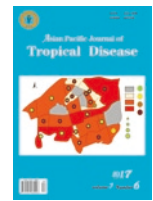


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Surveillance of *Aedes* mosquitoes in different residential types in central zone of Shah Alam, SelangorSiti Nur Anis Hasnan¹, Nazri Che Dom^{1,2*}, Zulkiflee Abd Latif³, Faiz Madzlan¹¹Faculty of Health Sciences, Universiti Teknologi MARA, Selangor, Malaysia²Vector Control and Diseases Research Laboratory, Universiti Teknologi MARA, Malaysia³Applied Remote Sensing & Geospatial Research Group, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Selangor, Malaysia

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ABSTRACT

Objective: To determine the infestation profile by performing ovitrap surveillance in four types of residential areas in central zone of Shah Alam, Selangor.

Methods: 600 ovitraps were exposed for 4 days in intradomiciliary environments within 20 residential areas including independent houses, inter-connected houses, commercial buildings and mixed houses areas. The ecological conditions of the surrounding environment were observed and recorded. The distributions and abundances of the *Aedes* mosquitoes were presented in terms of positive ovitrap index (POI) and mean eggs per trap (MET). One-way ANOVA test was used to determine the association between the type of residential areas and the number of ovitrap with eggs and the egg count.

Results: The result implied that Seksyen 7 has the highest reading of both ovitrap index and egg count (POI = 86.21%, MET = 41.68 eggs). There was no significant difference in the POI and MET of *Aedes* mosquitoes between the type of housing areas ($P > 0.05$). The surrounding environmental conditions were believed to be the main influence of the abundance and distribution of the *Aedes* mosquitoes in Shah Alam. Unhygienic conditions were observed in all type of residential areas. These included the abandoned kitchen utensils and flower pots stored at the backyard which lead to collected stagnant water that later served as the favourable places for female *Aedes* to oviposit.

Conclusions: The key to effectively control the dengue outbreak is to have an advance understanding to all the high potential transmission areas or habitat which are generally the areas with the densest human and vector population.

1. Introduction

Aedes (Stegomyia) albopictus (Skuse), also known as the Asian tiger mosquito and *Aedes (Stegomyia) aegypti* (Linnaeus) (*Ae. aegypti*) are the mosquitoes responsible for the spread of dengue fever as well as Zika and chikungunya. The dengue viruses are transmitted to humans through the bites of these infected female mosquitoes. Both species were found to increase their geographical distribution which allows the viruses to get into new population of susceptible human host[1,2]. *Ae. aegypti* is an anthropophilic where this species preferably reside in human dwelling[3]. There

is a few studies that proved the infestation area of the *Ae. aegypti* were found nearly in domestic container[4,5], due to the rainwater-stagnated container in peri-domiciliary environments[3,4]. While *Aedes albopictus* is primarily a forest species that has adapted to rural, suburban and urban human environments. Notably, in terms of their life cycle, both species are closely associated with intradomiciliary human habitat, and breeds in containers with stagnant water, often tires or other containers[6,7]. However, due to the revolution of environmental conditions, both species have been found to overlap in their indoor and outdoor breeding habitat with single or mixed infestation in the same breeding container[3,8,9].

In general, Malaysia is undergoing the rapid development which brought to a massive infrastructure development and a very active construction sector for housing and commercial growth, thus creating many artificial breeding sites for *Aedes* to breed in[8]. Previous epidemiological studies in Malaysia had revealed that the distribution of dengue fever cases is higher in the residential

*Corresponding author: Nazri Che Dom, PhD, Faculty of Health Sciences, Universiti Teknologi MARA, Selangor, Malaysia.

Tel: +6019-6143465

E-mail: nazri@salam.uitm.edu.my

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area due to the favorable places for the *Aedes*' breeding caused by human in residential area[8,10]. These are also influenced by the vegetation cover and the right type of environmental breeding sites. Some aspect of human ecology also greatly influenced the mosquito distribution. A study in Nigeria positively indicates that density of mosquito is greater in human areas as the reason of the easy access to blood meal in their flight range[11]. Mosquito species, once established in an ecological zone, are difficult to dislodge. When the environmental factors that support their growth, development and survival are lacking, they only tend to temporarily disappear, only to return to thriving status once these factors are established[9,12].

