

Seasonal Prevalence of *Aedes aegypti* and *Ae. albopictus* in Three Topographical Areas of Southern Thailand

W. Preechaporn, M. Jaroensutasinee, and K. Jaroensutasinee

Abstract—This study investigated the seasonal prevalence of *Aedes aegypti* and *Ae. albopictus* larvae in three topographical areas (i.e. mangrove, rice paddy and mountainous areas). Samples were collected from 300 households in both wet and dry seasons in nine districts in Nakhon Si Thammarat province. *Ae. aegypti* and *Ae. albopictus* were found in 21 out of 29 types of water containers in mangrove, rice paddy and mountainous areas. *Ae. aegypti* and *Ae. albopictus* laid eggs in different container types depending on season and topographical areas. *Ae. aegypti* larvae were found most in metal box in mangrove and mountainous areas in wet season. *Ae. albopictus* larvae were also found most in metal box in mangrove and mountainous areas in both wet and dry seasons. All *Ae. albopictus* larval indices were higher than *Ae. aegypti* larval indices in all three topographical areas and both seasons. HI and BI did not differ in three topographical areas but differed between *Aedes* sp. HI for both *Ae. aegypti* and *Ae. albopictus* in all three topographical areas in both seasons were greater than 10 %, except *Aedes aegypti* in rice paddy area in wet season. This indicated high risks of DHF transmission in these areas.

Keywords—*Aedes aegypti*, *Aedes albopictus*, Season, Topography.

I. INTRODUCTION

THE dengue vectors in southern Thailand are primarily *Aedes aegypti* and *Ae. albopictus* [1]–[3]. An epidemic of Dengue Haemorrhagic fever (DHF) occurred in southern Thailand (e.g. Samui Island in 1966 and 1967 [4]) where *Aedes aegypti* and *Ae. albopictus* were abundant and widespread [5]. In Thailand, *Ae. albopictus* has been found in forested habitats ranging in elevation from 450 to 1,800 m as well as in a variety of other habitats in both rural and suburban areas [1], [2], [6]–[7]. *Ae. albopictus* is capable of breeding in a wide range of container types and water-holding containers. General breeding sites, such as tree holds, coconut shells, fruit

peels, water jars, preserved areca jars, metal boxes and discarded tires, and plant pots holding water have been found to contain *Ae. albopictus* larvae [5], [6]. Key breeding sites (i.e. the most abundant larval habitats) of *Ae. aegypti* have been well studied including cement tanks, and earthen jars inside and outside the dwellings [6]–[12]. There are several factors which influence DHF incidence including types of water storage, season, climatic and vector factors.

Despite the fact that *Ae. albopictus* is expanding its distribution throughout the world [13]–[14], less is known about the key breeding sites of *Ae. albopictus*. Previous studies report that *Ae. albopictus* is capable of breeding in small aquatic sites such as tree holes in forested habitats as well as in a variety of other habitats in rural and suburban areas [10], [11], [15]–[17]. Vector factors comprise of mosquito density, behaviour, vector competence, food level, duration of development, size at emergence, flight range, survival and biting activity [2], [18]–[20]. Because preventative care is an increasingly important part of the strategy, topographical factors that influence key breeding sites of *Ae. aegypti* and *Ae. albopictus* larvae must be more closely investigated [2], [7].

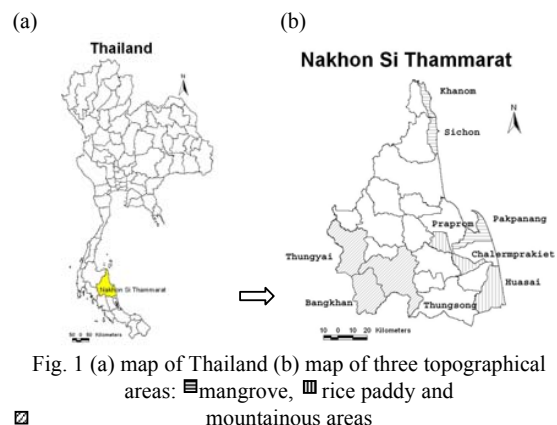


Fig. 1 (a) map of Thailand (b) map of three topographical areas: ▨ mangrove, ▩ rice paddy and ▤ mountainous areas

