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Spatial and Temporal distribution of *Aedes* (Diptera: Culicidae) mosquitoes in Shah Alam

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Abstract. Surveys are conducted at central zone of Shah Alam in determining the distribution of dengue vector mosquito population. A minimum of 100 houses was randomly searched for breeding at every 24 localities in central zone of Shah Alam. Number of buildings at central zone of Shah Alam was obtained from the local authorities in order to calculate the sample size. The positive and wet containers in each locality were recorded and the types of container for positive containers were categorized accordingly. The numbers of larvae in each container were collected. The pupal index (PI), house index (HI), container index (CI), and the Breteau index were calculated for each locality. Plastic containers (CID 1) showed the highest number of positive, while Seksyen 1 and Seksyen 14 showed the highest percentage of BI with 70% and 80% respectively. This study would provide the information regarding Aedes mosquito infestation and , highlighted the central region as the dengue fever was fluctuating in these area. It can also help to create strategy to reduce the mosquito menace in our country with more cost-effective mosquito larval control.

INTRODUCTION

Mosquitoes are one of the primary vectors that are responsible in the transmission of disease to more than 700 million people across the globe (Rajakumar & Rahuman, 2011). In urban areas, one of the big problems facing the human race that is causing significant health burden is mosquito-borne disease which is dengue fever (DF) (LaDeau *et al*., 2015). Current statistic revealed that about 390 million dengue cases were reported and 96 million manifest clinically every year (Bhatt *et al*., 2013). *Aedes aegypti Linnaeus* 1762 and *Aedes albopictus Skuse* 1884 are the two main vectors that contribute to the transmission of dengue (Dom *et al*., 2016). *Aedes* mosquito needs a standing clear water in order to complete the lifecycle, therefore even a small standing water will act as an potential larval habitat for *Aedes* mosquito (Vezzani *et al*., 2004). Commonly, *Aedes aegypti* were found nearby the residential area as the flight range of *Aedes* mosquito are approximately 500m (Dom *et al*., 2016) while *Aedes albopictus* are usually found outdoors and breeds in both natural and artificial containers (Delatte *et al*., 2009). In urban areas, the increasing number of dengue cases have been highly related with increasing number of mosquito breeding habitat (Alirol *et al*., 2011).

DF has become a very important public health issue throughout the world. Over a decade, the reported case of this disease has increased tremendously. It is endemic in many regions throughout the world and recent data shows that DF has been a threat to more than 2.5 billion people (Guillena *et al*., 2010). Approximately about 50-100 million dengue cases were reported every year (Getachew *et al*., 2015). Clinical manifestations of DF vary from fever, shock, hemorrhage, and death with fatality rate of 10-15% (Gargi *et* *al*., 2013). Dengue epidemic has become the central issues and also causes significant economic and health burden worldwide.

The menace to control this mosquito problems involves many methods and it mainly involves the usage of insecticides, but this method has been proven not competent as the mosquito are adapting and developing resistance towards the insecticides (Ranson *et al*., 2010). Thus, reduction at source through surveillance is more preferred and also entomological surveillance is the common method being used in determining the changes in the density and distribution of the vector to ensure timely response and control. *Aedes* mosquitoes are commonly found in tropical and subtropical areas, especially the urban areas (Patel *et al*., 2015). In urban and suburban areas of Malaysia, ovitrap and larval surveillance are the main method being conducted in controlling dengue vector (Rozilawati *et al*., 2015). Intensive knowledge regarding the spatial and temporal distribution of entomological information will provide the local authorities the advantages by focusing on the high risk area for a more effective mitigation measures can be taken to reduce the disease transmission (Chi *et al*., 2015). Surveillance is a very crucial step in monitoring the dengue transmission in a specific area and should be practiced regularly for early detection of an incoming outbreak and also to enhance a more proper and effective control measures. Thus, the objectives of this study were to determine the breeding preference and abundance of dengue vector (DV) in selected dengue prone localities in Shah Alam (SA), Selangor using larval survey method.

