Med & Health Dec 2020; 15(2): 224-235 https://doi.org/10.17576/MH.2020.1502.20

ORIGINAL ARTICLE

Monitoring *Aedes* Population using Ovitrap Index and Larval Abundance in an Urban University Residence

EMMA AISHAH A, MUHAMMAD FIRDAUS MF, NUR SYAFIQAH T, ROZANA MS, SUGASINI SL, SYAMSA RIZAL A, AHMAD FIRDAUS MS, AISHAH HANI A*

Department of Parasitology and Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur, Malaysia

ABSTRAK

Ovitrap autosidal berperanan penting dalam pemantauan dan kawalan vektor denggi, Aedes aegypti and Aedes albopictus. Beberapa jenis ovitrap ini telah digunakan di Malaysia termasuklah Mosquito Larvae Trapping Device (MLTD) yang diperkenalkan oleh Dewan Bandaraya Kuala Lumpur. Kajian ini bertujuan untuk menilai kepadatan larva Aedes dan pembolehubah meteorologi setempat di sebuah penempatan pelajar di Cheras, Kuala Lumpur. MLTD (n=30) dengan umpan larutan baja NPK (5:5:5) organik telah digunakan. Pengumpulan larva dan penyelenggaraan ovitrap telah dilakukan setiap minggu selama lapan minggu. Pemeliharaan larva dan penentuan spesies telah dijalankan di makmal. Daripada sejumlah 2,152 larva Aedes, 85% merupakan Ae. albopictus manakala selebihnya Ae. aegypti. Ae. albopictus lebih banyak dikumpulkan di luar berbanding di dalam bangunan (purata larva per ovitrap, 9.28 lawan 6.08). Sebaliknya, Ae. aegypti lebih banyak dikumpulkan di dalam berbanding di luar bangunan (1.72 lawan 0.86). Ovitrap indeks yang paling tinggi adalah semasa minggu kelima (90%) dan keenam (93%). Minggu pertama menunjukkan ovitrap indeks yang paling rendah (30%). Analisis mendapati korelasi positif antara kepadatan larva Aedes dan suhu maksimum (r=0.830, p=0.011), manakala kelembapan relatif minimum menunjukkan korelasi negatif (r=-0.778, p=0.023). Pemantauan rutin bagi peringkat pramatang vektor denggi boleh memberikan maklumat mengenai kepadatan dan naik turun populasi nyamuk setempat. Apabila digandingkan dengan faktor meteorologi sejajar, maklumat ini dapat memberi panduan bagi perlaksanaan kawalan vektor sebagai sebahagian strategi pencegahan denggi.

Kata kunci: Aedes, cuaca, denggi, indeks, kelembapan, larva, surveilans, suhu

Address for correspondence and reprint requests: Dr Aishah Hani Azil. Department of Parasitology and Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur, Malaysia. Tel: +603-9145 9597 Email: aishah.azil@ppukm.ukm.edu.my

ABSTRACT

Autocidal ovitraps have played a significant role in surveillance and control of dengue vectors, *Aedes aegypti* and *Aedes albopictus*. Malaysia has witnessed the deployment of several types of autocidal ovitraps, which includes the Mosquito Larvae Trapping Device (MLTD) introduced by Kuala Lumpur City Hall. This study aimed to assess *Aedes* larval abundance and local meteorological variables in a university residence, in Cheras, Kuala Lumpur. MLTD (n=30) baited with organic NPK fertiliser (5:5:5) solutions were deployed. Larvae collection and trap servicing were performed weekly for a duration of eight weeks. Rearing and species identification for larvae were conducted in the laboratory. Out of 2,152 *Aedes* larvae, 85% of them were *Ae. albopictus* whilst the remaining were *Ae. aegypti*. Outdoor collection of *Ae. albopictus* surpassed its indoor collection (mean larvae per trap of 9.28 versus 6.08). Conversely, an indoor collection of *Ae. aegypti* was greater than its outdoor collection (mean larvae per trap of 1.72 versus 0.86). The highest ovitrap indices were observed in Week 5 and 6 which were 90% and 93%, respectively. Week 1 had the lowest ovitrap index, 30%. Our analyses revealed a positive correlation between *Aedes* larval abundance and maximum temperature (r=0.830, p=0.011) whereas minimum relative humidity was shown to have a negative correlation (r=-0.778, p=0.023), with the larval abundance. Routine monitoring of dengue vectors at its immature stages can provide information on the density and fluctuation of the local mosquito population. Coupled with concurrent meteorological variables, it can guide vector control operations as part of dengue prevention strategies.