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Nakhon Si Thammarat province is located in southern Thailand (Fig. 1a). Since 1984, there have been several cyclic DHF outbreaks in this area and in 1990 a large outbreak occurred. After that, dengue epidemics decreased and reappeared again in 1998 and 2002 [21]. In 2002, the number of deaths in Nakhon Si Thammarat was the highest in Thailand (i.e. 6,603 DHF cases reported or 631.40 cases per

100,000 people and the fatality rate was 0.92) [22]. The previous study reported that *Ae. aegypti* larvae were found most in preserved areca jars in mangrove and mountainous areas and in banana trees in rice paddy areas. *Ae. albopictus* larvae were found most in preserved areca jars in mangrove areas, in plant plates in rice paddy areas and in metal boxes in mountainous areas [6]. This study aimed at examining the effect of seasons and topography on key breeding sites of *Ae. aegypti* and *Ae. albopictus*. This study investigated three topographic types: mangrove, rice paddy and mountainous areas (Fig. 1b) and two seasons: wet and dry seasons.

II. MATERIAL AND METHODS

A. Data Collection

We conducted our mosquito larval survey in Nakhon Si Thammarat province located at 8° 32' 16.5" N latitude and 99° 56' 50.7" E longitude in March-April and October-November 2006 covering three topographical areas (i.e. mangrove, rice paddy and mountainous areas) (Fig. 1). Samples were collected in households from all sub-districts in nine districts using stratified simple random sampling. Topography was assigned as strata. There were 100 households per topographical area with a total of 300 households both wet and dry seasons.

B. Entomological Studies

All water containers were sampled for mosquito larvae both indoors and outdoors using fishnets. Very small water containers were emptied through the fishnet. Larger water containers were sampled by dipping the net in the water, starting at the top of the container and continuing to the bottom in a swirling motion that sampled all edges of the container [11], [16]. All live mosquito larvae were collected in plastic bags, taken to the Vector Borne Disease Control Center 11.2 Nakhon Si Thammarat laboratory, preserved all mosquito larvae and identified up to species level using Rattanarithikul and Panthursiri's [23] keys. In this study, the first, second instars and pupae were discarded because immature mosquitoes at these stages could not be identified. There were a total of 29 container categories in this study. Plastic water containers were divided into two categories: large plastic containers using for water storages (>100 L) and plastic bottles (i.e. 0.5 – 2.0 L water bottle).

Three larval indices {i.e. House Index (HI), Container Index (CI) and Breteau Index (BI)} were worked out as per standard WHO guidelines. Breeding places were sampled both indoors and outdoors within 15 m of the houses [24]. Earthen jars were classified into two categories: small earthen jars with a volume of <100 L and large earthen jars with a volume of >100 L.

C. Statistical Analysis

All variables were tested for normality using the Komogorov-Smirnov test. The equality of variances was evaluated using Levene's test. Descriptive statistics of the data were analyzed. The numbers of mosquito larvae in different

types of water containers were compared using independent sampled *t*-tests. The number of positive containers, the number of households that had positive containers, and the number of *Ae. aegypti* and *Ae. albopictus* larvae in the three topographical areas were analyzed using one-way ANOVA tests. The larval indices were compared between wet and dry seasons by using paired *t*-tests. The larval indices were compared between topographical areas, seasons and the interaction between topographical areas and seasons using Chi-square tests. All significant tests were two-tailed.

III. RESULTS

A. *Ae. aegypti* and *Ae. albopictus* Larvae

There were *Ae. aegypti* larvae in 18 out of 29 types of water containers, *Ae. albopictus* larvae in 20 out of 29 types of water containers and both *Aedes* sp. larvae in 21 out of 29 types of water containers. For indoor containers, *Ae. aegypti* larvae were found in four types of water containers: ant guard, small earthen jar, large earthen jar and cement tanks (Fig. 2a-c). From these four types of indoor containers, *Ae. aegypti* larvae were found most in small earthen jars in rice paddy areas in wet season. For outdoor containers, *Ae. aegypti* larvae were found in 14 out of 29 types of water containers and found most in metal box in mangrove and mountainous areas in wet season (Fig. 2a-c).

