducted once in every two months at each habitat over a period of 11 months from August 2000 until June 2001. There was a significant difference between the three study sites in terms of potential breeding sites inspected ($p < 0.001$). There were more potential breeding sites found in the rural area when compared to the urban and suburban habitats. The mean Potential Container Index (PCI) values in descending order were as follows: rural habitat (57.72) > suburban (29.35) > urban habitat (16.97). Both breeding sites and potential breeding sites were the nominator and the total number of containers inspected as the denominator in the formula of PCI, thus the latter could be a potential indicator to initiate anti-dengue campaign at the community level to rid off potential *Aedes* breeding sites. The three most common potential breeding sites of *Aedes* species were similar for urban and suburban habitats (flower pots, pails and bowls respectively). However, flower pots, vases and tyres were the three most common potential breeding sites for the rural habitat. Another finding in this study was that various types of larval habitats were found indoors and outdoors for both species.

INTRODUCTION

Many studies carried out on habitats of dengue vectors were mainly focused in urban and suburban areas (Teng *et al.* 1999) in Taiwan; Cheong (1967), Lee & Cheong (1987), Lee & Hishamudin (1990), Lee (1991), Sulaiman *et al.* (1991), in Malaysia and Chan *et al.* (1971) in Singapore). Chan *et al.* (1971) reported that *Aedes aegypti* had a higher density (based on the larval count) indoors than outdoors (3.7:1) in 7 of 8 areas studied while *Aedes albopictus* had a lower density indoors than outdoors (0.7:1) in all 8 areas. Teng *et al.* (1999) also studied *Aedes* spp. breeding sites in open areas, indoors and outdoors revealed that *Ae. albopictus* preferred to breed in containers located outdoors.

In Malaysia, Lee & Cheong (1987) conducted surveys in 9 suburban areas in Kuala Lumpur City, and reported 90 and 30 containers positive to *Ae. aegypti* and *Ae. albopictus* breeding respectively and both species were found breeding indoors and outdoors. Lee (1991) through his study, found both *Ae. albopictus* and *Ae. aegypti* breeding indoors and outdoors while *Ae. aegypti* as the dominant indoor breeder. The ratio of indoor to outdoor breeding of *Ae. albopictus* and *Ae. aegypti* was 3.38:1 and 9.92:1, respectively.

Entomological parameters currently being used for *Aedes* spp. surveillance are *Aedes* Index (AI), Breteau Index (BI) and Container Index (CI). The formulae for these indices take into account only containers positive of *Aedes* species. However, the

potential breeding containers devoid of larvae are not included in the formulae. The objectives of the study were to categorize and compare potential breeding sites in urban, suburban and rural habitats in Johor, Malaysia. The Potential Container Index (PCI) is introduced in this study as a new indicator that takes into account both the positive and negative containers. By doing so, we could possibly analyze the true field situation in the surveillance of dengue vectors.

MATERIALS AND METHODS

Study sites were chosen from a 5-year list of dengue outbreak localities (Annual Reports, Vector-Borne Diseases Control Programme, Johor, Malaysia 1994–1998). Premises were randomly selected using multistage random sampling. The study sites chosen were Taman Permas Jaya 01° 30'N, 103° 50'E (urban habitat) located about 20 km northeast of Johor Bahru City, and Kg. Melayu Gelang Patah at 01° 27'N, 103° 35'E (suburban habitat), is approximately 40 km southwest of Johor Bahru City. Both study sites are located in Johor Bahru District. The third study site representing a rural habitat is FELDA (Federal Land Development Authority) Simpang Waha (01° 45'N, 104° 04'E) in Kota Tinggi District which is located approximately 70 km northeast of Johor Bahru city. Oil palm (*Elaeis guineensis Jacquin*) and rubber (*Hevea brasiliensis Muell. Arg.) were the two* major crops planted in Felda Simpang Waha.

Two teams comprising two persons in each team carried out a total of 18 *Aedes* surveys from August 2000 until June 2001 of which six surveys were carried out for each habitat. A minimum of 50 houses were inspected in each study site per survey. Each premise was inspected for receptacles that may serve as potential breeding sites for *Aedes* species. Inspection was carried out indoors and outdoors as well as around the perimeter of a premise.