Keywords: *Aedes*, dengue, humidity, index, larva, surveillance, temperature, weather

INTRODUCTION

Dengue is a mosquito-borne disease known to be associated with a spectrum of clinical presentations, including acute febrile illness, haemorrhagic and neurological manifestations, and dengue eye disease such as maculopathy (Umi Kalthum & Wong 2012). Malaysia is one of the countries in South-east Asia dealing with endemic dengue infection every year over the past few decades. The year 2019 recorded a higher number of dengue cases than the previous year. The current total cumulative number of dengue cases from all states in Malaysia reached 130,101 including 182 deaths. Selangor contributed to the vast majority of dengue cases along the 2019 period (72,543). In Kuala Lumpur and Putrajaya alone, the number of cases reported was up to 15,424 (Ministry of Health Malaysia 2020). This clearly shows that dengue infection is highly prevalent in urban areas with high population density.

Dengue virus is transmitted

primarily by *Aedes* mosquito, namely *Aedes aegypti* (Linnaeus) and *Aedes albopictus* (Skuse). These species are found in Malaysia at a great extent, leading to the commencement of various local studies to investigate their abundance. A recent outdoor ovitrap survey in Kuala Lumpur revealed a mosquito population dominated by *Ae. albopictus* (Ahmad-Azri et al. 2019). A similar finding was reported by ovitrap collections in the city fringe of Seremban, Malaysia (Sahani et al. 2012). Other studies conducted in different states also reported that the two species were found to share breeding sites in both indoor and outdoor settings (Norzahira et al. 2011; Wan-Norafikah et al. 2012) and dominant species changes according to the area (Wan-Norafikah et al. 2012). Meteorological factors, such as relative humidity and temperature of the environment, also played a huge role as factors affecting the abundance and development of *Aedes* mosquitoes (Yusof et al. 2018; Reinhold et al. 2018). Having a clear picture and better understanding of the nature of these vectors, interventions can be tailored accordingly in order to halt their abundance from spreading exponentially hence interfering with the transmission of dengue viruses.

Dengue vector surveillance is one of the necessary measures taken by Malaysia's local health authority in response to dengue cases. The larval survey that is being implemented in Malaysia has its drawbacks (Shah & Sani 2011; Shah et al. 2012) which can be mitigated with ovitrap surveillance. Kuala Lumpur City Hall introduced an autocidal ovitrap called Mosquito Larval Trapping Devices (MLTD). MLTD added with *Bacillus thuringiensis israelensis* (*Bti*) were used for surveillance and control of dengue vectors (Azil et al. 2011). In general, leaf infusion from local plants, either dried (e.g. hay) or fresh, have been used to increase collection of oviposition traps. Besides these, animal food pellet and organic NPK fertiliser were used for the same purpose (Ahmad-Azri et al. 2019).

To the best of our knowledge, there is no study reporting the relationship between MLTD ovitrap index and meteorological variables in an urban university residence, Malaysia. In addition, NPK fertiliser solution had never been added to MLTD ovitrap. Hence, the objective of this study was to investigate the abundance of immature *Aedes* spp. and meteorological factors that are associated with its fluctuation in a student residence in Cheras using MLTD baited with NPK fertiliser solution.

MATERIALS AND METHODS

Study Site

This study was conducted in a student residence in Cheras. Kuala Lumpur with a size of approximately 15,010.65 m^2 (161,573 ft^2). There were six blocks of four-storey buildings interconnected by covered walkways. The area is surrounded with tall trees, low-lying shrubs and planted with landscape plants. The residence is well managed, appeared clean with a good drainage system. Past dengue

cases involving students residing in the residence had been reported (personal communications with the students, March 2019) and the surrounding areas were known as hotspots for dengue cases (Ministry of Health Malaysia 2020).

Ovitrap Surveillance

Organic NPK fertiliser [nitrogen (N), phosphorus (P) and potassium (K), ratio 5:5:5] was utilised as an oviposition attractant, for the eight weeks of study following its proven effectiveness in previous studies (Ahmad-Azri et al. 2019; Anderson & Davies 2014). A total of 30 MLTD were used for this study. MLTD is known to be an autocidal ovitrap. The ovitrap is made up of cylinder-shaped plastic container measuring 24 x 13.5 cm with a lid, funnel, and black jacket. It can contain 1.6 L of water and weighs about 200 g each (Ahmad-Azri et al. 2019). These MLTD ovitraps were used to collect the larvae with 15 MLTD placed inside and outside of the student residential buildings, respectively. Ovitrap locations were determined partly based on the findings of our pilot study which provided us with information that the ovitraps had successfully attracted some mosquitoes and were in suitable locations. This minimises trap failure caused by animals or vandalism. The ovitraps also were placed in covered area, away from direct sunlight, rain and strong winds.