For indoor containers, *Ae. albopictus* larvae were found in two types of water containers: small earthen jar and large earthen jar (Fig. 2d-f). From these two types of indoor containers, *Ae. albopictus* larvae were found most in small earthen jars in rice paddy areas in wet season (Fig. 2e). For outdoor containers, *Ae. albopictus* larvae were found in 17 types of water containers and found most in metal box in mangrove and mountainous areas in both of seasons (Fig. 2d,f).

B. Larval Indices

All *Ae. albopictus* larval indices were higher than *Ae. aegypti* larval indices in all three topographical areas (Table I). HI in *Ae. aegypti* did not differ among topography, between seasons, and no interaction between topography and season (Chi-square: topographical area: $\chi^2_2 = 0.242$, ns; season: $\chi^2_1 = 2.272$, ns; topography x season interaction: $\chi^2_1 = 5.352$, ns (Table I). HI in *Ae. albopictus* differed among topography, between seasons, and no interaction between topography and season (Chi-square: topographical area: $\chi^2_2 = 9.660$, $P < 0.01$; season: $\chi^2_1 = 8.297$, $P < 0.01$; topography x season interaction: $\chi^2_1 = 0.737$, ns (Table I)). BI in *Ae. aegypti* did not differ among topography, between seasons, and there were some interactions between topography and season (Chi-square: topographical areas: $\chi^2_2 = 0.320$, ns; and season: $\chi^2_1 = 0.603$, ns, topography x season interaction: $\chi^2_1 = 7.544$, $P < 0.05$; (Table I). BI in *Ae. albopictus* differed among topography, did not differ between seasons, and no interaction between topography and season (Chi-square: topographical

areas: $\chi^2_2 = 16.924$, $P < 0.001$; and season: $\chi^2_1 = 1.142$, ns; topography x season interaction: $\chi^2_1 = 3.145$, ns (Table I).

TABLE I
THE NUMBER FOR HOUSEHOLDS AND CONTAINERS, AND LARVAE INDICES IN THREE TOPOGRAPHICAL AREAS IN WET AND DRY SEASONS

	Mangrove Area				Rice Paddy Area				Mountainous Area			
	<i>Ae. aegypti</i>		<i>Ae. albopictus</i>		<i>Ae. aegypti</i>		<i>Ae. albopictus</i>		<i>Ae. aegypti</i>		<i>Ae. albopictus</i>	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
No. of Households	49	55	49	55	37	56	37	56	40	67	40	67
No. of Positive Households	15	13	30	39	7	21	23	38	15	16	40	50
No. of Containers	1880	1847	1880	1847	1519	1347	1519	1347	1229	903	1229	903
No. of Positive Containers	20	14	56	47	9	24	28	37	16	14	42	55
Larval Index												
HI (%)	15	13	30	39	7	21	23	38	15	16	40	50
CI (%)	1.06	0.76	2.98	2.54	0.59	1.78	1.84	2.75	1.30	1.55	3.42	6.09
BI	20	14	56	47	9	24	28	37	16	14	42	55

IV. DISCUSSION

Our results supported previous findings that *Ae. aegypti* and *Ae. albopictus* may have different key breeding sites from one area to another [6], [11], [25]. This study clearly demonstrates that *Ae. aegypti* and *Ae. albopictus* laid eggs in different container types depending on season and topography. Phong and Nam [24] studied *Aedes* larval occurrence in Vietnam and found that *Ae. aegypti* larvae was mostly found in drums, jars, concrete tanks and discarded objects. On the other hand, *Ae. albopictus* larvae were mainly found in jars and discarded objects. Wongkoon et al. [10] studied *Aedes* larval occurrence in Nakhon Si Thammarat, Thailand and found *Ae. aegypti* and *Ae. albopictus* larvae in six water storage containers including pot plants, animal pans, tires, small water jars, bathroom tanks, and concrete tanks. They found that from these six containers, there were a higher number of *Ae. aegypti* larvae in water containers in bathrooms and concrete tanks than *Ae. albopictus* [11]. Our results supported previous findings and showed that key breeding sites of *Ae. aegypti* were the ceramic or earthen jars both inside and outside the dwellings and concrete water storage tanks served as the main breeding places of *Ae. aegypti* whereas preserved areca jars, metal boxes and coconut shells found outdoors were the major breeding site of *Ae. albopictus* [2], [6] (Fig. 2). Key breeding sites of *Ae. albopictus* were metal boxes and coconut shells in three topographical areas and both seasons. We found more *Aedes* larvae in coconut shells, banana trees and decay products. These natural containers are a signal of good food in term of quality and quantity known to attract ovipositing females [25]–[27].

