SOCIO-DEMOGRAPHIC AND ENVIRONMENTAL FACTORS ASSOCIATED WITH *AEDES* BREEDING PLACES IN PHUKET, THAILAND

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Abstract. This study aimed to determine the socio-demographic and environmental factors influencing potential breeding sites of the dengue vector in Phuket Province. Three hundred houses were recruited by cluster random sampling for larval inspection. Of all the types of water containers, a high proportion of tires and discarded items were infested by *Aedes* larva (42% and 32%, respectively). Due to the abundance of water tanks, jars for using water and discarded containers (1.7, 2.1, 0.8 per house), these were the main breeding sites (0.29, 0.35, and 0.28 infested containers per house, respectively). Buddhists' houses were significantly more likely to have a larvae-infested flower vase than Muslims' houses. Townhouses had relatively few infested containers, while those on rubber plantations had 18.3 times higher odds of having at least one container with larva. No window screens increased the odds of larva infestation in the discarded containers by 4.2 times. With this information and given a reliable piped water supply, the number of water containers can be reduced to minimize the breeding places. Garbage should be properly disposed of. Screens should be installed, if possible. Buddhists should be advised on the proper protection of flower vases.

INTRODUCTION

In Thailand, rapid urbanization has led to a shortage of water and an increased need for water containers, with the subsequent promotion of breeding sites for *Aedes aegypti.* Various communities have different types of containers contributing to larval indices, and socio-cultural and environmental factors which play important roles in these differences (Wellmer, 1983). However, few research projects have ever documented these patterns.

In our study, we aimed to delineate the effects of socio-demographic and environmental factors on the possession of various potential breeding containers in communities in southern Thailand, where the disease is endemic and the population has a diverse socio-demographic and economic background.

MATERIALS AND METHODS

Study site

The study was conducted in Phuket Province in October 1999 (end of the rainy season), following a dengue hemorrhagic fever (DHF) outbreak, with an incidence of 415 per 100,000 population per year. This province is an island with a total area of 570 km^2, 70% of which is highland and mountains, on the west coast of peninsular, Thailand. There are 2 seasons: a rainy season from May to November and a dry season from December to April. The average annual precipitation is 2,269.8 mm. The average maximum and minimum temperatures are 33.4ºC and 22ºC, respectively. Routine registration revealed 90,686 houses with 199,847 residents in 1995 residing in 108 villages of 12 subdistricts in 3 districts.

Sampling method

Random cluster sampling was performed. Twenty-five villages/communities were randomly selected as primary sampling units based on the probability proportional to size (PPS) principle. A house was the main unit of analysis. Assuming a prevalence of *Aedes* larvae being 30%, the level of error of the estimate being 8%, the design effect being 2, the final sample size was 25 villages x 12 houses per village.

Larva inspection

A larva inspection was carried out by 5 of-

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ficers from the Vector-borne Disease Control Unit and 10 students and staff from the Epidemiology Unit, Faculty of Medicine, Prince of Songkla University. After obtaining verbal consent, a face-to-face interview using a structured questionnaire was carried out with an adult in each house. The potential breeding sites for *Aedes* mosquitos inside and outside (within 5 m from the house) were examined. Any containers with water (wet containers), with or without unsealed covers or lids were counted and inspected. Nine types of containers were specified: ant traps, toilet tanks, drinking-water jars, water-use jars, plant saucers, flower vases, discarded containers (tin can, bottles, broken jars), used tires, and others (coconut shells, coconut husks, etc).

Data analysis

The data were computerized and validated using Epi info version 6.0. In addition to routine larval indices, such as house index (HI), container index (CI) and Breteau index (BI), we computed wet container index and container-specific larval indices.

The specific-wet container index (SWCI) is defined as number of the specific type of unsealed container with water inside per 100 houses. If this number is high, that type of container can become a contributor breeding place, if the owner is careless in covering it.