Data gathered in this study were number of premises inspected, number of premises positive for *Aedes* spp. breeding, number of potential breeding sites inspected, number of breeding sites positive for *Aedes* spp. breeding, number of larvae collected per breeding site and type of containers found positive for *Aedes* spp. larvae. The Potential Container Index (PCI) is introduced in this study as a new indicator that takes into account both the positive and negative containers:

$$\text{PCI} = \frac{\text{(number of potential breeding sites + number of positive breeding sites)}}{\text{number of premises inspected}}$$

Statistical analysis (Two-way between-group ANOVA and post-hoc tests) were carried out using SPSS programme version 11.5.

RESULTS

A total of 1,254 premises were inspected during the study period, 362 premises at Taman Permas Jaya (urban), 426 premises at Kampung Melayu Gelang Patah (suburban) and 466 premises at Felda Simpang Waha (rural). A total of 45,547 receptacles were inspected for the three localities, namely 6,144 (13.49%) in urban habitat, 12,504 (27.45%) in suburban and 26,899 (59.06%) in rural habitats. There were more potential breeding sites found in rural habitat as compared to urban and suburban habitats (Table 1).

Twelve types of potential breeding sites inspected were common in the urban, suburban and rural habitats as high as 99% each in Taman Permas Jaya and Kg. Melayu Gelang Patah and 97% in Felda Simpang Waha. It was observed that for storing water, small-sized containers such as earthern-ware jars were used in the urban and suburban habitats, while big-sized containers such as plastic and metal drums as well as culverts that can hold up to 2,000 liters of water were used in the rural habitat. Table 2 shows top twelve receptacles that served as potential breeding sites and inspected at the three study sites.

Only nine premises were found positive for *Aedes* breeding (5 *Ae. albopictus* and 4

Table 1. Comparison of total receptacles examined according to locality and categorization

Locality	Urban habitat		Suburban habitat		Rural Habitat			
Receptacle Category	TPJ	%	KMGP	%	FSW	%	Total	%
Water storage containers	1765	3.88	2957	6.49	4941	10.85	9663	21.21
Garden accoutrements	3968	8.71	8748	19.21	19299	42.37	32015	70.29
Kitchen utensils	336	0.74	429	0.94	460	1.01	1225	2.69
Discarded items	36	0.08	315	0.69	2107	4.63	2458	5.40
Other Habitats	39	0.09	55	0.12	92	0.20	186	0.41
Total	6144	13.49	12504	27.45	26899	59.06	45547	100.00

Locality: KMGP = Kg. Melayu Gelang Patah, FSW = Felda Simpang Waha, TPJ = Taman Permas Jaya.

Table 2. Top twelve receptacles at three study sites (localities) in Johor, Malaysia (August 2000-June 2001)

	Urban habitat		Suburban habitat		Rural Habitat			
Receptacle Type	TPJ	%	KMGP	%	FSW	%	Total	%
Flower pots	3938	64.1	8653	69.2	13853	51.5	26444	58.1
Pails	651	10.6	838	6.7	834	3.1	2323	5.1
Bowls	467	7.6	725	5.8	942	3.5	2134	4.7
Refrigerator trays	313	5.1	500	4.0	457	1.7	1271	2.8
Plastic drums	178	2.9	413	3.3	1453	5.4	2043	4.5
Flower pot plates	49	0.8	113	0.9	188	0.7	350	0.8
Tyres	12	0.2	88	0.7	1991	7.4	2090	4.6
Dipper	203	3.3	463	3.7	0	0.0	665	1.5
Plastic containers	117	1.9	263	2.1	0	0.0	379	0.8
Assorted tin cans	92	1.5	113	0.9	0	0.0	205	0.4
Earthenware jars	18	0.3	100	0.8	0	0.0	118	0.3
Vases	61	1.0	0	0.0	5057	18.8	5119	11.2
Water compartments	0	0.0	50	0.4	377	1.4	427	0.9
Bottles	0	0.0	0	0.0	215	0.8	215	0.5
Culverts	0	0.0	0	0.0	484	1.8	484	1.1
Metal drums	0	0.0	0	0.0	215	0.8	215	0.5
Total	6101	99.0	12316	99.0	26066	97.0	44483	97.7
Grand Total	6414	100	12504	100	26899	100	45547	100

Locality: KMGP = Kg. Melayu Gelang Patah, FSW = Felda Simpang Waha, TPJ = Taman Permas Jaya.