In addition, the rural-urban migration and the influx of immigrants contribute to the bad environmental conditions. This coupled with illegal settlement of solid waste, improper solid waste management and the climatic changes which offer the favorable habitat for *Aedes* breeding, thus giving rise to the dengue transmission in this country[10]. The dengue transmission involves three factors, namely the pathogen (virus), the vector represented by the mosquitoes and the human as the host[13]. In order to control the spread of dengue fever, the transmission chain has to be broken. This can be done through the eradication of the mosquito population in human environment. Therefore, it is crucial to have a vector surveillance to determine the presence of vectors, their frequency of occurrences, as well as the epidemiological parameters related to its vector capacity. In the study area, it has been reported that the dengue incidents are well distributed and the occurrences are clustered at the area which identified as undergoing urban development as well as high population density[10,14]. In Selangor, the housing typology comprised of different housing type; for instance, bungalows, terraced houses, shop-houses and multi-storey houses[14]. Previous studies have reported that, there are not just environmental factors that contributed to the occurrence of dengue cases but it is also coupled with the inadequacies in urban infrastructure which commonly have a problem of improper solid waste disposal system[10,15]. Besides that, their distribution is also more associated with the presence of vegetation either in urban setting or rural area, and its abundance is generally limited to spaces modified by human activity[6]. This condition could enhance the *Aedes* to breed in natural or non-natural containers in and around the houses as well as the abandoned area and construction sites.

In order to do that, a better understanding of *Aedes* infestation profile is needed to provide fundamental information in conducting the vector control program. The utilization of ovitrap in this study may provide such information beneficial for planning and managing the dengue vectors. The ovitrap is proven to serve as the useful tools for providing the spatial and temporal data and successfully monitors the impacts of control measures[1,6,15,16]. Moreover, entomological studies in Taiwan reported that ovitrap data are more sensitive than the traditional way of larval survey in detecting the low population of *Aedes* mosquitoes[17,18]. Ovitrap data also have been effectively used to monitor the impact of the control measures

involving sources reduction and insecticides applications[18]. On top of that, the ovitrap method is capable of detecting mosquitoes from unexposed breeding sites and surrounding areas which can be found more in residential area. Therefore, this method was selected for vector control surveillance in Selangor.

This study is carried out to provide fundamental information of the *Aedes* infestation profile in urbanized areas in accordance to the different type of housing area. In addition, this current study focused on the environmental condition of the housing areas where the favorable breeding sites for *Aedes* mosquitoes existed. The alteration of *Aedes*' habitat can be more effective in controlling the *Aedes*' density in communities.

2. Materials and methods

2.1. Study site

This study was established in the capital state of Selangor. Shah Alam is located 25 km and 45 min away from Kuala Lumpur with coordinate of 3°05'48.74" N, 101°33'02.39" E to 2°58'22.93" N, 101°44'39.69" E. Shah Alam is divided into three zones which are northern (NZ), southern zone (SZ), and central zone (CZ) with a total population of 763416 in year 2014. This entomological study of *Aedes albopictus* were conducted in central zone of Shah Alam covering Seksyen 1 to Seksyen 24 with the exemption of Seksyen 1, 5, 14 and 21 due to non-residential area. This zone was concerned as the study area as the dengue cases showed the clustered pattern in between 2012 and 2015 which was reported from Vector Borne Disease Control Unit, Health Department of Selangor State.

2.2. Study design

The study is aimed to investigate the relationship between *Aedes*' infestation profiles with respect to the residential types in central zone of Shah Alam, Selangor. Prior to this study, a hybrid study design was applied. An epidemiological data of confirmed dengue cases were gathered from Vector Borne Disease Control Unit of Selangor state to scrutinize the pattern of dengue prevalence rate in year 2015. The data contained the complete data of the patients' addresses, serology status and onset of the dengue cases. Besides, the population data of the localities were obtained from the Department of Statistic to firstly study the dengue prevalence rate per 1 000 people[19,20]. Few studies have reported incidence rate as an indicator of imminent public health problems and the way to predict the disease events in the close future[20]. The prevalence rate is the number of new cases per population at risk in a given time period. As in this study, dengue incidence rate is measured by the assumption of dengue fever to likely occur once per 1 000 population.

The field work of this study was then continued with the ovitrap surveillance to determine the infestation profile of *Aedes* mosquitoes

as well as to collect the eggs along the way. Random-spatial sampling was applied to setting up the ovitraps in specified distance range[21]. The method of oviposition trap (ovitraps) procedure was performed to achieve the infestation profile of *Aedes* mosquitoes. In parallel to ovitraps surveillance, an observational method was also being practiced to notify the ecological condition of the localities. The ecological criteria were recorded in the form and were captured to visualize the real condition thus support and strengthen the findings.

2.3. Housing type classification

In this study the housing type were classified based on the possibility and potential of the dengue disease transmission and the distribution with the type of houses. This study considered four different type of housing area which was (i) interconnected house, (ii) independent houses, (iii) commercial building and (iv) mixed houses.