The specific container index (SCI) is the percentage of that type of container with Aedes larvae. It reflects the preference of ovi-position and hatching of Aedes mosquitos. A type of container with a high level of this index is a potentially dangerous container, it has a high probability of being a breeding place. However, as with CI, the SCI does not indicate its frequency in the community.

The container-specific Breteau index (CSBI) is defined as the number of that type of container with *Aedes* larvae per 100 houses. A type of container with a high CSBI is definitely an important contributor to *Aedes* breeding.

The differences in larval indices in various conditions of socio-demographic and environmental factors, such as age groups, gender, ethnicity, occupation, education levels, number of family members, housing area, house style and presence of window screens, etc were tested by the Student's *t*-test, one-way ANOVA test and multiple logistic regression using STATA version 6 (Stata Corp, 2001) and program R version 1.9.1 (Venables and Smith, 2004).

RESULTS

Demographic data

Of the 300 houses selected, one owner did not consent to inspection but agreed to answer the questionnaire. The house and demographic characteristics of the informants are summarized in the second column of Table 1. The sample represents a mixture of cultures (as specified by ethnic group), occupation, educational background, and house setting.

A total of 2,855 wet containers were encountered and inspected. One hundred and sixty-eight houses had larvae with 463 containers being infested. Therefore, the house index (HI), overall container index (CI) and Breteau index (BI) were 56.2, 16.2, and 154.8, respectively.

In the third column of Table 1, numbers in brackets are HI broken down by specific variables. Among the independent variables tested, only the house style and availability of window screen were associated with the presence of mosquito larva in the house. Houses in the rural style, such as a dwelling on a rubber plantation or a traditional single house were more likely to have mosquito larva than ones in the urban style. Table 2 shows that specific container index of used tires was the highest, followed by that of discarded items.

Table 3 breaks down SWCI by various independent variables. The value of SWCI was 955 indicating an average of 9.5 wet containers per house. Out of these, the most common types of wet containers were jars containing using water (2.1 per house) and tank for the toilet (1.7 per house), which accounted for over one third, followed by others and flower vases.

Ethnicity was associated with wet container possessions. Buddhists had more average wet containers per household than Muslims. The more wet containers in the Buddhists' houses were mainly due to more flower vases and, to a lesser extent, more other containers and plant

Table 1
Demographic variables and number of larva positive houses and means with standard deviation of larva positive containers per house.

Demographic variables	No. of house (%)	N (%) larva +ve house	Means±SD of +ve containers per house
Age group (year)			
15-24	27 (9.0)	-	-
25-44	158 (52.7)	-	-
45-60	80 (26.7)	-	-
> 60	35 (11.7)	-	-
Gender		-	
Male	97 (32.3)	-	-
Female	203 (67.7)	-	-
Education level			
Illiterate	36 (12.0)	-	-
Primary school	168 (56.2)	-	-
Secondary school	70 (23.4)	-	-
Bachelor	25 (8.4)	-	-
Ethnicity			
Buddhist	204 (68.2)	116 (56.9)	1.5±2.1
Muslim	95 (31.8)	51 (53.7)	1.4±1.8
Occupation			
Rubber planter	23 (7.7)	14 (60.9)	2.0±2.8
Employee	73 (24.4)	41 (56.2)	1.7±2.2
Merchant	63 (21.1)	32 (50.8)	1.4±2.1
Goverment officer	16 (5.3)	7 (43.7)	1.1±1.7
Student	8 (2.7)	5 (62.5)	2.2±2.4
House wife	101 (33.8)	56 (55.4)	1.5±2.1
Other	15 (5.0)	12 (80.0)	1.3±1.2
Family member			
1-2	38 (12.7)	21 (55.3)	1.5±2.3
3-4	126 (42.1)	72 (57.1)	1.6±2.1
5-6	89 (29.8)	46 (51.7)	1.3±1.8
6+	46 (15.4)	28 (60.9)	1.6±2.2
House style			
Town house	72 (24.1)	33 (45.8)[a]	0.9±1.4[a]
Modern single house	70 (23.4)	36 (51.4)	1.0±1.6
Slum house	41 (13.7)	22 (53.7)	1.3±1.7
Traditional single house	77 (25.7)	53 (68.8)	2.0±2.3
House rubber plantation	33 (11.0)	21 (63.6)	2.8±3.0
Other	6 (2.0)	2 (33.3)	1.0±2.2
Window with screen			
Yes	75 (25.0)	27 (36.0)[a]	0.9±1.5[a]
No	217 (72.6)	135 (62.2)	1.7±2.2
Other	7 (2.4)	3 (42.8)	2.4±2.3
Total	299 (100.0)	168 (56.2)	1.5±2.0