MATERIALS & METHODS

The epidemiology data on daily DF cases from 2012 to 2014 were obtained from Majlis Bandaraya Shah Alam (MBSA) and further analyzed. Through the spatial analysis of DF cases, some properties of the DF epidemic may be expressed by comparing the zones for the incidence of DF. The central zones of Shah Alam (SA) were recorded as the highest DF cases as compared to north and south zone of SA. The DF cases in the central zone are cluster and have high population density. Therefore, based on this information, the central zones are chosen as the study sampling area. In this study, dengue risk area in the central zone of SA area is chosen as the main research site which has a significant public health implication in relation to the control and prevention of dengue. SA consists of 3 zones which are Northern Zone, Central Zone and Southern Zone. The landscape profile of this area is the urban area with rapidly developed. The major land area in this study area is the residential, commercial and industrial area. Besides that the forested areas and construction area also have shown the rapid changes trend, and this might affect the trend of DVs distribution.

A group of 5 persons were appointed to carry out the larval surveillance from October 2015 to December 2015 at the justified specific localities. A house-to-house cross-sectional entomological survey was carried out at the peridomestic area to search for larval breeding. The survey was conducted between 8 am to 12 pm. A minimum of 100 houses will be inspected in each of the locality. All possible outdoor containers or receptacles holding water were thoroughly inspected. The surveillance compound also extended up to 200 meter radius from each house as practicable as possible to represent the *Aedes* species that infested the particular area. According to WHO (2016), *Aedes* species flight range is not far and particularly *Aedes aegypti* flight range is 100 meter. They will travel within the 100 meter from where they emerged and feeding almost entirely on human during daylight hours both indoors and outdoors (WHO, 2016). The level of infestation of *Aedes* mosquito can be enhanced by the characteristics of the surrounding environment. Natural and artificial water containers were inspected visually for the presence of mosquito larvae and pupae (Rozilawati *et al*., 2015). Each of the containers was examine and recorded the container type, sun exposure, lid status, and water type.

The immatures are being sampled by using dipping and pipette method (Vikram *et al.*, 2016). Dipper and pipette is the most commonly used tools for collecting mosquito larvae from a wide variety of habitat. Larvae collected from the field were identified to determine the species. The equipment that was used for identification is the compound microscope. The identification was aided by the Pictorial Key for Identification of Mosquito by Leopoldo M. Rueda (Rueda, 2004; Dom *et al.*, 2013).

Four indices were used to record mosquito density level which is house index (HI), container index (CI), Breteau index (BI) and pupal index (PI). When HI>5% and/or BI>20% for any locality thus will be classified as dengue sensitive area and therefore adequate preventive measures should be taken. Depending on potential outbreak, an area can be placed in following categories (Minhas and Sakhon, 2013; Patel *et al.*, 2015). A locality was classified into Priority I group when there are death due to dengue confirmed. Priority II group or being labeled as dengue sensitive area is when HI>5% and/or BI>20% for any locality. Priority III group when HI<5% and/or BI<20% for any locality and a locality will be classified into Priority IV group when despite active search already conducted, there are no positive breeding sites found.

The containers observed at the sampling sites were given an identification number known as container identity (CID) as showed in Figure 1. A container with any amount of water was considered a wet container (WC). The WC with any number of larvae or pupae was considered a positive container (PC).

All WC collected from the field were classified according to the intended use and importance in practical life. They were arranged under 7 classes of containers. Class 1 was considered the most important and comprised large-sized containers (water reservoirs). The city dwellers usually use them to store water for their regular use. Class 2 containers (buckets, empty paint cans, and covers) were medium to small in size. People use them for household purposes. Class 3 containers consisted of ornamental containers (flower vases and earthen pots). Class 4 containers included used or discarded but recyclable objects (tires, plastic pots, polyethylene sheets, etc.). Class 5 containers were discarded and non-recyclable (ceramics, metal cans, car parts, etc.). Class 6 was a small group of necessary containers (dustbins and antguards), which could not be discarded but easily maintained. Class 7 containers were natural mosquito larval habitats (tree holes, leaf axils, etc.).

RESULTS

A total of 2080 houses were inspected in central zone of SA and 113 houses were classified as positive house or premise that had presence of immature *Aedes* species. 663 containers were classified as wet container and 171 were classified as positive container cumulatively. Most of the larvae collected are *Aedes albopictus* (90.71%) and *Aedes aegypti* (9.29%).

Figure 2(A) shows that Seksyen 2 and Seksyen 4 have the most number of houses (>150) inspected during this study. Most of the localities inspected had more than 100 houses. There are 5 localities inspected with less than 100 houses which are Seksyen 1, Seksyen 9, Seksyen 10, Seksyen 14 and Seksyen 22. There are also localities where surveys were nt conducted which is Seksyen 5, Seksyen 12, Seksyen 15, Seksyen 16, Seksyen 21and Seksyen 23. All localities that were inspected showed that the number of positives varied from 1 to 13 houses with Seksyen 14 are the least with 1 house and Seksyen 17 with the highest positive houses with 13 houses.