The establishment and spread of *Ae. albopictus* was associated with a reduction in abundance and range of *Ae. aegypti* [28]–[31]. *Ae. albopictus* larvae are superior to those of *Ae. aegypti* in growth and survivorship under conditions of intra- and interspecific competition in the presence of limiting litter-based resources [32]–[34]. From our larval survey, we found that all *Ae. albopictus* larval indices were higher than *Ae. aegypti* larval indices. This lower number of *Ae. aegypti* larvae because *Ae. aegypti* tends to disseminate eggs from the same batch among several containers [35]–[38] and avoid ovipositing in containers that

already have larvae from the same female or those of conspecifics [36]. *Ae. aegypti* females exhibit this strategy to benefit their offspring by decreasing sibling competition and distributing risk. However, it is counter-intuitive from the perspective of adult survival and conservation of energy reserves. In addition, our results suggest that *Ae. albopictus* establishes well and in greater numbers than *Ae. aegypti* in both seasons and all three topographical areas, especially most *Ae. albopictus* larvae were found in artificial outdoor containers in mangrove and mountainous areas in wet season. These results support previous studies that *Ae. albopictus* inhabits forest areas [8], [10], [11], [14], [16].

There were many suitable oviposition sites located within houses in Thailand. Kittayapong and Strickman [11] found that the infestation of indoor containers by *Ae. aegypti* was greater than outdoor containers. Many studies have demonstrated that *Ae. aegypti* prefers to rest indoors, feed indoors [2]–[39] and oviposit indoor [3]. Our results did not support this previous finding. We found that *Ae. aegypti* larvae were found in a lower number of indoor containers than *Ae. albopictus* larvae.

Our results revealed that storage jars and cement water storage tanks (in bathroom) were the main breeding sites of *Aedes* larvae indoor and outdoor in both wet and dry seasons. On the other hand, indoor small earthen jars, plant plates, plant pots, drinking water storage jars, ant guards and natural sites served as minor breeding sites during both seasons. Our results also supported the previous study [6], [9]. revealed that *Ae. aegypti* bred in both domestic and peridomestic sites. However, peridomestic breeding sites such as discarded containers, flower vessels, tire dumps and water meter chambers supported the maximum breeding in both wet and dry seasons.

Our results showed that the number of *Ae. aegypti* and *Ae. albopictus* larvae in all types of both indoor and outdoor containers did not differed between seasons, except for *Ae. aegypti* in the metal boxes. The number of *Ae. aegypti* in the metal boxes in mountainous area in the wet season were greater in the dry season. This could be because many water-storage containers are still kept in and around each house for collection and storage of rain as well as domestic water. To

supplant the precarious source of domestic water supply, the local people catch and store rain water in small to large jars and tanks. In addition, the local people prefer to use rainwater

to the piped water. These multitude of water storage containers provide preferred breeding sites for *Aedes* species.

