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ENVIRONMENTAL ASSESSMENT AND INFESTATION LEVEL OF THE DENGUE VECTORS AT RESIDENTIAL AREA IN PUNCAK ALAM, SELANGOR

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Abstract: The control of mosquitoes in residential areas calls for in-depth knowledge of the breeding habits of the mosquitoes, especially *Aedes aegypti* and *Aedes albopictus*. Therefore, this study aims to assess the environmental condition and infestation level of Aedes vectors at selected residential areas in Puncak Alam, Selangor. The aims of this study are to understand the environmental profile of residential areas towards infestation level of dengue vectors. A pilot study was conducted in Puncak Alam in order to understand the infestation profile of dengue vectors in residential areas by assessing the environmental condition index (ECI) in front and yard area of residential area. In this study, a minimum of a hundred houses in each residential area was observed for the environmental condition of front and yard of the premises. Concurrently, a total of thirty ovitraps were placed randomly at outdoor premises in order to measure the infestation level of the Aedes mosquitoes. A total of 318 households were inspected in both front area (F_A) and yard area (Y_A) where in general, the environmental condition in front of houses is better than the yard area. The same pattern was also observed in which the infestation level of Aedes mosquito population in F_A and Y_A ranged from 15.40 – 35.25 and 11.88 – 47.91, respectively. In conclusion, environmental conditions play a main role in the distribution of dengue vector.

Keywords: Residential area, environmental condition, infestation level, Aedes.

Introduction

Urbanisation is a factor that can increase the number of preferred habitats for Aedes mosquito thus increasing the density and survival of Aedes mosquito especially in a residential area (Saleeza *et al*., 2011). Another factor that contributes in dengue transmission and distribution is environmental parameters. This parameter can cause changes in dengue transmission that is related to the host, such as the demographic pattern. Furthermore, the land use such as housing type, soil moisture and greenness can contribute to the epidemic of dengue transmission (Aziz *et al.,* 2011).

Community areas, particularly residential areas, are located in close proximity to major mosquito habitats. Previous entomological studies showed that dengue vectors have been captured in vegetated areas (Hayden *et al.,* 2010; Vezzani *et al.,* 2005), rubber plantations (Paily *et al.,* 2013; Sumodan, 2003), marshy swamps (Sarfraz *et al*., 2012) and brackish waters (Idris *et al.,* 2013; Ramasamy *et al.,* 2011). The presence of vegetation condition between community area and mosquito breeding site provides a disposal route for biting insect to community areas. According to Kesetyaningsih *et al.,* (2016) the mosquito survival was affected by humidity that is maintained by the presence of vegetation. Next, human ecology is responsible for the creation of a mosquito genic environment. Generally, residential area is a potential source for the existence of breeding sites due to environment condition, either indoor or outdoor area.

Vector surveillance can be used to determine changes in the distribution and vector density and to obtain relative control measurement of the vector population. It also can serve to identify high-density infestation study area and selection of sampling method depending on the vector surveillance objective. Thus, several

indices have been described as vector population monitor for dengue transmission. There are three approaches of dengue measures commonly used in Aedes surveillance in residential areas namely: (i) premise condition index (Roberto *et al*., 2013; Parasuraman *et al.,* 2012a) (ii) ovitrap surveillance (Rozilawati et al., 2007 and Ligia *et al.,* 2013) and (iii) integrating both approaches (Roberto *et al.,* 2013 and Leticia *et al.,* 2005). Premise condition index (PCI) value score indicates a simple index incorporating predictor of the mosquito breeding (house condition, yard tidiness and degree of shade) that does not require indoor inspection of the premises (Tun-Lin *et al.*, 1995). However, vulnerability of the PCI includes inability of the inspector to observe many rear yards' condition and the risk of seeing inconsistent PCI scoring between different inspectors (Parasuraman & Radhakrishnan 2012b). Review conducted ~~by~~ from Ligia *et al.,* (2013) showed that mosquito behaviour is the main factor in the disease epidemiology transmitted by mosquitoes. Therefore, the ovitrap acts as an effective tool for providing spatial and temporal data in dengue control measures. In general, most of the surveillance studies, either the epidemiological evidence or quantitative methods were used for assessing the dengue transmission.