According to Figure 2(B), Seksyen 20 shows the highest number of wet containers(105) followed by Seksyen 1(73). The least wet container was recorded in Seksyen 9 with only 5 wet containers. On the other hand, the numbers of positive containers varied from 2 to 15 containers. The highest and lowest numbers of positive containers are found in Seksyen 17 and Seksyen 9 respectively.

Figure 1. List of container identity (CID) adopted from Saifur *et al*. 2013.

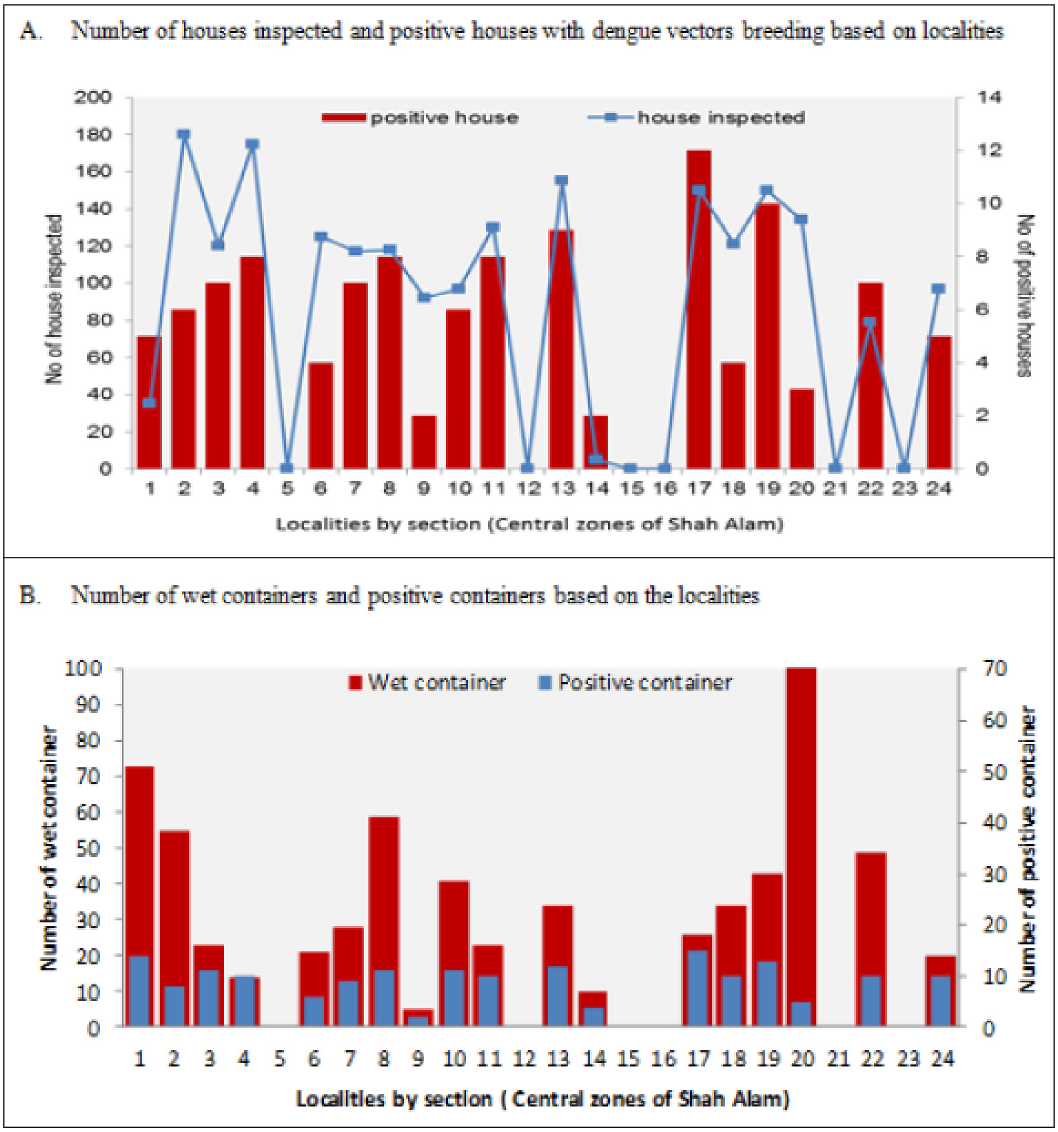

Figure 2. Traits of dengue vectors collection throughout central zones of Shah Alam, Selangor; A) Number of houses inspected and positive houses with dengue vectors breeding based on localities; B) Number of wet containers and positive containers based on the localities.