Ae. aegypti). All the nine premises were in the rural habitat (*Aedes* Index (AI) = 2.0%, Breteau Index (BI) = 2.0 and Container Index (CI) = 0.03%). All the containers containing *Ae. albopictus* were found outdoors, while three out of four containers positive for *Ae. aegypti* were also found outdoors.

In this study, the criterion for categorization of potential breeding sites was based on the intended use of the receptacles or containers. Five categories for *Aedes* spp. potential breeding sites consisted of: garden accoutrements (32,015 receptacles = 70.29%) such as flower pots,

flower pot plates, vases and watering cans; water storage containers (21.22%) such as earthenware jars, plastic containers, metal drums, assorted tin cans and water compartments; discarded items (5.40%) such as discarded electrical goods (washing machines, televisions) and old furniture, kitchen utensils (2.69%) such as pots and pans, plates, cups and saucers; and other habitats (0.41%) such as animal drinking pans and aquariums. Detailed information is shown in Figure 1.

There were significant differences in number of receptacles inspected at the study sites. Mean receptacles inspected outdoors at all the three localities was significantly more abundant than those found indoors and outdoors with shade (Table 3). The total number of potential breeding sites was significantly high in the rural habitat followed by suburban and urban habitats.

Potential Container Index (PCI) for urban, suburban and rural habitats were 16.97, 29.35 and 57.72 containers per premise, respectively. There were significant difference in PCI between urban and suburban habitats, between suburban area and rural habitats ($p<0.001$). The PCI values in descending order were as follows: Felda Simpang Waha (57.72) > Kg. Melayu Gelang Patah (29.35) > Taman Permas Jaya (16.97) There is no significant difference in PCI between months within the same locality (Figure 2).

There was no significant difference ($p=0.852$) in number of potential breeding sites between the six surveys (months) at study sites. Significant factors ($p<0.001$) affecting number of potential breeding sites were locality; location; category; locality and location; locality and category; location, receptacle and category; and locality, location and category. It was observed that there were significant interaction effect for locality and location ($p<0.001$), locality and category ($p<0.001$), location and category ($p<0.001$) but no interaction exist between month and locality ($p=0.545$), between month and location ($p=0.284$), and between month and category ($p=0.580$). (Note: Locality = Taman Permas Jaya, Kg. Melayu Gelang Patah, Felda Simpang Waha; Location = Indoors, Outdoors, Outdoors with Shade; Month = August, October, December, February, April, June; Category = Receptacle Category namely water storage containers, garden accoutrements, kitchen utensils, discarded items, other habitats).

The total number of receptacles inspected at all three localities (urban, suburban and rural habitats) was significantly different ($p<0.001$). Both water storage compartment and garden accoutrements categories were significantly more abundant at all three study sites ($p<0.001$). Using post hoc test (Tukey test), there were significant differences between urban and suburban habitats ($p<0.001$) and