Organic NPK fertiliser solution with a concentration ratio of 5:5:5 was added up to the cut-off limit of the device. Weekly samplings were done, whereby the ovitraps were collected from the designated area every seven days for a total duration of eight weeks. The samples were then brought to the Entomology Laboratory, Department of Parasitology and Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia (UKM) for larvae preservation before species identification process.

Identification of Larvae

The contents of each ovitrap were first transferred to different plastic containers with labels. The larvae were fed on fish food and reared until the fourth instar. Next, the larvae were examined using stereo and light microscopes in the laboratory for species identification. The number of larvae collected in each positive MLTD ovitraps and the identified species was recorded.

Meteorological Data Collection

Two data loggers were installed at key locations, both indoor and outdoor, to collect the data for temperature (°C) and relative humidity (%). The data was retrieved at the end of each collection week and the data loggers were set again for the upcoming week. Meteorological data collected during this study were relative humidity, as well as minimum and maximum temperature.

Ethical Consideration

The study was approved by UKM Ethics Committee (IRB Ref no: UKM.

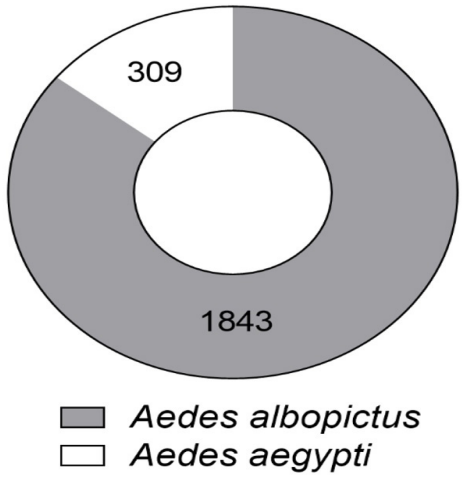

Figure 1: Total number of *Aedes* larvae collected from eight weeks of surveillance in the study site

PPI.800-1/1/5/JEP-2019-337).

Data Analysis

The data obtained from this study was analysed as follows: (i) Ovitrap Index (OI), also known as the MLTD index, the percentage of positive ovitrap (for *Aedes* spp.) over the total number of ovitrap deployed at the sites; (ii) Mean number of larvae per ovitrap, the total number of larvae against the total number of ovitrap recovered.

The significant distribution of the mean number of both *Aedes* larvae species per ovitraps was calculated using Mann-Whitney test. Spearman correlation was also performed to find the correlation between the mean number of larvae and meteorological variables. The data analysis was performed using SPSS (version 22) (IBM Corp., Armonk, NY). The level of statistical significance was determined at $p \leq 0.05$.

RESULTS

A total of 2,152 *Aedes* larvae were collected from both indoor and outdoor settings throughout the study period. Figure 1 shows the total

Table 1: Comparison of mean number of larvae per ovitrap between *Ae. aegypti* and *Ae. albopictus* from indoor and outdoor settings and overall ovitrap index for eight weeks of continuous surveillance

Collection week	Ovitrap index (%)	Mean number ± SE larvae per ovitrap			
		Ae. aegypti		*Ae. albopictus*	
		Indoor	Outdoor	Indoor	Outdoor
Week 1	30.00	0.00 ± 0.00	0.00 ± 0.00	0.53 ± 0.32	0.73 ± 0.35
Week 2	70.00	0.47 ± 0.33	1.80 ± 1.06	1.60 ± 0.91	12.00 ± 3.52
Week 3	66.67	1.23 ± 0.78	1.77 ± 0.98	1.31 ± 0.87	14.00 ± 5.21
Week 4	73.33	1.27 ± 0.61	1.00 ± 0.41	5.33 ± 2.91	8.53 ± 1.62
Week 5	90.00	4.00 ± 1.85	0.73 ± 0.53	11.00 ± 3.26	12.33 ± 3.20
Week 6	93.33	2.80 ± 1.65	0.80 ± 0.36	9.00 ± 2.40	15.93 ± 5.49
Week 7	66.67	0.67 ± 0.25	4.53 ± 1.49	0.27 ± 0.21	4.13 ± 2.24
Week 8	73.33	2.67 ± 1.28	0.67 ± 0.37	14.87 ± 5.16	8.40 ± 4.03
Overall mean	70.41 ± 6.80	1.72 ± 0.38	0.86 ± 0.20	6.08 ± 1.00	9.28 ± 1.28