[a]p-value ≤ 0.05

saucers. Muslims had more jars containing using water. The overall wet container index was not associated with the occupation of the respondents. However there were distinctly higher numbers of jars in students' houses and discarded containers in rubber planters' houses. The latter finding is consistent with the finding of higher numbers of jars, discarded containers

Table 2
Specific container indices.

Variables	Ant trap	Tank in toilet	Drinking water jar	Using water jar	Plant saucers	Flower vase	Disc cont	Tire	Other	Total
Total	8	16	3	17	25	11	32	42	15	16

Table 3
Specific wet container indices.

Variables	Ant trap	Tank in toilet	Drinking water jar	Using water jar	Plant saucers	Flower vase	Disc cont	Tire	Other	Total
Total	84	175	75	206	20	124	86	23	162	955
Ethnicity										
Buddhist	86	176	72	193[a]	24[a]	163[a]	86	23	189	1,012[a]
Muslim	77	170	81	232	12	41	85	22	103	823
Occupation										
Rubber planter	130	196	91	217[a]	44	104	287[a]	39	83	1,191
Employee	55	159	67	199	15	115	89	11	230	940
Merchant	63	187	81	191	22	125	48	24	149	890
Gov officer	125	175	69	69	31	112	81	75	75	812
Student	100	187	75	463	12	200	50	0	125	1,212
House wife	99	177	68	216	16	150	68	20	150	964
Other	75	137	113	219	12	125	63	31	187	962
Housing area										
Urban	77	187	89	185[a]	12	175[a]	86[a]	3[a]	168	982
Slum	86	188	60	133	25	140	10	6	208	856
Rural	86	166	74	234	21	100	106	36	147	970
House style										
Town house	76	180	94[a]	156[a]	10	125	28[a]	24	258	951[a]
Modern single house	63	159	47	154	31	130	143	19	94	840
Slum house	83	190	63	127	22	139	12	7	127	770
Traditional single house	109	169	79	291	14	104	108	25	113	1,012
House on rubber plantation	88	197	100	324	30	145	140	52	194	1,270
Window with screen										
Yes	65	159	61	153[a]	16	131	61[a]	25	174[a]	845[a]
No	88	183	79	222	21	121	94	23	138	969

[a]p-value ≤ 0.05

and tires in rubber planting rural areas. Houses without window screens tended to have more jars and discarded containers.

The breakdown of the container specific Breteau index (CSBI) in Table 4 has a similar pattern with that of the wet container index: higher among rural houses and in rubber plantation areas. Comparing ethnic groups, infested vases were the only item more common in Buddhists' houses than in Muslims' houses. Interestingly, the difference in the overall BI between the houses with window screens and those without them was more distinct in this analysis than that of SWCI.

For multivariate analysis, logistic regression was used. Outcome variables included the availability of specific containers containing Aedes larvae in the house. For each outcome, all inde-

Table 4
Container specific Breteau indices.