Ovitrap surveillance was used as a sampling technique to detect and measure the density of mosquito population by measuring the positive ovitrap index (POI) (Ligia *et al.,* 2013; Wan Norafikah *et al.,* 2009; Rozilawati *et al.,* 2007). POI is a percentage of Aedes positive ovitrap divided by number of ovitraps collected from the study (Wan Norafikah *et al.,* 2009). Prevention and control measures of the dengue disease are dependent on vector surveillance and control measures by integrating both approaches of ovitrap surveillance and the environmental condition index (ECI) as an indicator of mosquito infestation that could be used to relate between ECI and infestation to determine the density of mosquito population (Roberto *et al.,* 2013). The ovitrap has been used as a proxy to measure a number of adult mosquitoes present from the total number of eggs laid in their habitat. Therefore, this study was aimed to assess the environmental condition and infestation level of Aedes vectors at selected residential areas in Puncak Alam, Selangor.

Materials and Methods

Study Site and Study Population

Puncak Alam is the main township development in the Kuala Selangor District, ~~State of~~ Selangor, Malaysia and has been selected as the case study area. Kuala Selangor District is one of the less urbanised districts in Selangor. It is located approximately 20 kilometres in the northwest direction from Shah Alam, the state capital of Selangor. Puncak Alam development started in the late 90's under the management of Bukit Cherakah Development Sdn Bhd with approximately 57km^2 in size. Currently, most of the developments in Puncak Alam are housing area with a small percentage of commercial and industrial units. As a sub-urban area, Puncak Alam is surrounded by rural lands within the boundary of Kuala Selangor district. Puncak Alam was selected due to its population distribution with a variety of new residential areas and has a significant public health implication in relation to control and prevention of dengue outbreak.

Study Design

A minimum of 318 houses in selected residential areas in Puncak Alam was inspected in each zone (A, B and C). Within the selected residential area 30 houses chosen randomly/ zones were used to observe the condition of the environment and to measure the infestation of Aedes vectors, using ovitrap. The front and back yards of the premises were used to evaluate the environmental condition of the residential areas using the criteria that contribute to the existence of mosquito activities which include house maintenance, solid waste management, degree of shade and drainage facilities. Then each premise was scored from lower to the highest according to the method developed by Tun-Lin *et al.,* (1995). At the same time, the ovitraps were placed randomly at outdoor premises in a

shaded area in order to measure the infestation of Aedes vectors. After consecutive days of exposure, the ovitraps were recollected and then were brought to the laboratory for egg count and species identification (Hasnan et al., 2017).

Environmental Condition Assessment

The purpose of this assessment is to evaluate the environmental condition including drainage facilities and solid waste management. The poorly built and improperly managed drainage system can contribute to the high mosquito infestation. For instance, the clogged drains with clear stagnant water are considered good artificial container to female mosquitoes that lay their eggs to complete the life cycle. Mosquito infestation can become worse when residents illegally dump the waste or garbage around the housing area. Meanwhile, the condition of the premises was observed if they are structurally well kept or poorly maintained that could contribute to mosquito infestation. Table 1 shows the descriptions of components and scores used to assess the environmental condition.

As for scoring of the environmental condition index (ECI), the house was classified into three classes. Score 1 = well maintained house (structure in good condition, new paint, place is visibly clean and well maintained), Score 2 = reasonably well maintained (poor or simple structure, but well organised and clean) and Score 3 = poorly maintained (poor structure, peeling walls, broken or improvised items, little organisation or cleanliness). Yard classified as Score 1 = well maintained (organised, no apparent waste or scrap, grass is short, yard well maintained), Score 2 = reasonably well maintained (moderately well-kept or poor structure, but well organised and clean) and Score 3 = poorly maintained (disorganised, waste or scrap seen, unkempt grass, tires, bottles). The degree of shadow classified as Score 1 = little or no shade (external area with less than 25% of 41 shade, no large tress or any other structure that works as a sunblind), Score 2 = some shade (degree of shade in external area ranging from 25% to 50%) and Score 3 = plenty of shade (external area with over 50% of shade, large tress, a sunblind-like structure and layers

