Environment & Ecosystem Science (EES)

DOI: http://doi.org/10.26480/ees.02.2022.65.70

ISSN: 2521-0882 (Print)
ISSN: 2521-0483 (Online)
CODEN: EESND2

RESEARCH ARTICLE

THE CONSTRUCTION SITE PROVIDES A SUITABLE ENVIRONMENT FOR VECTOR MOSQUITOES IN THE FEDERAL TERRITORY OF KUALA LUMPUR, MALAYSIA

Faizul Akmal Abdul Rahim[a*], Mohd Amierul Fikri Mahmud[a], Mohd Farihan Md Yatim[a], Mohd Hatta Abdul Mutalip[a], and Hanipah Shahar[b]

[a]Centre for Communicable Diseases Research, Institute for Public Health, National Institute of Health, Ministry of Health, Malaysia, Jalan Setia Murni U13/52, Seksyen U13, Setia Alam, 40170 Shah Alam, Selangor Malaysia
[b]Entomology and Pest Unit, Federal Territory of Kuala Lumpur & Putrajaya Health Department, Jalan Cenderasari, Kuala Lumpur 50590, Malaysia
[*]Corresponding Author Email: faizul.fabregas@gmail.com

ARTICLE DETAILS

Article History:

Received 10 May 2022
Accepted 15 June 2022
Available online 20 June 2022

ABSTRACT

Construction sites are often blamed for dengue outbreaks in surrounding localities. The environment is suitable for immature mosquitoes to develop without predators and the convenience of female mosquitoes to feed on the exposed construction workers. The purposes of this study were to identify the species of mosquitoes present at construction sites and the types of their preferred breeding habitats, and also to determine the vertical distribution of the mosquitoes. Nineteen construction sites in the Federal Territory of Kuala Lumpur were cross-sectionally surveyed for the presence of immature mosquitoes in 2018. All water-holding containers were inspected for the presence of immature mosquitoes. Types of water-holding containers were recorded and counted. The number of immature mosquitoes was counted from each positive container and then transferred to the laboratory for species identification. A total of 1,643 immature mosquitoes were collected, comprising 1,287 larvae and 356 pupae. *Aedes aegypti* immature was the most abundant mosquito species (76%), followed by *Culex quinquefasciatus* (19%), and the *Aedes albopictus* (5%). The most productive breeding sites were flooded floors, drains, plastic containers, elevator shafts, water drums, and pails. We discovered that the immature mosquitoes were most abundant from the ground floor to the second floor, with *Ae. aegypti* immature could disperse up to the thirteenth floor. This study has provided useful information to the health department regarding the preferred breeding habitats of vector mosquitoes at construction sites. Consequently, it contributes to effective and efficient vector prevention and control measures, thus saving time and manpower.

KEYWORDS

Aedes, breeding sites, construction sites, dengue, vertical distribution

1. INTRODUCTION

Urbanisation is the process of changing the natural environment, transforming rural areas into urban areas, and expanding population distribution in urban areas from rural areas. This includes changes in occupational types, improvements in living standards, culture, and behaviour, as well as changes in demographic and social structures in urban and rural areas (Montgomery et al., 2013). Urbanisation is growing worldwide, and it is strongly linked to the existence of construction sites (Mutebi et al., 2018). A construction site is any land where activities to construct roads, buildings, or other structures are carried out. The proliferation of construction sites often results in disturbance to the environment by land-use modifications, increased human presence, and increased the number of wastes, which adversely affect the habitats of flora and fauna (Knop, 2016).

Malaysia has experienced rapid industrial and economic growth over the past few decades, with massive infrastructure development and a continuous process of urbanisation. It has led to an increased incidence of dengue cases in Malaysia (Mudin, 2015). The number of reported dengue cases and deaths at construction sites in 2015 increased by 11.2% and 50% respectively as compared to 2014 (Fernandez, 2016). The situation has created concern among the community, especially among those who are living near the construction site areas. Furthermore, the existence of construction sites in some countries has increased the number of dengue cases (Sampaio, 2009).