Interconnected houses are defined as the housing areas which are linked to each other like terraces houses, apartments and condominiums. Meanwhile the independent houses refer to the single houses for instance bungalow and houses found in the villages[10]. In this study, it is important to consider the commercial area as one of the categories in the housing types due to the real situation in the ground where it is clearly observed that some of the areas, residential houses are located in the same building as commercial shop[14]. During this study, the area is grouped as the commercial building houses where is it observed as purely for commercial purposes or the areas where shop and houses located in the same building. The last housing type is the mixed houses defined as the housing area which has mixed types of houses. For example, it is found that terrace houses, flat, commercial, small industry and squatter area were situated in the same locality[10].

2.4. Oviposition traps (ovitraps) method/sampling technique

The entomological surveillance for the purpose of mosquito eggs collection was conducted in the study site. The eggs were collected using the oviposition trap. Oviposition trap or ovitraps are made from black plastic container (base diameter 6.5 cm, opening diameter 7.8 cm, and height 9.0 cm). The ovitraps were filled with a 100 mL of dechlorinated water together with the two surface hardboard paddles (8.0 cm × 2.0 cm × 0.3 cm) which served as the damp site for *Aedes* female to oviposit. A total of 30 ovitraps per locality were set up with radius of 10 m apart from each other with considering their preferences habitat[6,22]. The ovitraps were placed near to adult resting sites in complete shade which is out of weather and human interferences. Besides that, the ovitraps were also placed in direct line of sight and one close to the ground[2,22]. Before the ovitraps were set up at the place, the property-owner was briefed on the purpose of placing the ovitraps outside of the premises and

informed consent was obtained. After consecutive days of exposure, the ovitraps were recollected. At this stage, the paddles inside the ovitraps were transferred into the airtight plastic (13 cm × 6 cm). Meanwhile the ovitraps were tightly covered with the lid and were brought back to the laboratory for the purpose of mosquito colonization and eggs enumeration. All the collected ovitraps were labeled according to their prescribed localities. During the pre-experimental work, the paddles were first dried under room temperature 29 °C to facilitate the process of eggs count. The numbers of eggs in the water were also taken into account as the eggs might be in the water[6]. The eggs in the ovitraps were filtered first using the filter paper and dried same as paddle. The eggs were then enumerated under stereo-microscope (Zeiss Stemi DV4).

2.5. Data management

The physical environmental conditions of the study localities were evaluated by noted down their ecological conditions and some photos were taken to visualize the surrounding area. Then to evaluate the density of the mosquito in terms of their distribution and abundance, the indices of positive ovitraps index (POI) and mean eggs per trap (MET) were calculated. POI for each locality was calculated by dividing the number of positive ovitraps with the total number of recovered ovitraps and multiplying the result with 100. While the MET of each locality is calculated by dividing the number of total eggs collected with the number of positive ovitraps.

Geographical information system (GIS) was used to capture the spatial distribution of the *Aedes* infestation profile (POI and MET) and the severity of the disease (represented by incidence rate) [23,24]. POI, MET and incidence rate of the study localities were mapped and the layer of each map were overlaid to identify trends and patterns of infestation profile and severity of the disease. The analysis of *Aedes*' infestation profile in different type of housing was subjected to parametric test, One-way analysis of variances (ANOVA) with the significant level of 0.05,

3. Results

3.1. Epidemiological characteristics of dengue cases in central zone of Shah Alam, Selangor

A total of 3 507 confirmed dengue cases that had clear and existing address were recorded in central zone of Shah Alam. In order to understand the epidemiological characteristic of dengue cases in the study area, the dengue prevalence rate was calculated as shown in Table 1. The distribution of prevalence rate in the study area ranged from 8 to 44 cases. From the result obtained in Table 1, Seksyen 15 ($n = 44$ cases) recorded the highest prevalence rate while Seksyen 12 ($n = 8$ cases) determined the lowest prevalence rate in central zone. In this study, the incidence rate in year 2015 had been spatially mapped accordingly by localities by using GIS.

Table 1

The distribution of dengue incidence rate of study sites based on type of residential.

Type of house	Locality (Seksyen)	No. of DF cases in 2015	Population data in year 2015	Dengue incidence rate (IR) per 1000 people in year 2015
Inter-connected houses	10	40	1929	20.73
	11	69	3768	18.31
	18	132	10320	12.79
	19	201	10900	18.44
	20	187	11165	16.75
	22	64	2764	23.15
	23	49	2101	23.32
	24	336	15910	21.12
Independent houses	2	51	3000	17.00
	3	13	1525	8.52
	9	110	10455	10.52
	12	4	484	8.26
Commercial	15	237	5436	43.60
	16	120	6479	18.52
Mixed house	4	29	2510	11.15
	6	85	3490	24.35
	7	950	37415	25.39
	8	145	9528	15.22
	13	382	9789	39.02
	17	271	8403	32.25
	Total	3507	157371	