SE = standard error

Table 2: Ovitrap index and mean number of *Aedes* larvae per ovitrap with respect to the location (indoor and outdoor) from eight weeks of continuous surveillance

Collection week	Ovitrap index (%)		Mean number ± SE larvae per ovitrap		
	Indoor	Outdoor	Indoor	Outdoor	Mann-Whitney U
Week 1	20.00	40.00	0.53 ± 0.32	0.73 ± 0.35	U = 5787.50 z = -2.67 p = 0.008
Week 2	53.33	86.67	2.07 ± 0.94	13.80 ± 3.59	
Week 3	46.67	86.67	2.54 ± 1.49	15.77 ± 0.62	
Week 4	53.33	93.33	6.60 ± 3.11	9.53 ± 1.73	
Week 5	80.00	100.00	15.00 ± 4.50	13.07 ± 3.44	
Week 6	86.67	100.00	11.80 ± 3.50	16.73 ± 5.54	
Week 7	80.00	53.33	5.20 ± 1.59	4.40 ± 2.29	
Week 8	73.33	73.33	17.53 ± 5.84	9.07 ± 4.10	

p≤0.05=significant difference
SE=standard error

number of collected larvae segregated into species. The percentage of *Ae. albopictus* larvae (85%) collected throughout the eight weeks of study was higher than *Ae. aegypti*, to almost six folds.

Table 1 shows the weekly abundance of *Ae. aegypti* and *Ae. albopictus* retrieved from both indoor and outdoor ovitraps with overall OI ranges from 30.00-93.33%. During Week 1, the OI was 30.00% despite none of *Ae. aegypti* being collected. This was due to the presence of *Ae. albopictus* larvae which contributed the number of positive of ovitraps. For the indoor setting, the mean number of *Ae. aegypti* per ovitrap ranged from 0.00±0.00 to 4.00±1.85; while it ranged from 0.00±0.00 to 4.53±1.49 for ovitraps retrieved from the outdoor setting. Nevertheless, the mean number *of Ae. albopictus* per ovitrap from indoor ovitraps ranged from 0.27±0.21 to 14.87±5.16 while outdoor ovitraps yield ranged from 0.73±0.35 to 15.93±5.49. The mean numbers of *Ae. aegypti* larvae gathered from indoor ovitraps were moderately high at Week 3 to Week 6, ranging from 1.23±0.78 to 4.00±1.85 and also at Week 8 (2.67±1.28). *Ae. albopictus* were constantly higher in the outdoor settings compared to indoors, except for Week 8 in which the indoor collection of *Ae. albopictus* was higher compared to outdoor collection (14.87±5.16 versus 8.40±4.03). Overall, *Ae. aegypti* were predominantly found in indoor settings (1.72±0.38) rather than outdoor (0.86±0.20). In contrast, the overall mean number of *Ae. albopictus* larvae was higher in outdoor than indoor with mean of 9.28±1.28 and 6.08±1.00, respectively.

The OI and mean number of *Aedes* larvae from indoor and outdoor settings were shown in Table 2. Indoor OI ranged from 20.00% to 86.67%; while outdoor OI ranged from 40.00-100.00%. The ovitraps retrieved from outdoor settings were all positive for harbouring *Aedes* larvae for two consecutive weeks, at Week 5 and

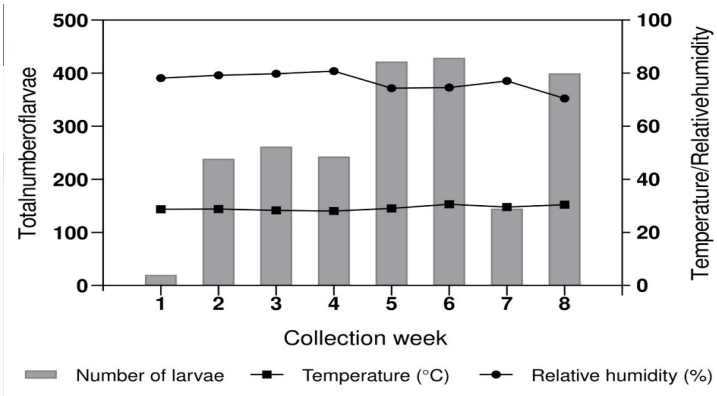

Figure 2(a): Relation between *Aedes* larval abundance with average temperature and average relative humidity