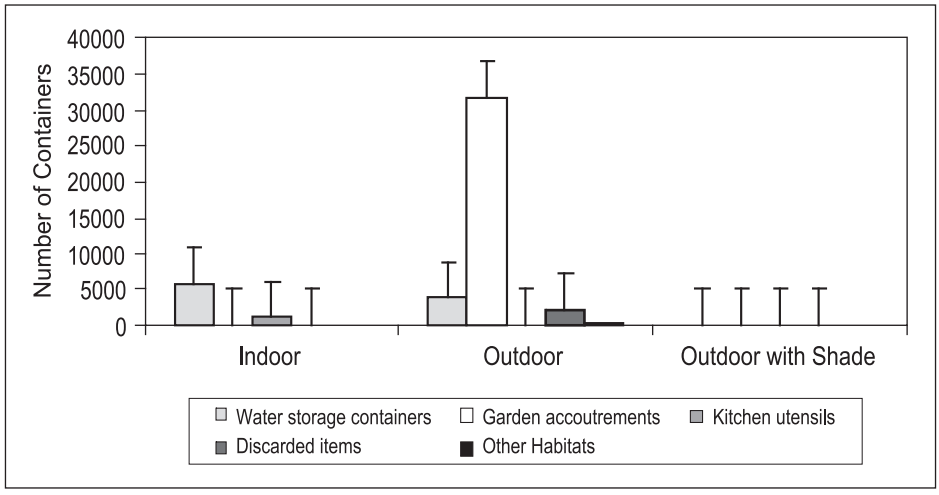

Figure 1. Categorization of potential breeding sites according to its location.

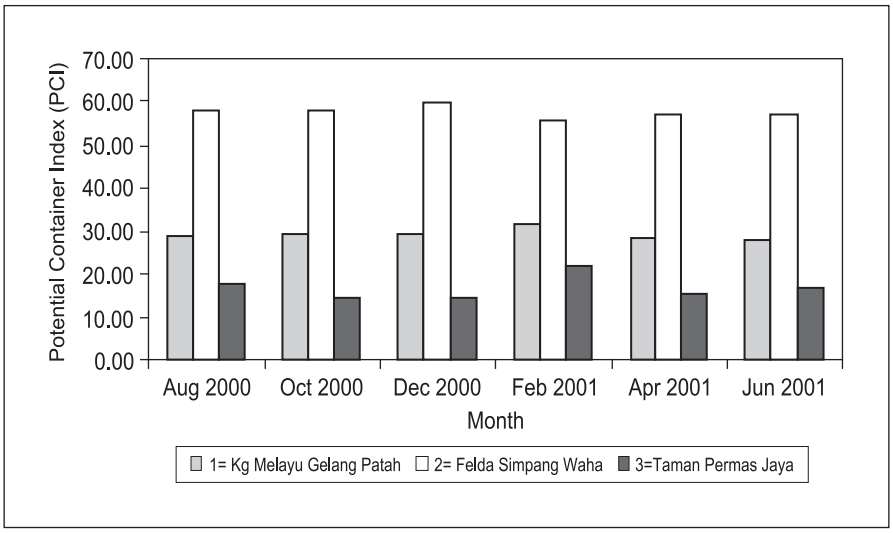

Figure 2. Potential Container Index (PCI) per survey according to localites and categories in Johor, Malaysia August 2000 – June 2001).

Table 3. Comparison of number of receptacles according to locality and location

Location	Mean number of receptacles per premise per survey (95% Confidence Interval)			
	Urban habitat (Taman Permas Jaya)	Suburban habitat (Kg Melayu Gelang Patah)	Rural habitat (Felda Simpang Waha)	Total
Indoor (ID)	0.920 (0.615, 1.225)	1.158 (0.877, 1.439)	1.243 (0.974, 1.513)	1.093 (0.929, 1.256)
Outdoor (OD)	2.282 (1.988, 2.575)	4.410 (4.110, 4.710)	10.243 (9.975, 10.512)	5.809 (5.645, 5.972)
Outdoor with shade (ODS)	0.016 (-0.301, 0.334)	0.750 (0.484, 1.015)	0.059 (-0.211, 0.328)	0.029 (-0.134, 0.193)

between suburban and rural areas ($p<0.001$) as well as rural and urban habitats ($p<0.001$). There was no difference in number of containers inspected for the six surveys (months), therefore no further analysis was carried out. It seems that there was no significant difference in number of potential breeding sites inspected in each study site throughout the 6-month study period.

Table 4 shows the mean number of the potential breeding sites according to its location and usage (categorization) for each study site. It was observed that water storage containers and garden accoutrements were significantly more abundant indoors and outdoors respectively at all study sites. For the third location (outdoor with shade), only garden accoutrements category in suburban habitat were significantly more abundant than the other categories.