3.2. Ecological characteristics of the study localities

During this study, 20 residential localities had been exploited for the surveillance activities and their surrounding environments were observed. The ecological conditions of the study localities were summarized in Table 2. From the general observation, central zone of Shah Alam was intensified with green landscape as most of the localities cultivated with vegetation. The localities were then classified into the residential groups of independent houses, inter-connected houses, commercial buildings and mixed houses. From the infrastructural characteristics, the commercial building (Seksyen 15 and 16) surrounded with poor sanitation and the buildings itself were not well maintained. Basically, the inter-connected houses in central zone of Shah Alam experienced the same environmental problems where their backyards were not sustained and dirty. Despite that, it was found that the interconnected-house in Seksyen 19 and 20 were kept maintained with clean environment. During the survey, it can be observed that the independent houses area tends to have their own crops as they had extra spaces compared to others. There are many scattered vegetation and tall trees around the houses. The mixed houses area experienced the same landscape as the interconnected houses area but rubbish like plastic containers, coconut shell, *etc.* can be found scattered in abandoned areas as observed in Seksyen

Table 2

The study localities in central zone, Shah Alam.

Locality (Seksyen)	Geographical coordinate	Houses/residential type	Ecological condition
2	3°46.348" N/ 101°30'58.608" E	Independent house	<ul style="list-style-type: none"> Surrounded with various vegetation such as trees and shrubs The environment is not properly managed and maintained
3	3°429.946" N/ 101°30'29.213" E	Independent house	<ul style="list-style-type: none"> There many scattered vegetation and tall trees around the residential areas
4	3°442.15" N/ 101°30'44.711" E	Mixed house	<ul style="list-style-type: none"> Many household have ornamental plants on the balcony Many rubbish and unused items in the residential areas
6	3°52.652" N/ 101°30'35.207" E	Mixed house	<ul style="list-style-type: none"> Surrounded by with vegetation, trees, and vegetation Not managed properly and unclean
7	3°426.784" N/ 101°29'31.989" E	Mixed house	<ul style="list-style-type: none"> Have the vegetation in the surrounding area A well-managed and clean area
8	3°523.453" N/ 101°30'28.152" E	Mixed house	<ul style="list-style-type: none"> Surrounded with vegetation, trees, and shrubs Properly managed and clean area
9	3°459.988" N/ 101°31'39.41" E	Independent house	<ul style="list-style-type: none"> Have the vegetation in the surrounding area A well-managed and clean area
10	3°450.214" N/ 101°31'29.892" E	Inter-connected house	<ul style="list-style-type: none"> There are many houses with vegetation The environment is clean
11	3°426.796" N/ 101°31'43.607" E	Inter-connected house	<ul style="list-style-type: none"> The backyard of the residential is poor sanitation
12	3°413.89" N/ 101°32'7.602" E	Independent house	<ul style="list-style-type: none"> Many houses have ornamental plants with proper maintenance The area is properly managed
13	3°455.38" N/ 101°32'20.011" E	Mixed house	<ul style="list-style-type: none"> Unclean environment Rubbish ae scattered in abandoned area
15	3°429.802" N/ 101°31'6.419" E	Commercial	<ul style="list-style-type: none"> The commercial buildings is not well maintained Poor sanitation
16	3°325.884" N/ 101°30'6.321" E	Commercial	<ul style="list-style-type: none"> The building is not well maintained and rubbish Poor sanitation
17	3°246.9" N/ 101°30'20.991" E	Mixed house	<ul style="list-style-type: none"> There are many scattered vegetation and tall trees around the residential area The environmental is not well maintained
18	3°238.195" N/ 101°31'5.801" E	Inter-connected house	<ul style="list-style-type: none"> Unclean environment The residential backyard full of vegetation with poor maintenance
19	3°255.151" N/ 101°32'3.681" E	Inter-connected house	<ul style="list-style-type: none"> The environment is clean Houses with many vegetation are well maintained
20	3°3'19.357" N/ 101°32'20.76" E	Inter-connected house	<ul style="list-style-type: none"> The environment is properly managed
22	3°417.692" N/ 101°33'18.007" E	Inter-connected house	<ul style="list-style-type: none"> Unclean environment Unused tyres were found at the backyard of some houses
23	3°246.439" N/ 101°31'43.42" E	Inter-connected house	<ul style="list-style-type: none"> There many vegetation in the residential area Rubbish can be found at the abandoned area
24	3°219.14" N/ 101°31'5.051" E	Inter-connected house	<ul style="list-style-type: none"> The backyard of the houses is generally unclean and not well managed