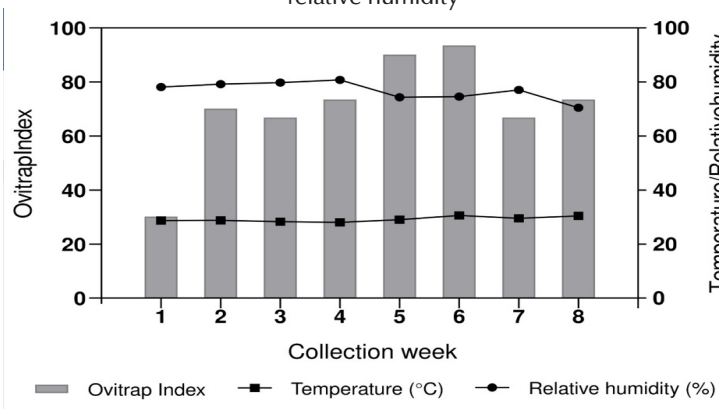

Figure 2(b): Relation between overall ovitrap index with average temperature and average relative humidity

6. The mean number of larvae per ovitraps from indoor settings ranged from 0.53±0.32 to 17.53±5.84; while at its lowest, the outdoor mean number of larvae per ovitraps was 0.73±0.35 and 16.73±5.54 at its peak at Week 6 of study. A Mann-Whitney test indicated that the distribution of mean number of both *Aedes* larvae per ovitraps were significantly different between indoor (mean rank = 108.73, n = 120) and outdoor (mean rank = 132.27, n = 120) settings, U = 5787.50, z =2.67 (corrected for ties), p=0.008, two-tailed. Minimum-maximum indoor temperature and relative humidity ranged from 25.5-33°C and 47.5-88.5%, respectively, whereas minimum-maximum outdoor temperature and relative humidity ranged from 23-37°C and 47.5-93.5%, respectively.

To examine the fluctuation trend of entomological variables regardless of *Aedes* species, we present here Figure 2a & 2b. Week 1 demonstrated the lowest larval abundance and ovitrap index. These parameters rose steadily in the next three weeks (Weeks 2, 3 and 4) when the average temperature was approximately 28°C and the average relative humidity reached

Table 3: Correlation of meteorological variables with larval abundance

Meteorological variables	r	P value
Maximum temperature	0.830	0.011
Minimum temperature	0.204	0.629
Maximum relative humidity	-0.299	0.471
Minimum relative humidity	-0.778	0.023

80.8% by Week 4. A sharp increase in larval abundance was observed in the following two weeks (Weeks 5 and 6) when the humidity drops to 74% and temperature ranges from 29.1-30.6°C; OI was highest during these weeks. Both parameters decreased in Week 7 before increasing again in Week 8.

To demonstrate the relationship of average temperature and average relative humidity on the abundance of *Aedes* larvae, non-parametric correlation test (Spearman Correlation) was performed because the data obtained were not normally distributed. Larval abundance manifested moderate correlation on weekly average temperature and relative humidity. It was shown that larval abundance was directly correlated with maximum temperature (r=0.830; p=0.011) and inversely correlated with minimum relative humidity (r=-0.778; p=0.023), with both of these correlations being statistically significant. Correlation coefficients for minimum and maximum temperature and relative humidity with larval abundance were stated in Table 3.

Correlation coefficient (*r*) between average temperature and relative humidity was -0.857 with a p-value of 0.007. This shows that these two variables are inversely correlated meaning relative humidity decreases when temperature increases. Correlation between OI and number of larvae demonstrated a high correlation coefficient, r of 0.880 with a p-value of 0.004. This suggests that the two parameters can be used interchangeably to monitor changes in mosquito population density.

DISCUSSION

Based on our study, the overall predominant site of breeding of *Aedes* spp. was outdoors compared to indoors. This is largely due to the outdoor preference of *Ae. albopictus*, the dominant species, for breeding. Our findings were parallel with a similar urban study conducted in Keramat, Kuala Lumpur and Shah Alam, Selangor in which indoor and outdoor ovitrap collections revealed that *Ae. aegypti* was more frequently found indoors, whereas *Ae. albopictus* bred more in outdoor ovitraps, with the latter being the dominant species in both areas (Noor-Afizah et al. 2018). Similar findings were also reported by Wan-Norafikah et al. (2009) and Rozilawati et al. (2015) in their studies conducted in Kuala Lumpur. *Ae. aegypti* are predominantly higher in indoor settings as they preferred to breed in a place with high human density due to its anthropophilic

nature, whereas *Ae. albopictus* prefer to rest and breed outdoors where vegetation and natural water-holding containers are available.