The construction sites have been identified as contributing to a substantial increase in mosquito breeding habitats, with *Aedes aegypti* and *Aedes albopictus* which are the vectors for dengue often widely found in construction site areas (El Badri, 1999). In addition, *Ae. aegypti* and *Culex quinquefasciatus* are among the species of mosquito vectors that can grow in urban-dwelling near human populations (Kraemer et al., 2015; Samy et al., 2016). These mosquitoes survive in the construction site's environment which provides suitable breeding sites to oviposit their eggs (McKinney, 2002). Meanwhile, water puddles on various surfaces such as drains, elevator shafts, stair shafts, and concrete floors are common breeding habitats for *Ae. aegypti* at construction sites (Hammond, 2007; Wilke et al., 2018). A previous study has stated that Aedes mosquitoes preferred to breed in water-holding plastic containers at outbreaks localities near construction sites (Rahim, 2021).

The suitable environment at the construction sites will facilitate the female mosquitoes to obtain blood sources from exposed construction workers (Wilke et al., 2018). The spread of infection is easier among workers because Aedes mosquitoes tend to bite during the day, with the

Quick Response Code	Access this article online	
	Website: www.environecosystem.com	**DOI:** 10.26480/ees.02.2022.65.70

biting activity increasing within 2 hours after sunrise and several hours after sunset. It is a time when construction workers are still working outside and making them easier targets for infection. As is known, construction workers commonly work all day without wearing personal protective equipment such as long-sleeved shirts and repellents, which may susceptible to becoming infected by mosquito-borne diseases (Sang, 2014). Therefore, due to the lack of awareness by both workers and construction companies about the importance of eradicating mosquito breeding habitats, construction workers and nearby communities are very vulnerable to mosquito bites (Moore, 2017). Furthermore, poor cleanliness conditions, high humidity, the existence of numerous water-holding containers, and a heavily populated, make construction sites suitable breeding places for Aedes mosquitoes (Atique, 2018).

Currently, not much information is known regarding the mosquito species found at construction sites, the type of its breeding sites, the factors influencing its abundance, and the risk of high numbers of vector mosquitoes breeding at construction sites in the surrounding communities (Wilke et al., 2018). The information is important to assist in the planning of vector prevention and control activities by the health department, hence reducing vector-borne disease cases. Therefore, this study aimed to identify the mosquito species that are present at the construction sites, the types of water-holding containers in which it breeds, and to determine the vertical distribution of mosquitoes in the construction sites.

2. MATERIALS AND METHODS

2.1 Study Area

We used a cross-sectional study design to survey nineteen construction sites in the Federal Territory of Kuala Lumpur for immature stage mosquitoes from January to December 2018 (Figure 1). Construction site selection criteria are according to the construction phase, size, and location. Surveillance activities at all construction sites were carried out after the basic frame structure of the building was fully constructed, with no windows and doors installed that allow mosquitoes to fly inside. Construction site size is defined as small if the size of a residential house or residential building (300 m2); medium, residential or commercial buildings with an area of not more than five floors or one acre; large, buildings with more than five floors or one acre of the area (Wilke et al., 2018).