13. All these environmental conditions enhanced the presence of the *Aedes*' infestation in communities[25].

3.3. The infestation profile of *Aedes* mosquitoes in central zone of Shah Alam

The infestation profile of *Aedes* mosquitoes were represented by their distribution and abundance in the environment. A total of 600

ovitraps were deployed during the ovitrap surveillance. After 4 days of placement, about 92.67% of ovitrap ($n = 556$) were recovered back. The loss of the other 44 ovitraps in the field is due to the cleaning process by the municipality or community of the particular area and disturbance by human or animal. Out of 556 recovered ovitraps, about 62.23% ($n = 346$) of them showed the presence of the *Aedes* infestation. This implicated that central zone of Shah Alam has high *Aedes* infestation. The total of *Aedes*' eggs collected in this

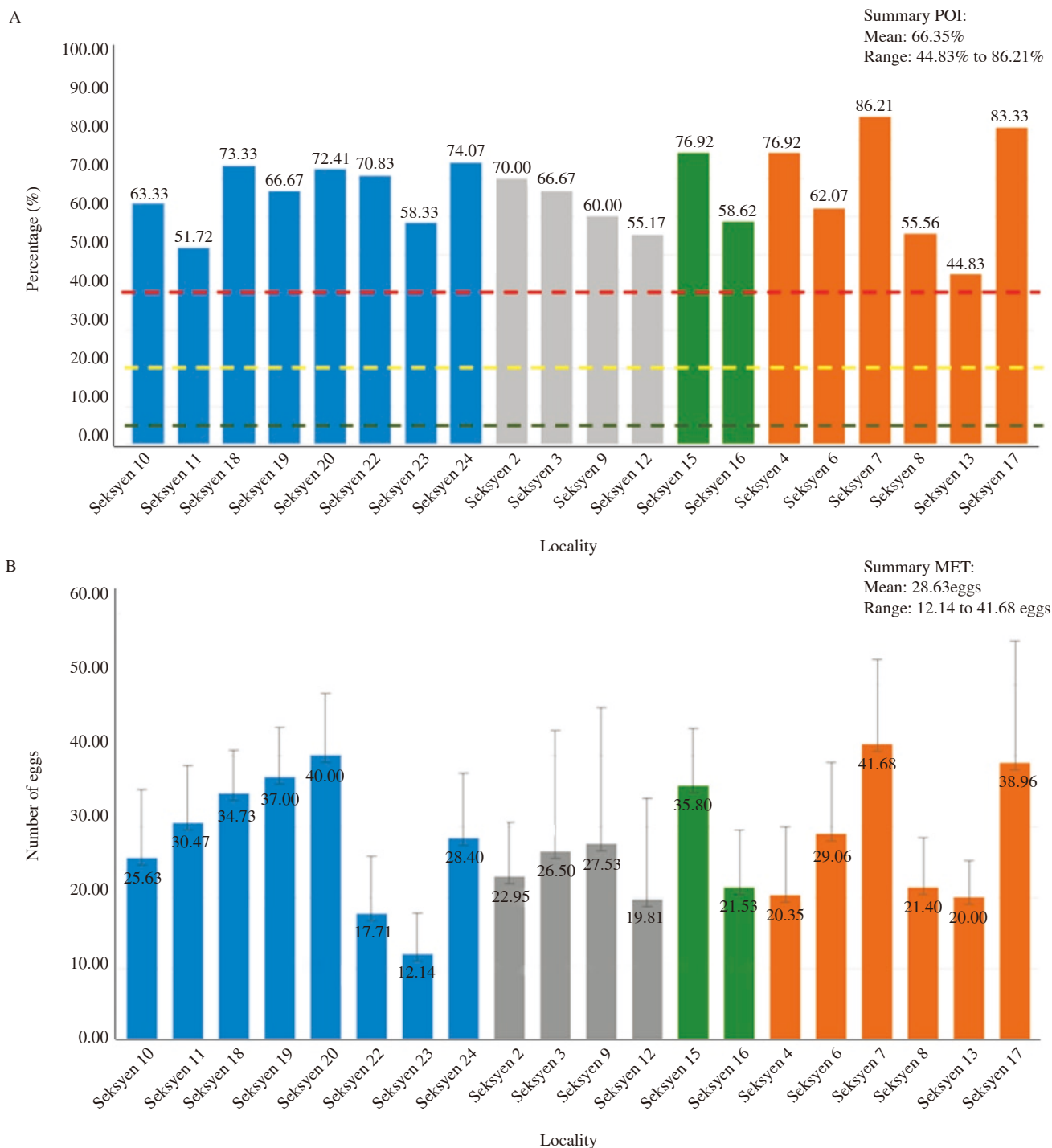


Figure 1. The infestation *Aedes*' mosquitoes based on (A) POI and (B) MET.