Table 1: The descriptions of components and scores used to measure the environment condition index (ECI) (Tun-Lin *et al.,*1995)

Score	House Condition	Front/Yard Condition	Degree of Shade	Drainage Facilities
3	**Poorly maintained** (poor structure, peeling walls, broken or improvised items, little organisation or cleanliness)	**Poorly maintained** (disorganised, waste or scrap, unkempt grass, tires, bottles)	**Plenty of shade** (external area with over 50% of shade, large tress, a sunblind-like structure, and layers of shrubs with a greenhouse effect)	**Poorly maintained** (poor structure, little organisation or cleanliness)
2	**Reasonably well maintained** (poor or simple structure, but well organised and clean)	**Reasonably well maintained** (moderately well-kept or poor structure, but well organised and clean)	**Some shade** (degree of shade in external area ranging from 25 to 50%)	**Reasonably well maintained** (poor or simple structure, but well organised and clean)
1	**Well maintained** (structure in good condition, new paint, place is visibly clean and well maintained)	**Well maintained** (organised, no apparent waste or scrap, grass is short, yard well maintained)	**Little or no shade** (external area with less than 25% of shade, no large trees or any other structure that works as a sunblind)	**Well maintained** (structure in good condition, well organised and well maintained)

of shrubs with a greenhouse effect. Whereas, the score of drainage facilities regarded as Score 1 = well maintained (structure in good condition, well organised and well maintained), Score 2 = reasonably well maintained (poor or simple structure, but well organised and clean) and Score 3 = poorly maintained (poor structure, little organisation or cleanliness). Finally, the environmental condition was classified based on the average score. The interpretations of the scores are: Good (Score 4 & 5), Regular (Score 6 & 7), Bad (Score 8 & 9) and the Worst (Score 10 & 11).

Infestation of Aedes Vector Using Ovitrap Surveillance

A total of thirty ovitraps were placed randomly in each residential area and was pre-determined to be placed outdoor. Wan Norafikah *et al.,* (2011) mentioned that all ovitraps should be placed in proximity to other potential breeding containers with minimum physical and environmental disturbance and then recovered after three to four days. Before that, the remaining water contained inside the ovitrap was not disposed, instead, it was kept and the ovitrap container was wrapped ~~by~~ with plastic to prevent water from leaking and then brought to the insectarium. Next, the water in the ovitrap container was filtered in order to collect eggs that had fallen from the paddle.

Data Analysis and Management

(i) Environmental condition assessment: Premises was scored from lower to the highest. After scoring each parameter, the final score was evaluated to indicate the environmental condition of the residential area. *(ii) Infestation of Aedes vectors*: Positive ovitrap index (POI) was calculated and classified into four levels, namely level 1 (POI<5%), level 2 (5% < POI<20%), level 3 (20% < POI < 40%) and level 4 (POI > 40%) to determine the infestation level. The trend analysis was used to determine the pattern of environmental condition and infestation level at selected residential areas. All statistical calculation was performed using Statistical Package for Social Science (SPSS).

Results and Discussion

A total of 318 households were inspected in both the front area (F_A) and the yard area (Y_A) for the presence of pre-mature and adult *Aedes albopictus*. The number and percent distribution of the positive houses according to the environmental condition assessment was ranked as shown in Table 2. The lowest score indicates a good condition and low risk for mosquito infestation at a residential area, while the highest score indicates the worst condition and favourable breeding environment for mosquitoes.