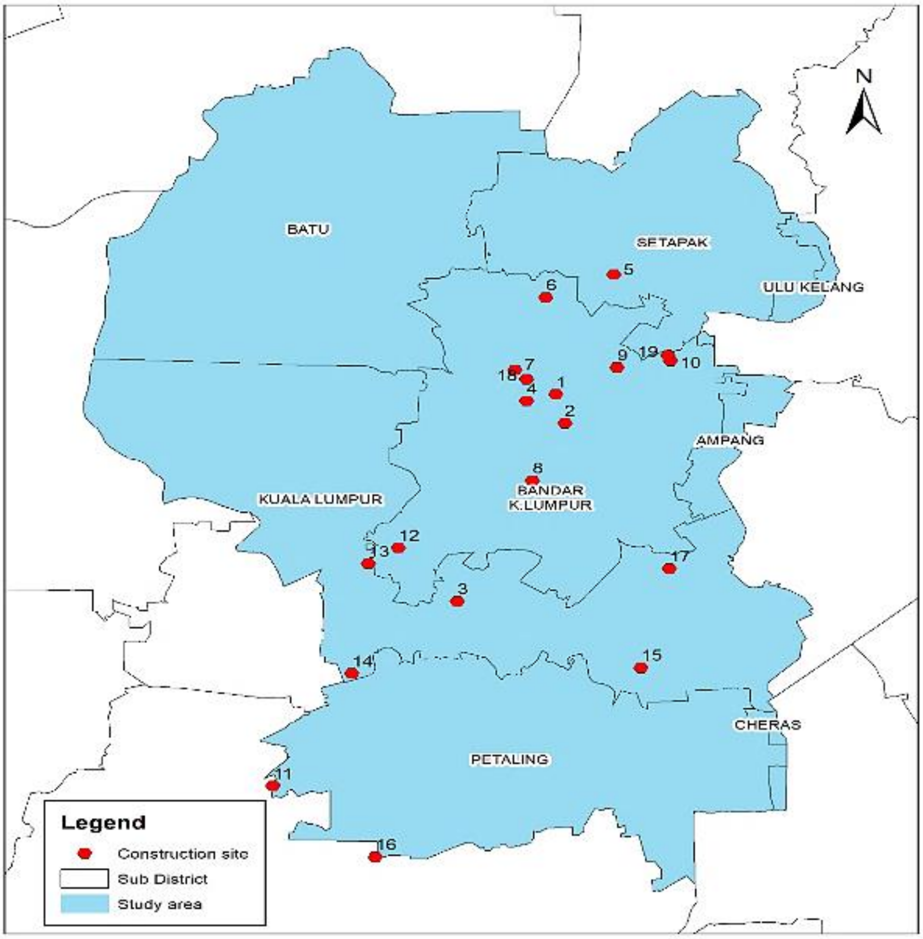

Figure 1: Map displaying the surveyed construction sites in the Federal Territory of Kuala Lumpur

2.2 Immature Mosquitoes' Collection and Examination

All water-holding containers were inspected for the presence of immature (larvae and pupae) mosquitoes from different floors of the construction site areas. The floor levels were grouped into three categories which are the ground floor to the fourth floor (category one), fifth floor to the ninth floor (category two), and tenth floor to the thirteenth floor (category three). Each water-holding container was counted, and the type of containers and the location found was recorded (Rahim, 2021). The immature mosquitoes were collected from containers with a pipette or dipper depending on the container's type. The total number of immature mosquitoes was then counted from each positive container. All collected immature mosquitoes were transferred into the specimen bottles, then transported to the Entomology and Pest Unit, Health Department of Federal Territory Kuala Lumpur & Putrajaya's Laboratory. Species identification of the immature mosquitoes was performed using a microscope and referred to identification keys (Rohani et al., 2014).

2.3 Data Analysis

Data entry and statistical analyses were conducted using Microsoft Excel and Statistical Package for Social Sciences (SPSS) Version 26.0. The larval index used in the investigation is Container Index (CI) as per guidelines issued by the Ministry of Health, Malaysia. The threshold for larval index value for CI is < 10%, and was calculated and analysed using the following mathematical formulae (MOH, 2014);

$$CI = \frac{\text{Number of positive containers}}{\text{Total number of containers inspected}} \times 100\%$$

The Kruskal-Wallis test was conducted to determine if there are any significant differences between the number of mosquitoes collected and the floor level categories.

Table 1: The total number of immature mosquitoes collected at construction sites in Kuala Lumpur

Construction Site	Species									Total
	Aedes aegypti			*Aedes albopictus*			*Culex quinquefasciatus*			
	Larvae	Pupae	Total	Larvae	Pupae	Total	Larvae	Pupae	Total	
1	73	11	84	5	0	5	15	3	18	107
2	35	14	49	7	2	9	21	8	29	87
3	26	4	30	0	0	0	0	0	0	30
4	37	7	44	6	0	6	0	0	0	50
5	37	5	42	0	0	0	44	12	56	98
6	57	16	73	0	0	0	0	0	0	73
7	38	8	46	0	0	0	0	0	0	46
8	100	35	135	13	3	16	41	17	58	209
9	35	13	48	0	0	0	16	11	27	75
10	37	5	42	0	0	0	7	0	7	49
11	132	49	181	22	1	23	13	6	19	223
12	32	6	38	0	0	0	0	0	0	38
13	80	18	98	0	0	0	24	8	32	130
14	72	20	92	0	0	0	0	0	0	92
15	43	11	54	0	0	0	17	2	19	73
16	18	1	19	0	0	0	31	14	45	64
17	62	19	81	0	0	0	0	0	0	81
18	39	7	46	0	0	0	0	0	0	46
19	31	18	49	21	2	23	0	0	0	72
Total			1251			82			310	1643
Median			49			0			7	
Interquartile Range (IQR)			42			6			29	
Minimum			19			0			0	
Maximum			181			23			58	