The blue bar indicates the localities in interconnected-house area, grey bar represents independent house area, green color is commercial building and orange bar indicates mixed-house area. The red dotted line in (POI \geq 40%) classified as level 4 in *Aedes*' infestation indicator using ovitrap index. The yellow dotted line (POI: 20.01% to 39.99%) classified as level 3, the green dotted line (POI: 5% to 19.9%) classified as level 2. While level 1 is considered in between 0.0% to 4.99% of positive ovitrap index.

study is 10625 eggs as documented based on residential type basis tabulated in Table 3.

From the result in Table 3, POI in central zone of Shah Alam was in the range of 44.83% to 86.21%. Highest index exhibited from Seksyen 7 (POI = 86.21%) followed by Seksyen 17 (POI = 83.33%) from mixed houses area. Lowest POI value was also recorded in mixed houses area at Seksyen 13 (POI = 44.83%). This situation is likely due to the sanitary level of the area[25,26]. Apart from that, this present study used the guideline suggested from World Health Organization (2009) as an indicator to the degree of cleanliness and action to be taken using the POI. Figure 1A showed the *Aedes* mosquitoes were well distributed in all 20 localities. All the localities were categorized as level four as they recorded POI value more than 40%. These findings indicated that the special operations needed to be conducted in central zone of Shah Alam to eliminate all the

breeding or potential breeding places of *Aedes* mosquitoes. Besides that, the robust control measures by using larvicides or adulticides must be feasible.

The abundance of the *Aedes* mosquitoes was translated into MET. MET in central zone of Shah Alam showed the fluctuation patterns with a range of 12.41 eggs to 41.68 eggs per trap as presented in Figure 1B. Seksyen 23 from independent house area yielding the lowest eggs recorded ($n = 317$ eggs) while the highest eggs collected is 1023 eggs in Seksyen 7 from mixed house area.

During this ovitrap surveillance it was found that Seksyen 7, 17 and 20 experienced high indices for both POI and MET. This distribution pattern was mapped together with the dengue incidence rate (IR) as showed in Figure 2. From the analysis, it was indicated that despite of high infestation rate of *Aedes* mosquitoes, it did not mean that the incidence rate of dengue will be high. Besides that, the

Table 3
POI and MET of the study sites based on the residential type.

Type of house	Locality (Seksyen)	Ovitrap placement	No. of recovered ovitrap	No. of positive ovitrap	POI (%)	No. of eggs	MET (Mean ± SD)
Inter-connected houses	10	30	30	19	63.33	487	25.63 ± 9.56
	11	30	29	15	51.72	457	30.47 ± 8.18
	18	30	30	22	73.33	764	34.73 ± 6.08
	19	30	30	20	66.67	740	37.00 ± 6.94
	20	30	30	21	72.41	840	40.00 ± 8.72
	22	30	29	17	70.83	301	17.71 ± 8.21
	23	30	24	14	58.33	170	12.14 ± 5.67
	24	30	27	20	74.07	568	28.40 ± 9.14
Independent house	2	30	28	21	70.00	482	22.95 ± 7.64
	3	30	27	18	66.70	477	26.50 ± 17.00
	9	30	23	15	60.00	413	27.53 ± 19.23
	12	30	29	16	55.17	317	19.81 ± 14.21
Commercial	15	30	26	20	76.92	716	35.80 ± 8.03
	16	30	29	17	58.62	366	21.53 ± 8.01
Mixed house	4	30	23	20	76.92	407	20.35 ± 9.60
	6	30	29	18	62.07	523	29.06 ± 10.00
	7	30	29	25	86.21	1023	41.68 ± 11.92
	8	30	27	15	55.56	321	21.40 ± 7.01
	13	30	29	13	44.83	260	20.00 ± 5.15
	17	30	28	21	83.33	974	38.96 ± 17.18
Total		600	556	371		10625	