DISCUSSION

In Malaysia, studies on relationship between dengue cases and three common parameters

Table 4. Mean number of containers inspected according to its location and locality

	Receptacle Category	Mean containers inspected per premise per survey (95% Confidence Interval)		
		Urban habitat (Taman Permas Jaya)	Suburban habitat (Kg Melayu Gelang Patah)	Rural habitat (Felda Simpang Waha)
Indoor (ID)	Water storage containers	3.584 (2.904,4.263)	4.651 (4.033, 5.269)	5.043 (4.444, 5.642)
	Garden accoutrements	.012 (-0.667, 0.692)	.074 (-0.544, 0.692)	5.5E-015 (-0.599, 0.599)
	Kitchen utensils	.845 (0.165, 1.524)	.941 (0.323, 1.559)	.989 (0.390, 1.588)
	Discarded items	.015 (-0.664, 0.694)	.098 (-0.520, 0.716)	.123 (-0.476, 0.722)
	Other Habitats	.006 (-0.673, 0.686)	7.5E-016 (-0.618, 0.618)	.010 (-0.589, 0.609)
Outdoor (OD)	Water storage containers	1.089 (0.409, 1.768)	2.264 (1.646, 2.882)	5.415 (4.816, 6.014)
	Garden accoutrements	10.956 (10.277, 11.636)	20.484 (19.866, 21.102)	41.293 (40.694, 41.892)
	Kitchen utensils	.094 (-0.586, 0.773)	.060 (-0.558, 0.679)	-1.3E-014 (-0.599, 0.599)
	Discarded items	.089 (-0.591, 0.768)	.558 (-0.060, 1.176)	4.432 (3.833, 5.301)
	Other Habitats	.075 (-0.604, 0.754)	.127 (-0.491, 0.746)	.196 (-0.403, 0.795)
Outdoor with shade (ODS)	Water storage containers	.035 (-0.644, 0.714)	.004 (-0.614, 0.622)	.098 (-0.501, 0.697)
	Garden accoutrements	2.9E-014 (-0.679, 0.679)	.022 (0.596, 0.640)	.184 (-0.415, 0.783)
	Kitchen utensils	-2.8E-015 (-0.679, 0.679)	-1.1E-014 (-0.618, 0.618)	7.6E-017 (-0.599, 0.599)
	Discarded items	-2.0E-015 (-0.679, 0.679)	.060 (-0.558, 0.679)	.004 (-0.595, 0.603)
	Other Habitats	.032 (-0.647-0.711)	3.88E-015 (-0.618, 0.618)	-8.5E-017 (-0.599, 0.599)
Total	Water storage containers	1.57 (1.177, 1.961)	2.31 (1.949, 2.663)	3.52 (3.173, 3.864)
	Garden accoutrements	3.66 (3.264, 4.048)	6.86 (6.503, 7.217)	13.83 (13.480, 4.172)
	Kitchen utensils	0.31 (-0.100, 0.725)	0.34 (-0.023, 0.691)	0.33 (-0.016, 0.676)
	Discarded items	0.04 (-0.314, 0.427)	0.24 (-0.118, 0.596)	1.52 (1.108, 1.932)
	Other Habitats	0.04 (-0.354, 0.430)	0.04 (-0.314, 0.399)	0.07 (-0.277, 0.414)

E = Exponent.

(AI, BI and CI) showed no significant relationship in a district in Penang (Tan & Yasmin, 2000) and no correlation between dengue cases and AI, and BI in most of the study areas (Sulaiman *et al.*, 1996). In Singapore, discarded water-bearing receptacles were the main breeding habitats found in the open areas; hence Tan (1997) suggested that a new and reliable indicator to measure the extent of *Aedes* breeding found in these areas needed be explored.

In this study, PCI was used to include all receptacles inspected both indoors and outdoors. These receptacles then were divided by the number of premises inspected. Whereas BI was only meant to cater for receptacles positive of *Aedes* species against the number of premises inspected. *Aedes* breeding was recorded only in August 2000 in the rural area. This could be due to frequent *Aedes* surveys carried out by the authority, and thus residents became more familiar to *Aedes* preventive measures.