Environmental condition assessment: Generally, the majority of houses in the residential areas in Puncak Alam were classified as regular condition. Furthermore, the conditions of the front and the yard of houses were also evaluated where the yard condition recorded the highest score (Y_A: 105) as compared to the front condition of the houses (F_A: 94). This finding indicates that the environmental condition in front of the houses is better than the yard area. This finding reflects the favourable breeding environment condition in residential housing areas (Figure 2).

Figure 2: Environmental condition of housing in the residential area in the front and the yard conditions based on different scores, which reflect the favourable condition for Aedes vectors

Infestation profile of Aedes in residential areas: A total number of 270 ovitraps were deployed randomly which were placed in residential areas. During the survey, 87% - 90% of ovitraps were recovered after four consecutive days. In general, all residential areas in both settings, either in the front of houses or the yard, the conditions had high infestation level and the POI percentage was recorded at more than 50% (Figure 3A). The results indicate that the residential area acts as the main area for distributing the dengue virus due to the availability of artificial breeding places, mainly caused by the surrounding conditions that are capable of storing water.

Trend analysis was conducted in searching the connection between the pattern of environmental condition and infestation of Aedes vectors in residential areas and this has led to a comparison of the environmental condition and infestation of Aedes vectors. This preliminary analysis has demonstrated that most of the high infestation of Aedes vector was observed in residential areas with bad environmental conditions. In fact, the possibility of detecting positive breeding of Aedes was higher in the premises with more shade (75%) compared with very little shade (25%). Furthermore, the ECI score in the front/yard conditions may affect the occurrence of the *Aedes* species eggs (Figure 3B).

From this study, some patterns of habitat preferences were observed. This result shows that the infestation of Aedes vectors in this study is related to human population and human activities due to some factors such as low relative shaded area at human settlement (Gerusa *et al*., 2014; Dom *et al*., 2016). Polystyrene cups, tins and plastic bottles are widely used by our community nowadays. Improper disposal or littering of these materials may increase the number of containers made available for mosquitoes to breed. Source reduction or elimination is known as the most effective way to reduce the population of *Aedes* mosquitoes and the diseases they caused to ▪ the human population. If the effort is done frequently it will lead to a permanent and effective control. Other than that, source reduction is also known as the most economical and easy method to be conducted within the affected areas of this disease-bearing insect. This can be done easily by turning upside down large earthenware to prevent *Aedes* female mosquitoes from breeding,

Table 2: Pattern of environmental condition of residential area based on the front of houses (F_A) and in the yard area (Y_A). The result was based on the criteria for environmental condition namely house condition (V_1), waste management (V_2), degree of shade (V_3) and drainage facilities (V_4)

Locality	Total Premises (TP)	Front Area, F_A Score							Yard Area, Y_A Score						
		Criteria for Environmental Condition Index (ECI)							Criteria for Environmental Condition Index (ECI)						
		V_1	V_2	V_3	V_4	Total Score (TS)	*Average ECI (TS/TP)	Level ECI	V_1	V_2	V_3	V_4	Total Score (TS)	*Average ECI (TS/TP)	Level ECI
1 (A)	35	35	53	87	39	214	6.11	Regular	35	83	48	60	226	6.46	Regular
1 (B)	32	32	52	59	38	181	6.66	Regular	34	67	37	58	196	6.13	Regular
1 (C)	39	39	60	75	40	214	5.49	Good	45	92	53	75	265	6.79	Regular
2 (A)	38	38	68	55	43	204	5.37	Good	45	93	55	63	256	6.74	Regular
2 (B)	35	35	64	70	55	224	6.40	Regular	35	80	53	52	220	6.29	Regular
2 (C)	34	34	51	70	37	192	5.65	Good	34	78	38	70	220	6.47	Regular
3 (A)	36	50	94	87	74	305	8.47	Bad	43	85	53	71	252	6.92	Regular
3 (B)	36	47	70	56	41	214	5.89	Good	54	105	53	83	295	8.19	Bad
3 (C)	33	33	72	55	45	205	6.21	Regular	33	85	64	60	242	7.33	Regular
Average	**318**	**343**	**584**	**614**	**412**	**1951**	**6.14**	**Regular**	**358**	**768**	**454**	**592**	**2169**	**6.82**	**Regular**

*Note: The environmental condition was classified based on the average score. The interpretations of the score are: Good (Scores 4 & 5), Regular (Scores 6 & 7), Bad (Scores 8 & 9) and the Worst (Scores 10 & 11). The annotations in bracket, (A, B and C) represent the zones used to observe the environmental condition and measuring the infestation of Aedes vectors by using ovitrap surveillance.