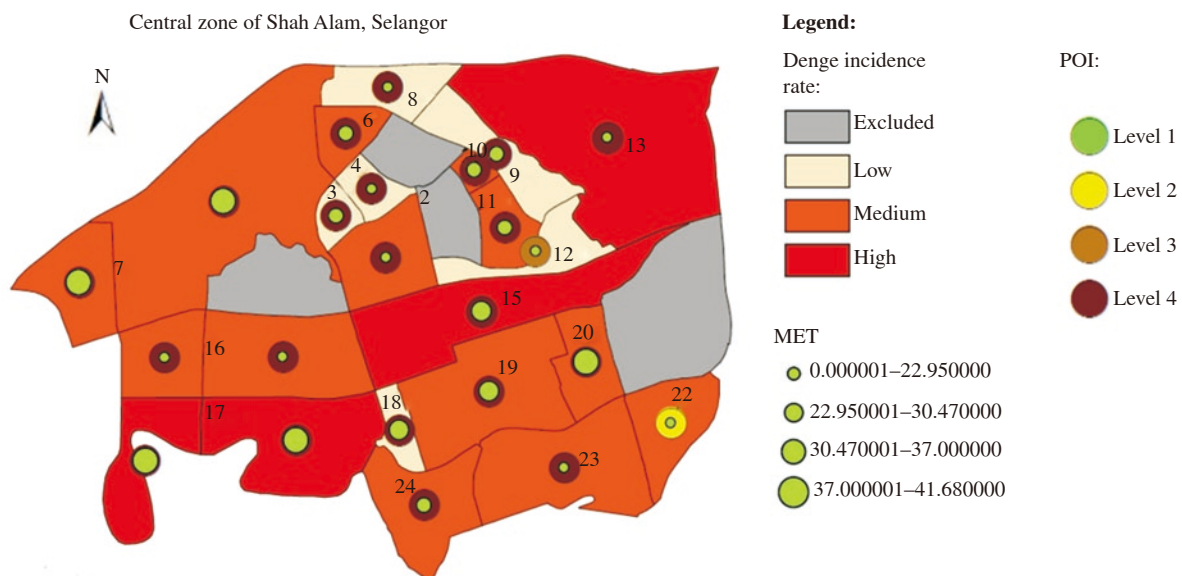


Figure 2. The prevalence rate and infestation profile of *Aedes* mosquitoes.



Figure 3. The environmental condition in few study localities.

A: Backyard condition of the interconnected houses in Seksyen 20; B: The abandoned flower pots were left at the backyard in Seksyen 24; C: The abandoned kitchen utensil were left in stagnant water in Seksyen 2; D: Illegal settlement of garbage at independent housing area in Seksyen 9; E: The construction materials were prolonged stored at the backyard of a commercial building in Seksyen 16; F: The breeding habitat on the abandoned display table used in commercial activities; G: Improper storing of unused materials offers a breeding habitat in mixed housing area of Seksyen 7; H: The backyard with vegetation in Seksyen 17.

result also showed that the localities with low incidence rate could experience the high reading of POI as well as MET value.

Table 4 presented the statistical analysis of One-way analysis of variances (ANOVA) between the POI and MET in relation to the type of housing area in central zone of Shah Alam. From the result, it is clearly shown that there was no significant difference in the distribution and abundance of the mosquitoes in between type of habitat referred as different type of houses. The type of housing is not contributing to the density of the *Aedes* mosquitoes in central zone of Shah Alam.

Table 4

The relationship of infestation profile (POI and MET) with different type of houses.

Variables	Type of house	n	Median (SD)	F statistic (df)	P value
POI	Interconnected houses	8	63.33 (8.04)	0.174 (3;19)	0.912
	Independent houses	4	62.96 (6.65)		
	Commercial	2	67.77 (12.94)		
	Mixed houses	6	68.15 (16.57)		
MET	Interconnected houses	8	28.26 (9.55)	0.246 (3;19)	0.863
	Independent houses	4	24.20 (3.52)		
	Commercial	2	28.66 (10.09)		
	Mixed houses	6	28.58 (9.72)		

One-way ANOVA test applied. Significant value: $P > 0.05$

3.4. The breeding habitat characteristics of *Aedes* mosquitoes in central zone of Shah Alam

The surrounding conditions of the houses were the key factor of the *Aedes* infestation. Figure 3 revealed the environmental conditions of some localities in central zone of Shah Alam. It was observed that the lack of proper storing and the cleanliness offered the favorable

conditions for *Aedes* to breed in. The plastic materials were stored outside the house and exposed to the rainwater to produce stagnate on them. Besides that, the backyards were also neglected from being maintained and were not regularly checked. Figure 3 shows the actual backyard condition which decorated with unpleasant view where the vegetations were not maintained and the backyards were functioning as the place to discard the unused materials.

4. Discussion

The result obtained from this study has an important implication for further research, surveillance and control of dengue fever outbreak in Malaysia. Based on the epidemiological analysis, it shows that the pattern of dengue fever cases was already circulating in central zone of Shah Alam and most likely influenced by the environmental condition in relation with the ecology of *Aedes* mosquitoes surrounded in the study localities. The evolution of the *Aedes* in human habitat is significantly correlated with the environmental factors of weather variables (relative humidity, temperature, and precipitation) but the researchers ignored the environmental characteristic that serves as the fertile ground for *Aedes* to breed in[24,27]. Besides that, the land-use pattern in Malaysia plays a role in distribution of dengue incidence. The residential areas are found to be contributing to higher incidence of dengue fever cases compared to industrials and commercial areas[8,10,11]. This is due to the high population density in residential area as well as favourable places for *Aedes* to infest which created by humans themselves.