In addition, outdoor extreme temperatures, up to 36-37˚C as recorded by our data loggers might not be favourable for *Ae. aegypti* to thrive. For instance, adult survivorship of field strains was greatly affected when the temperature reaches 36˚C (Marinho et al. 2016) and egg production and hatching significantly reduced at 35˚C when compared to 30˚C (Costa et al. 2010). According to Marinho et al. (2016), who conducted a study on three different populations of *Ae. aegypti* in Brazil, the largest number of eggs per female was observed at 28˚C and the lowest was at 36˚C. Furthermore, embryonic development took longer at 36˚C as compared to 28˚C and 33˚C for two out of three populations. It was found that the extreme temperature of 39˚C suppressed the embryonic development and survival of larval stages (Marinho et al. 2016). Our indoor temperature ranged from 25.5-33˚C, supporting the optimal development of the species.

On the other hand, a wider range of temperature and relative humidity is more accommodating to *Ae. albopictus*. The species has been shown to have high endurance to weather anomalies enabling it to survive in temperate, subtropical and tropical countries (Reinhold et al. 2018). Rozilawati et al. (2016) discovered that immature stages of *Ae. albopictus* successfully developed into adults at 35˚C with survival rates of 68% and 86% for Kuala Lumpur and Selangor field strains, respectively. At 40˚C, these strains managed to develop until L3 stage. However, tolerance to weather and climate might be different with geographical regions as mosquito strains of different genetic compositions exist.

The abundance of immature *Aedes* spp. larvae showed a consistent increase with maximum temperature. This is supported by the studies done by Rohani et al. (2011) and Madi et al. (2012). These studies, including ours, have measured ambient air temperatures instead of water temperature of larval habitats. Changes of temperature in these habitats directly affect the larval and pupal development, while air temperature determines the development of eggs and adult phase. Measuring water temperature in breeding containers can help to better understand the role of fluctuating temperature on immature stages development (Waldock et al. 2013). Unlike temperature, our study showed an increase in relative humidity will decrease the abundance of immature *Aedes* spp. or vice versa (i.e. a significant negative correlation), which is in line with studies by Wan-Norafikah et al. (2009). In contrast, Rohani et al. (2011) and Madi et al. (2012) reported a consistent increase in the larval abundance with increasing maximum relative humidity. The discrepancy between our results and others' may be due to the duration of the ovitrap collections in which a clearer picture can be obtained when data from one year or more is examined. Relative humidity influences longevity, fecundity, oviposition and

larvae survival of *Aedes* (Costa et al. 2010). At high humidity, mosquitoes generally live longer and produce more eggs. Relative humidity also directly affects the evaporation rates of vector breeding sites. The effect of the same temperature but dissimilar relative humidity on mosquito development was previously investigated (Costa et al. 2010). In their laboratory study, they found out that lower humidity (60% versus 80%) at the same temperature cause less egg hatching, and oviposition inhibited for some *Ae. aegypti* females, which indicates that humidity does play a role in determining the magnitude of temperature effect on mosquito's life cycle. However, in real-world situations, this effect might be occurring subtler in the environment due to the constant fluctuations of relative humidity in a tropical climate, especially outdoors which can range from 47.5-93.5%, as occurred in our study.

This study had incorporated the use of NPK fertiliser as an attractant for female *Aedes* mosquitoes. Bacterial growth in fertiliser-baited ovitraps contributes to the availability of food for the larvae. Previous study by Darriet et al. (2010) stated that NPK fertiliser is a potential alternative of attractant for *Aedes* mosquitoes. NPK fertiliser is commercially available and easier to prepare as compared to hay infusion. Besides, it is suitable to be used in ovitrap that is placed indoors as it does not bring any foul or unpleasant smell, unlike the hay or leaf infusions. According to Marques et al. (2013), ammonia (NH_3) volatiles released from water were able to attract the female *Aedes* mosquitoes to oviposit. In Malaysia, Ahmad-Azri et al. (2019) has demonstrated the effectiveness of NPK fertiliser solution as an oviposition attractant for *Ae. albopictus* and *Ae. aegypti*. It was reported in another study conducted in Timor Leste that NPK fertilisers are found to be attractive to gravid *Ae. albopictus* and may be useful in the control and monitoring program (Anderson & David 2014). In addition, Darriet et al. (2010) has shown that *Ae. aegypti* was also attracted to the solution. Study to compare its attractancy between the two mosquito species has yet to be conducted, but evidence stated here shows its potential as an oviposition attractant for both mosquito species.