Variables	Ant trap	Tank in toilet	Drinking water jar	Using water jar	Plant saucers	Flower vase	Disc cont	Tire	Other	Total
Total	6	29	2	35	5	14	28	10	25	154
Ethnicity										
Buddhist	7	30	3	30	6	18[a]	29	8	27	159
Muslim	5	27	1	46	3	4	25	12	20	143
Occupation										
Rubber planter	0	35	0	26	13	4	74[a]	26	22[a]	200
Employee	11	33	3	34	7	20	26	7	31	172
Merchant	6	29	2	40	9	13	27	11	9	146
Gov officer	0	6	0	19	6	12	31	38	0	112
Student	0	50	0	112	0	0	13	0	50	225
House wife	8	29	4	31	0	15	23	3	26	139
Other	0	19	0	37	0	6	6	13	56	137
Housing area										
Urban	11	33	3	7[a]	3	14	20[a]	2[a]	11	104[a]
Slum	10	33	6	25	6	17	8	4	23	132
Rural	4	26	1	49	6	13	36	15	31	181
House style										
Town house	17	25	4	13[a]	0	11	4[a]	1	22	97[a]
Modern single house	0	16	0	6	6	16	41	6	16	107
Slum house	3	44	7	32	7	12	12	5	17	139
Traditional single house	9	35	1	68	5	14	34	13	30	209
House in rubber plantation	0	39	0	79	12	21	61	37	33	281
Window with screen										
Yes	13[a]	18	1	21[a]	3	8	8[a]	3	16	91[a]
No	2	33	2	39	6	15	35	12	28	172

[a]p-value ≤ 0.05

pendent variables in Table 5 were initially included. Stepwise regression with backward elimination was carried out to select the best fitted model with lowest value for the Akaike information criterion (AIC) (Akaike, 1970). In brief, this method selects the model with lowest number of explanatory variables yet retaining the highest level of likelihood, in contrast to other methods which aimed at only statistically significant variables. The coefficients of each independent variable selected from this process were transformed and presented as the odds ratio shown in Table 5. Buddhists' houses had 3.57 times greater odds than Muslims' houses of having at least one infested flower vase. In general, townhouses had a lower risk of infestation. Modern single houses had the lowest risk to having infested tanks and jars, although they had a lot more infested discarded containers. Houses on rubber plantations had the highest odds for all the categories of containers. Additionally, unscreened houses were more likely to have infested containers, especially discarded containers, than screened houses.

DISCUSSION

The study revealed overall high larva indices and complex relationships between sociocultural and environmental factors leading to the infestation of *Aedes* larvae in various kinds of containers. Houses at high risk were those in

Table 5
Odds ratio (95%CI) from multiple logistic regression models for containers infested with larva.

Variables	Tank in toilet	Using water jar	Flower vase	Discarded container	Total
Ethnicity					
Muslim	-	-	1.0	-	1.0
Buddhist	-	-	3.57[a]	-	1.67
			(1.3-10.0)		(1.0-3.3)
House style					
Townhouse	1.0	1.0	-	1.0	1.0
Modern single	0.9	0.4	-	7.0[b]	7.6[b]
house	(0.4-2.4)	(0.1-1.6)		(1.9-26.0)	(2.0-28.4)
Slum house	-	2.8[a]	-	2.8	2.6
		(1.03-7.9)		(0.6-12.6)	(0.6-11.5)
Traditional single	2.2	4.3[b]	-	4.2[a]	4.8[a]
house	(0.9-5.4)	(1.8-10.2)		(1.2-15.6)	(1.3-17.7)
House on rubber	2.8	5.1[b]	-	15.1[b]	18.3[b]
plantation	(0.8-6.7)	(1.8-14.0)		(3.9-58.9)	(4.5-73.5)
Window with screen					
Yes	-	-	-	1.0	1.0
No	-	-	-	4.2[a]	4.5[b]
				(1.4-12.9)	(1.5-13.9)

[a]p-value= 0.01 - 0.05
[b]p-value < 0.01

rubber plantations, single houses, and slum houses, where using-water storage jars or several discarded containers were infested. Buddhists' houses had remarkably more infested flower vases. Finally, unscreened houses were more likely to have infested containers, especially discarded items, than screened ones.