Based on Figure 3(A)(B)(C), this study has showed that Seksyen 1 and Seksyen 14 showed the highest HI with 25% and 20% respectively whereas the lowest HI were recorded at Seskyen 20 with 2.5%. The highest CI was recorded at Seksyen 4 with 71.32% followed by 57.69% at Seksyen 17. The lowest CI was recorded at Seksyen 20 with 4.76%. There is big difference of reading recorded for BI which varied from 2.67% to 80%. Seksyen 14 shows the highest percentage with 80% followed by Seksyen 1 with 70% while Seksyen 9 shows the lowest BI recorded.

Table 1 shows that CID 1 has the highest positive containers (111) followed by CID 4, 5 and 6 recorded the least number of positive containers with only 4 containers each. Among the CID, CID 6 has shown the highest CI with 44.44% followed by CID 7 with 37.93%. Moreover, CID 5 had the highest BI with 14.63% followed by 12.39% for CID 1. The least BI were recorded for CID 8 with only 2.29%.

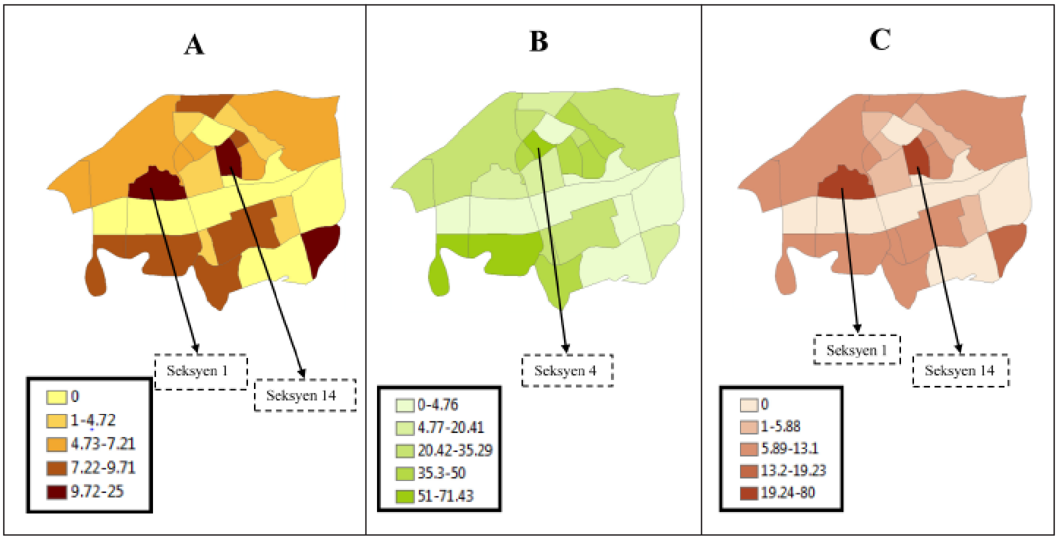

Figure 3. Spatial distribution of the dengue vector indices in central zones of Shah Alam; A) House index (HI); B) Container index (CI) and C) Breteau index (BI).

Table 1. Type of container with container index, pupal index, container productivity and container efficiency

Container class	CID	Positive container (n)	CI (%)	PI (%)	Container productivity[1] (%)	Container Efficiency[2]
1	2	18	18.56	9.33	10.39	0.99
2	5	4	20.00	14.63	2.15	0.92
3	4	4	21.05	7.69	1.25	0.53
3	8	7	35.00	2.29	0.72	0.18
4	3	12	14.29	8.08	4.66	0.66
5	1	111	28.83	12.39	75.99	1.17
6	7	11	37.93	6.42	3.41	0.53
7	6	4	44.44	10.53	1.43	0.61

[1]Productivity = number of immatures × 100/all immatures.
[2]Efficiency = productivity/ prevalence of container. Prevalence of container = number of wet containers × 100/all containers.