An 8-week ovitrap collection limit us from acquiring more data to associate entomological and weather variables. This is unavoidable to due to some technical and manpower constraints. An extended period of ovitrap surveillance would be more meaningful as it could strengthen the predictive capacity of the data which would bear a more conclusive relationship between entomological and meteorological variables. Nonetheless, short-term surveillance using entomological indices as demonstrated in our study can be utilised to rapidly assess the status of vector population density in an area. This can trigger vector control actions whenever deemed necessary, especially in a large dengue outbreak where swift vector control need to be taken.

CONCLUSION

Based on this study, the total number of *Aedes* species collected throughout the study proved that *Ae. albopictus* was the dominant species in the area, especially outdoors, as compared to *Ae. aegypti,* which was more frequently found in the indoor area. A targeted control method based on the distribution of each respective species can be formulated and used together with current interventions. Furthermore, the study showed that larval abundance is directly correlated with maximum temperature and inversely correlated with minimum relative humidity. Thus, a predictive model of *Aedes* spp. abundance can be developed with the integration of these parameters provided by data from previous and extensive future studies. This study also had utilised MLTD with NPK fertiliser solution as an attractant for the surveillance of immature *Aedes* abundance, which has been proven to be effective in monitoring *Aedes* larval abundance.

ACKNOWLEDGEMENT

The authors convey their gratitude to Faculty of Medicine, UKM for the approval and financial support for this study. This work was supported by Dana Fundamental PPUKM (Project Code: FF-2019-239). The authors also thank Head and staff of Department of Parasitology and Medical Entomology for the technical and advisory support for this project. The author acknowledge the help received from Mohd Farihan Md Yatim and Shezryna Shahrizal.

REFERENCES

Ahmad-Azri, M., Syamsa, R.A., Ahmad-Firdaus, M.S., Aishah-Hani, A. 2019. A comparison of different types of ovitraps for outdoor monitoring of *Aedes* mosquitoes in Kuala Lumpur. *Trop Biomed* **36**(2): 335-47.

Anderson, E.M., Davis, J.A. 2014. Field evaluation of the response of *Aedes albopictus* (*Stegomyia albopicta*) to three oviposition attractants and different ovitrap placements using black and clear autocidal ovitraps in a rural area of Same, Timor-Leste. *Med Vet Entomol* **28**(4): 372-83.

Azil, A.H., Li, M., Williams, C.R. 2011. Dengue vector surveillance programs: a review of methodological diversity in some endemic and epidemic countries. *Asia Pac J Public Health* **23**(6): 827-42.

Costa, E.A.P.D.A., Santos, E.M.D.M., Correia, J.C., Albuquerque, C.M.R.D. 2010. Impact of small variations in temperature and humidity on the reproductive activity and survival of *Aedes aegypti* (Diptera, Culicidae). *Rev Bras Entomol* **54**(3): 488-93.

Darriet, F., Zumbo, B., Corbel, V., Chandre, F. 2010. Influence of plant matter and NPK fertilizer on the biology of *Aedes aegypti* (Diptera: Culicidae). *Parasite* **17**(2): 149-54.

Madi, M., Ahmad, R., Kulaimi, N.A.M., Ali, W.N.W.M., Ismail, S., Lee, H.L. 2011. Climatic influences on *Aedes* mosquito larvae population. *Malaysian Journal of Science* **31**(1): 36-44.

Marinho, R.A., Beserra, E.B., Bezerra-Gusmão, M.A., Porto, V.D.S., Olinda, R.A., dos Santos, C.A. 2016. Effects of temperature on the life cycle, expansion, and dispersion of *Aedes aegypti* (Diptera: Culicidae) in three cities in Paraiba, Brazil. *J Vector Ecol* **41**(1): 1-10.

Marques, G.R., Chaves, L.S.M., Serpa, L.L.N., Arduíno, M.D.B., Chaves, F.J.M. 2013. Public drinking water supply and egg laying by *Aedes aegypti*. *Rev Saude Publica* **47**(3): 579-87.