Using-water jars and tanks in the toilets were the most abundant. The number was as high as 3 or more water jars per house on rubber plantations, where a piped water system was not available. With moderate percentages of larvae infestation, the contribution to breeding places for the *Aedes* mosquito was very high.

Tanks in the toilets were quite uniformly available in all socio-demographic and housing groups. This may indicate the long-standing practice of the study population to store water in the bathroom, one for bathing, the other for toilet use. In townhouses and modern single houses and residences of government officers, piped water was available the whole year. The number of these tanks was, however, not significantly reduced.

The availability of using-water jars was slightly different. It varied by socio-demographic and housing factors. Houses of government officers had remarkably lower numbers of this type of container, whereas traditional single houses and houses on rubber plantations had higher numbers. This variation may be explained by the difference in the availability of water supplies and rain water facilities. Our findings are consistent with previous studies in Thailand and Venezuela, which reveal that the number of jars and metal drums were higher if the water supply is poor (Roberta *et al*, 1993; Chareonviriyaphap *et al*, 2003) and there is a reason for the collection of rain water (Strickman and Kittayapong, 2002).

Plants and flowers have important roles in the every day life of our study population. Buddhists in the study area tended to grow more plants than the Muslims, resulting in significantly more plant saucers collecting water, but these were not statistically different in the likelihood of having an infested plant saucer in the house. The more important difference was in the flower vase. It is a common practice of Buddhists to place flowers in a vase in front of a Buddha statue or in a spirit house. Both the number of vases and the likelihood of having at least one infested vase were higher in the Buddhists' houses, indicating its important role as a breeding place.

Discarded items lead to outbreaks of dengue around the world (Chen *et al*, 1994; Diarrassouba and Dossou-Yovo, 1997; Hanna *et al*, 1998). In this study, discarded containers and used tires had very high specific container indices (32% and 42%, respectively). This is consistent with an experimental finding that among several kinds of surface breeding containers, the surface of the tire is the most preferred for the egg-laying of *Aedes* mosquitos (Thirapatsakun *et al*, 1981).

House style has a very strong relationship with water jars and discarded items. Town houses and slum houses had a relatively low quantity of discarded wet containers, whereas single houses and those on rubber plantations had 3-15 times higher odds. The former two styles of houses had small areas and were better covered by the roof leading to fewer wet discarded items. The latter types of houses had more open space where discarded items could be easily filled with rain water.

Finally, window screens have a complicated relationship with larvae infestation. It was only associated with the infestation of discarded items, but not any other types of containers. This could not be explained by the confounding effects of housing patterns because the latter had been adjusted for. Having window screens was shown to be a protective factor against DHF, whereas residing near a market place was a risk factor during an outbreak in Taiwan (Ko *et al*, 1992). Data from that study might suggest that the infective mosquito from the market intruded the house and bit the residents. The situation was probably different in our setting. The possible different explanation in our setting is that *Aedes* mosquitos inhabit and lay eggs inside the house, thus infestation of larva is not prevented by screen. Most discarded containers are outside the house. Their access by *Aedes* mosquitos was significantly blocked by the screen.

We recommend that the housing style and the socio-cultural aspect of the water collection system and garbage management should be reviewed in each community. For the study area where piped water is already reliable, using-water jars and tanks in the toilet are not necessary and their use should be discouraged. Buddhists should be educated to protect their vases. Disposal of waste in single houses, especially on rubber plantations, needs to be improved. Although window screens are not effective in preventing infestations of jars, tanks and vases, they may reduce the infestation of discarded items and should be promoted.

One might argue that the indices used in this study have been shown to have less predictive value for DHF outbreaks than pupa indices (Focks and Chadee, 1997; Focks *et al*, 2000) Our study was conducted before the pupa index was widely accepted. There is evidence that the pupa index has a significant correlation with the indices that we used. (Focks and Chadee, 1997) Thus our study may still reflect the situation and enables the hypothesis to be tested, to a certain extent.

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