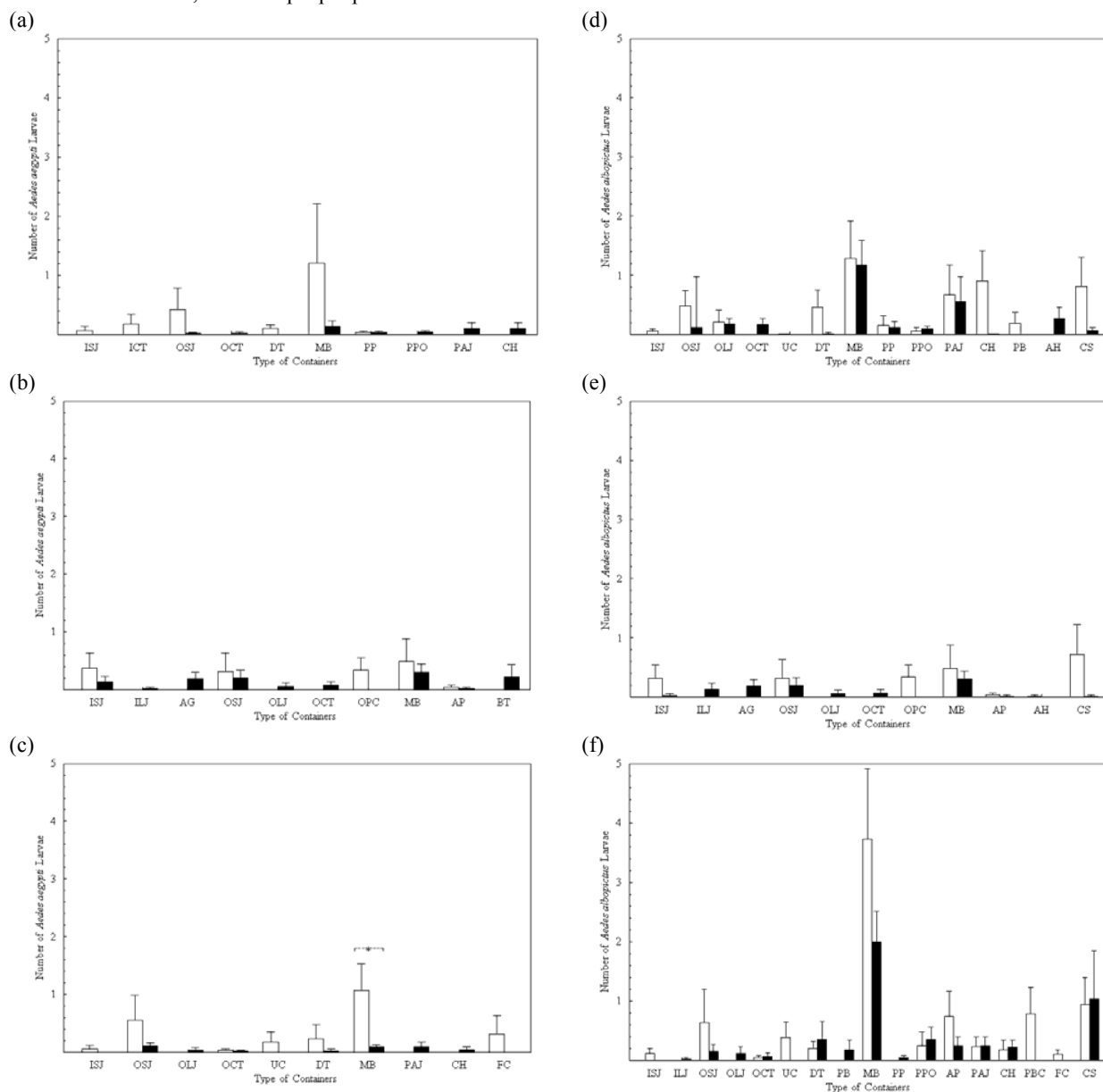


Fig. 2 *Aedes* larval occurrence at □ wet and ■ dry seasons in three topographical areas (a-c) *Ae. aegypti*, (d-f) *Ae. albopictus* that ISJ, ILJ, ICT, IPC, AG, OSJ, OLJ, OCT, OPC, UC, DT, PB, MB, PP, PPO, AP, PAJ, CH, PBC, FC, BT and CS were represented by indoor small earthen jar, indoor large earthen jar, outdoor cement tank, indoor plastic container, ant guard, outdoor large earthen jar, outdoor plastic container, used can, discarded tire, plastic bottle, metal box, plant plate, plant pot, animal pan, preserved areca jar, cement hole, plastic bucket, foam container, banana tree and coconut shell, respectively

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