Previously, dengue vector surveillances in Malaysia found that the *Aedes* abundance is related to the population and human activity[25]. The occurrence of positive ovitraps in sampled houses is

an indication of human activity that provides a suitable environment for the propagation of the *Aedes* species in the residential areas. The ovitraps are likely to be a sensitive, economical and a useful technique to monitor the dengue vector in communities[17,28]. Besides that, this ovitrapping method is convenient in monitoring the number of eggs laid in standard trap in a specific time period which would give a relative measure of the number of mosquito in the same area[17,29]. On top of that, the placement of the ovitraps can also indicate the neglected or the effectiveness of the current prevention and control measure such as larvicides application. Many researchers have reported in their studies, especially in Brazil and America, the ovitraps do not provide the estimation of *Aedes* mosquitoes population densities but they can give insight into relative changes in the adult female populations[16,30]. However, in this present study, the variables numbers of *Aedes* among study localities were observed in our data as tabulated in Table 3 and presented in Figure 2. These findings are likely to associate with the competition for the natural oviposition sites[24]. When applying the indices of POI and MET for this surveillance, one must be aware that an ovitrap error may come from the competitive deposition probability with other natural oviposition sited for female mosquitoes and it varies from site to site. In order to fill this gap, this present study also analyzed the environmental conditions of the study localities to scrutinize the environmental factors of the *Aedes* infestation in different type of housing areas.

The present study also tried to relate the infestation profile of *Aedes* mosquitoes using the POI and MET indices with the type of housing area without considering the epidemiological data of dengue fever cases. The result in Table 4 showed that there is no significant difference ($P > 0.05$) exhibited in the relationship between infestation profile and the housing areas. The housing type does not influence the distribution and abundance of *Aedes* mosquitoes in central zone of Shah Alam. This means that all type of houses can act as the exposed area in distributing the dengue virus. It is very important to understand the presence of water that will provide breeding sites for the mosquito and which will then increase the vector population density as well as the possibility of transmitting the dengue virus to human beings[11]. Therefore, it is crucial for all the parties especially publics to be alert with the *Aedes* breeding sites like water holding containers.

The result from the environmental survey (Figure 3) revealed that the residential areas play a main role in serving the fertile ground for *Aedes* infestation and subsequently transmit the dengue viral pathogen to human population. The housing areas in central zone of Shah Alam mostly demonstrated the greenery view of the backyard where people tend to decorate it with the ornament plant and other vegetation types. These situations then lead to the irresponsible people to leave with unsanitary environment thus promotes ideal conditions for breeding site[8]. The public should notice that the vegetation surrounding also provide the avenue for *Aedes* mosquitoes to breed. This is due to the fact that certain types of vegetation are able to serve breeding places for mosquitoes. In particular, plants with large leaves that curl up after being shed on the ground, such as *Artocarpus elasticus*, tend to trap rain water and become potential

breeding sites[8]. Besides that, the fallen leaves or other debris would necessarily trap the clear water and give rise to the *Aedes* breeding habitat.

The nature of the vector breeding habitat was also associated with the influence of human social factor. The people living in central zone of Shah Alam regardless of their economic status were still practicing the behavior and traditional habits of managing the municipal waste. This can be proven in the findings in Figure 3, where the public did not achieve the satisfying level of hygiene awareness. Despite that the local authorities have a regular waste management collection schedule, there is still illegal settlement as shown in Figure 3D. People are still practicing their old way of gathering the garbage which will then be burnt and finally the leftover will act as suitable water holding site for *Aedes* to breed. On the other hand, the result also revealed the improper storage of the unused materials like broken flower pots, kitchen utensils and other man-made containers are being left outside and not covered. As a tropical country, Malaysia experienced a frequent raining throughout the year thus promotes the water to stagnate in the exposed containers.

These findings indicate that the surrounding environments have effect on the breeding habitat of *Aedes* mosquitoes. The improvement of environmental condition can permanently control the dengue fever outbreak. The principle dengue transmission chain can be broken by destructing the *Aedes* habitat; it is either the destruction of the immature stages or disruption of the mosquito immature life cycle. The preventive measure of *Aedes* infestation is as simple as withdrawing the stagnant water by reversing the containers. These can be effectively achieved through a public participation with guidance from health authorities in motivating the public to actively contribute vector control activities.

As a conclusion, the key to effectively control the dengue fever outbreak is to have an advanced understanding to all the high potential transmission areas or habitat which are generally the areas with the densest human and vector population. These findings in present study demonstrated environmental characteristics of all the indices measured across the study area. However, it was noteworthy that there was no significant difference to prove that type of housing area can affect the infestation profile of *Aedes* mosquitoes. The environmental risk factor is the key of the *Aedes* distribution that should be effectively control to reduce the dengue transmission in Shah Alam.

Conflict of interest statement

We declare that we have no conflict of interest.

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