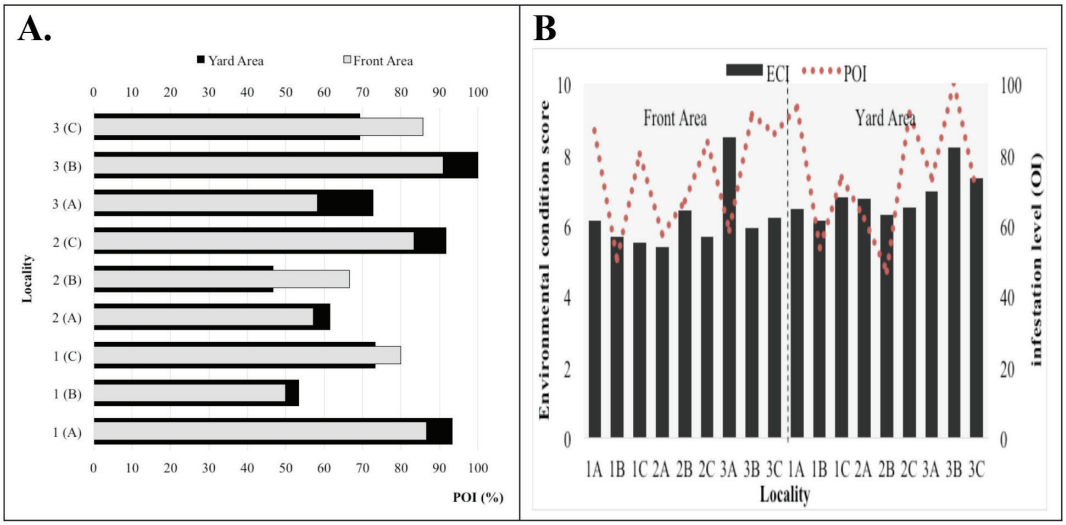

Figure 3: (A) Infestation profile of Aedes vectors in different settings in residential areas (B) Relationship of the environmental condition score with the infestation of Aedes vectors in residential areas.

discarding water retained from all old containers around the houses, as well as properly cleaning up all containers like flower vases that could retain stagnant water. Individuals should be tactful at all times and conduct self-inspection around their houses to see whether there are positive breeding sites under shaded trees or other hidden places that could retain water.

Conclusion

Overall this study found that environmental condition of houses may provide a favourable condition for the Aedes species. The conditions differ based on peoples' habits, such as in water management, water storage due to water scarcity, and works associated with water, like cement works. Thus, the use of ECI indicator can be used in improving the method for vector surveillance. An effective surveillance system is essential for planning, implementation, and monitoring of disease control programmes. Findings from this study help to conduct a rapid survey of Aedes mosquitoes in a place with a minimal number of manpower and in turn, with the help of ECI, delimitation is very possible in residential areas based on the sources of Aedes species breeding habitats. To employ ECI, more experimental studies may be required to make it more suitable

Community-based approach should go hand in hand with educational approach to ensure that the community is exposed to the knowledge of vector control and what the diseases are that vectors would likely spread. Several parties like JKKK (*Jawatankuasa Kemajuan Kampung*) and RT (*Rukun Tetangga*) should play their roles in taking care of safety, health and welfare of the community in their areas. This could be done through "*gotong-royong*" by cleaning the areas and compounds that are prone to be mosquito breeding sites. Also, they can together clean up clogged drains and unused wells to prevent the breeding. Communities that understand the need to make behavioural changes are the ones that are most effective in controlling diseases like dengue.

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