The classification of potential breeding sites is useful in promoting appropriate long-term control and preventive actions taken by the public such as proper disposal of discarded items, covering or addition of larvicides to water storage containers. There was not much difference in the habitats of *Aedes* species and breeding site categorizations from other studies. Chan *et al.* (1971) classified breeding habitats into 6 categories namely natural habitats, domestic habitats, rubber tyres, water and sewage-disposal installations, building equipment and parts of machinery (cement-mixers, concrete blocks, scrap irons) and boats. Other classifications done by several researchers ranged from two categories

(Dennis-Lozano *et al.*, 2002) to ten categories (Teng *et al.*, 1999). Teng *et al.* (1999) categorized breeding habitats into 10 categories namely containers used for planting, containers for watering plants, trash/discarded items, drinking containers, containers for storing water for washing, temporarily unused containers, recreational, refrigerators, natural habitats and others. Barker-Hudson *et al.* (1988) in Australia categorized containers that collect water into seven categories namely materials found in the yard, water storage containers, discarded domestic items, rubbish, domestic items, recreational items and natural habitat. In Thailand larval habitats were categorized into three; water jars, miscellaneous containers and natural containers (Tonn *et al.*, 1969). In southern Mexico, Dennis-Lozano *et al.* (2002) categorized *Ae. albopictus* habitats into two categories, namely controllable containers and disposable containers. The former category includes pails, drums, plastic containers, tubs, small bottles, flower pots, flower pot plates, water tanks, wells and pots, disposal containers category includes water storage containers, tyres, tin cans, broken flower pots and others.

Similar *Aedes* larval habitats were documented by Cheong (1967), Chan *et al.* (1971), Nelson *et al.* (1976) and Lee & Cheong (1987). Ant traps and earthenware jars were the two main breeding habitats in Malaysia (Cheong, 1967), in Thailand (Tonn *et al.*, 1969) and in Singapore (Chan *et al.*, 1971). Other main breeding sites at that time recorded by Cheong (1967) in Malaysia included metal drums (12.1%), water compartments (9.1%), tin cans (6.8%), plates (6.4%), tyres (4.7%), pails (3.0%), flower pots (1.8%) and bottles (1.4%). Chan *et al.* (1971) in Singapore also recorded metal drums (6.03%), water compartments (7.43%), tin cans (6.80%), tyres (3.53%), pails (1.52%), flower pots (3.49%) and bottles (3.13%). In this study breeding sites recorded were culverts, water compartments, metal drums, plastic drums, pails and linolium. The first five potential breeding sites were used to collect and/ or to store water while the linolium was a discarded item. Seven potential breeding sites common in all three study areas were flower pots, pails, bowls, refrigerator trays, plastic containers, flower pot plates and tyres.

It was observed that interaction effect exist between locality and location but no interaction between time (month) with both locality and location. Other interactions affecting the number of potential breeding sites inspected were between locality and category; location and category; and locality, location and category. The total number of potential breeding sites was significantly high in the rural habitat followed by suburban and urban habitats.

In their study in Puerto Rico, Moore *et al.* (1978) also used similar formula as PCI which is introduced in this study. PCI is shown to be a suitable indicator to measure the magnitude of indoor and outdoor potential breeding sites. Thus PCI would be a useful indicator to be utilized particularly in neglected areas such as dumping ground for solid wastes.

In conclusion, PCI may be useful as an indicator in initiating anti-*Aedes* campaign at the community level. The potential breeding sites were abundant in rural area than in suburban and urban areas. The three most common potential breeding sites of *Aedes* spp. were similar for urban and suburban habitats (flower pots, pails and bowls, respectively). Flower pots, vases and tyres were the three most common potential breeding sites in the rural habitat. Garden accoutrement was the most abundant category of potential breeding sites followed by water storage containers, discarded items, kitchen utensils, and other habitats. This categorization is useful in promoting appropriate long-term control and preventive measures to be taken by the household.

Acknowledgements. The authors would like to thank staff of Vector-Borne Diseases Control Programme, Johor for technical assistance and the Director of Johor Health Department for his encouragement and interest in this work.

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