Ministry of Health Malaysia. 2020. iDengue Untuk Komuniti. http://idengue.arsm.gov.my/pdf/statistik.pdf#page=3. [31 January 2020]

Noor-Afizah, A., Mohd-Arif, A.K., Nazni, W.A., Lee, H.L. 2018. Ovitrap surveillance of *Aedes aegypti* and *Aedes albopictus* in dengue endemic areas in Keramat and Shah Alam, Selangor in 2016. *IMJM* **17**(3): 59-64.

Norzahira, R., Hidayatulfathi, O., Wong, H.M., Cheryl, A., Firdaus, R., Chew, H.S., Lim, K.W., Sing, K.W., Mahathavan, M., Nazni, W.A., Lee, H.L., Vasan, S.S., McKerney, A., Lacroix, R. 2011. Ovitrap surveillance of the dengue

vectors, *Aedes* (*Stegomyia*) *aegypti* (L.) and *Aedes* (*Stegomyia*) *albopictus* skuse in selected areas in Bentong, Pahang, Malaysia. *Trop Biomed* **28**(1): 48-54.

Reinhold, J.M., Lazzari, C.R., Lahondère, C. 2018. Effects of the environmental temperature on *Aedes aegypti* and *Aedes albopictus* mosquitoes: a review. *Insects* **9**(4): 158.

Rohani, A., Suzilah, I., Malinda, M., Anuar, I., Mohd Mazlan, I., Salmah Maszaitun, M., Topek, O., Tanrang, Y., Ooi S.C., Rozilawati, H., Lee, H.L. 2011. *Aedes* larval population dynamics and risk for dengue epidemics in Malaysia. *Trop Biomed* **28**(2): 237-48.

Rozilawati, H., Tanaselvi, K., Nazni, W.A., Mohd Masri, S., Zairi, J., Adanan, C.R., Lee, H.L. 2015. Surveillance of *Aedes albopictus* Skuse breeding preference in selected dengue outbreak localities, Peninsular Malaysia. *Trop Biomed* **32**(1): 49-64.

Rozilawati, H., Masri, S.M., Tanaselvi, K., Zairi, J., Nazn, W., Lee, H. 2016. Effect of temperature on the immature development of *Aedes albopictus* Skuse. *Southeast Asian J Trop Med Public Health* **47**(4): 731-46.

Sahani, M., Othman, H., Nor, N.A.M., Hod, R., Ali, Z.M. 2012. Kajian ekologi nyamuk *Aedes* di Senawang Negeri Sembilan, Malaysia. *Sains Malaysiana* **41**(2): 261-9.

Shah, S.A., Sani, J.A. 2011. Effectiveness of *Aedes* Index and Breteau Index in Predicting Dengue Outbreaks in Selangor, Malaysia. *Epidemiology* **22**(1): S144-5.

Shah, S.A., Sani, J.A.M., Hassan, M.R., Safian, N., Aizuddin, A.N., Hod, R. 2012. Relationships between *Aedes* indices and dengue outbreaks in Selangor, Malaysia. *Dengue Bulletin* **36**: 166.

Umi Kalthum, M.N., Wong, H.S. 2012. Dengue fever presenting as bilateral dengue maculopathy. *Med & Health* **7**(1): 57-61.

Waldock, J., Chandra, N.L., Lelieveld, J., Proestos, Y., Michael, E., Christophides, G., Parham, P.E. 2013. The role of environmental variables on *Aedes albopictus* biology and chikungunya epidemiology. *Pathog Glob Health* **107**(5): 224-41.

Wan-Norafikah, O., Chen, C.D., Soh, H.N., Lee, H.L., Nazni, W.A., Sofian-Azirun, M. 2009. Surveillance of *Aedes* mosquitoes in a university campus in Kuala Lumpur, Malaysia. *Trop Biomed* **26**(2): 206-15.

Wan-Norafikah, O., Nazni, W.A., Noramiza, S., Shafa'ar-Ko'Ohar, S., Heah, S.K., Nor-Azlina, A.H., Khairuh-Asuad, M., Lee, H.L. 2012. Distribution of *Aedes* mosquitoes in three selected localities in Malaysia. *Sains Malaysiana* **41**(10): 1309-13.

Yusof, M.M., Dom, N.C., Ismail, R., Zainuddin, A. 2018. Assessing the temporal distribution of dengue vectors mosquitoes and its relationship with weather variables. *Serangga* **23**(1): 112-25.

Received: 05 Aug 2020
Accepted: 03 Nov 2020