DISCUSSIONS

This study has showed an abundant population of *Aedes* mosquitoes in different areas of central zone. Shah Alam. Malaysia has a climate that is conducive for the life cycle of mosquitoes. Climatic properties such as temperature, humidity, and rainfall can influence the abundance of *Aedes* mosquito in a area (Patel *et al*., 2015). A variety of breeding containers were found at peri-domestic areas. Study by Saifur *et al*. 2013 stated that urban areas that are highly developed had more *Aedes aegypti* compared to rural areas. In this study the location of the survey was the central zone of Shah Alam which is a very highly developed area and the results are not the same as the results of previous studies. The present study shows that *Aedes albopictus* are more abundant than *Aedes aegypti*. This is due to the sampling areas are only focused on the peridomestic area. Most of the residential areas in central zone of Shah Alam has a green landscape which are more suitable for *Aedes albopictus*. Rozilawati *et al.*, 2015 state that *Aedes aegypti* are dominant indoors while *Aedes albopictus* remained as the dominant outdoor mosquito breeder. This also showed that the mosquitoes are evolving. Maybe their adaptation to the new environment has occurred.

Seksyen 2 and Seksyen 4 shows high number of houses inspected but there are difference in the number of wet and positive containers found in that particular area with Seksyen 2 having a higher wet container compared to Seksyen 4. This indicates that Seksyen 2 has a high probability for higher mosquitoes breeding. The numbers of houses that are positive in each locality are almost similar but Seksyen 17 showed the highest number of houses(13) that were positive but also had high low numbers of wet containers. This is supported by the CI at Seksyen 17 which was the second highest among all localities after Seksyen 4. It can be concluded that both Seksyen 4 and Seksyen 17 are most susceptible in terms of breeding containers as the CI were the highest. But, in term of HI, most of the locality are classified within the first priority group with HI more than 5%. HI, CI and BI are the most common method in developing countries (Petric *et al.*, 2014). Petric *et al.* (2014) also state that BI is more accurate when compared to HI and CI. According to Patel *et al.* (2015), the first priority in term of BI is when BI is more than 20%. From the results, Seksyen 1 and Seksyen 14 are show with a BI of more than 20% with 70% and 80% respectively. From the overall results it can be concluded that Seksyen 14 as the most susceptible locality for the breeding of mosquitoes and thus there is a need to focus the surveillance in that area by the local authority.

The characteristics and types of breeding sites can be related with the human habitat conditions and their social behaviors. The pattern and types of containers are changing tremendously within a short time, locality and urbanization. In this study, CID 1 (plastic container) such as dustbins, food container and discarded toys were classified as the key containers with an efficiency of 1.17. CID 1 is found to be the most prevalent as it covers 67.3% of containers from all localities with the container productivity of 75.99%. Most of the residences were not aware on the importance of discard the used plastic containers properly. The hectic pace of living makes city dwellers with less time to manage their backyards and discard plastic materials that act as the main potential source for mosquitoes breeding. There are also larger plastic containers that are used to store rain water for daily use, such as for watering their plants. Unfortunately, there is lack of awareness and water that was not utilized are not covered thus becoming a source for mosquito breeding. Saifur *et al.* (2013) state that lids can reduce mosquito breeding because covered water container are less attractive for mosquitoes as it has less scope for surface area for mosquito to lay eggs. As the study area is in the tropical country, the frequent rain in this particular region contributes to attract mosquitoes to breed, which which accounts for 45,0% of the breeding sites for mosquito (Saifur *et al.*, 2013).The CI is highest for CID 6 which is natural containers. Although the CI are high, the number of wet containers found are only few and almost all found contained *Aedes* species. This can be related as the natural container contains higher nutrients compared to other artificial containers. Thus, have lead CID 6 to have higher CI. Pupal index are higher in CID 5 with 14.63%. The results are supported by a study by Saifur *et al.* (2013) that stated that there is an increase of 50.0% in mosquito immatures due to the increase use of canned products.

CONCLUSIONS

CID 1which is plastic container are the most preferences breeding habitat for *Aedes* mosquito and the number plastic container being found also the highest which reflects the abundance of mosquito in those area. According to BI, Seksyen 1 and 14 shows high BI thus reflects that particular area have high mosquito abundance. The local authority can give a special attention to the key containers and specific locality in managing their task. This study also can be improved by conducting other method such as ovitrap surveillance together with the present methods. Positive ovitrap index (POI) and mean eggs per trap (MET) can be used to strengthen and supports the results obtained.

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