3. Result

Overall, 1,643 immature mosquitoes were collected from the construction sites, comprising 1,287 larvae and 356 pupae (Table 1). The immature mosquitoes collected were distributed among two genera (Aedes, and Culex,) and three species (*Aedes aegypti, Aedes albopictus, and Culex quinquefasciatus*). *Ae. aegypti* immature was the most abundant mosquito species collected at construction sites, comprising 1,251 specimens (984 larvae and 267 pupae), followed by *Cx. quinquefasciatus* immature with 310 specimens collected (229 larvae and 81 pupae), and *Ae. albopictus* immature with 82 specimens collected (74 larvae and 8 pupae). The nineteen construction sites in this study displayed a median of 49 *Ae. aegypti* immature (IQR = 42), with the minimum and maximum values, are 19 and 181 respectively. While for *Cx. quinquefasciatus* immature, the median of 7 (IQR = 29), with the minimum and maximum values are 0 and 58 respectively. Then followed by *Ae. albopictus immature*, the median of 6 (IQR = 6), with the minimum and maximum values, are 0 and 23 respectively.

Figure 2: The images of breeding sites for immature mosquitoes at construction sites in Kuala Lumpur.

The types of breeding sites for immature mosquitoes at construction sites are described in Table 2, with the images shown in Figure 2. From the many potential breeding sites present at construction sites, such as buckets, pipes, empty soda cans, stacks of construction supplies, etc., the most productive breeding site features were flooded floor, drain, elevator shaft, plastic container, water drum, and pail. The most common breeding site for *Ae. aegypti* was the flooded floor with 769 immature mosquitoes collected, comprising 592 larvae and 177 pupae, followed by the drain with 310 immature mosquitoes collected, comprising 256 larvae and 54 pupae, and the water drum with 134 immature mosquitoes collected, comprising 100 larvae and 34 pupae. The median of the flooded floor, drain, and water drum for *Ae. aegypti* are 42(IQR = 47), 18(IQR = 19), and 0(IQR = 17) respectively. In contrast, the most common breeding site for*Cx. quinquefasciatus* was the elevator shaft, in which 226 immature mosquitoes were collected, comprising 163 larvae and 63 pupae, with a median of 0 (IQR = 25). While for *Ae. albopictus*, the most common breeding site was the plastic container, in which 68 immature mosquitoes were collected, comprising 62 larvae and 6 pupae, with a median of 0 (IQR = 6)

Table 2: The type of breeding sites for immature mosquitoes at construction sites in Kuala Lumpur

Type of breeding site	*Aedes aegypti*				*Aedes albopictus*				*Culex quinquefasciatus*			
	Larvae	Pupae	Total	Med (IQR)	Larvae	Pupae	Total	Med (IQR)	Larvae	Pupae	Total	Med (IQR)
Flooded floor	592	177	769	42 (47)	0	0	0	0 (0)	59	18	77	0 (0)
Drain	256	54	310	18 (19)	0	0	0	0 (0)	7	0	7	0 (0)
Plastic container	15	1	16	0 (0)	62	6	68	0 (6)	0	0	0	0 (0)
Elevator shaft	0	0	0	0 (0)	0	0	0	0 (0)	163	63	226	0 (25)
Water drum	100	34	134	0 (17)	0	0	0	0 (0)	0	0	0	0 (0)
Pail	21	1	22	0 (0)	12	2	14	0 (0)	0	0	0	0 (0)

Table 3: The Container Index and type of breeding site according to floor level

Construction site	Number of inspected breeding site	Number of positive breeding site	Container Index (CI)	Type of breeding site (floor level)
1	39	6	15.38%	Flooded floor (5,6), Plastic container (0), Elevator shaft (0), Water drum (1), Pail (1)
2	23	4	17.39%	Flooded floor (4), Drain (5), Plastic container (0), Elevator shaft (0)
3	26	3	11.54%	Flooded floor (3), Drain (2,5)
4	41	4	9.76%	Flooded floor (4), Drain (3,7), Plastic container (0)
5	28	6	21.43%	Flooded floor (1), Drain (2,3), Plastic container (0), Elevator shaft (0), Water drum (2)
6	47	3	6.38%	Flooded floor (0), Drain (10,11)
7	46	3	6.52%	Flooded floor (2,4), Drain (9)
8	72	7	9.72%	Flooded floor (7,11,13), Drain (5), Plastic container (0,1), Elevator shaft (0)
9	54	3	5.56%	Flooded floor (1), Drain (3), Water drum (2)
10	38	3	7.89%	Flooded floor (2,3), Drain (1)
11	45	7	15.56%	Flooded floor (7,8), Drain (3), Plastic container (0,1), Elevator shaft (0), Water drum (1)
12	49	3	6.12%	Flooded floor (1,6), Drain (2)
13	62	5	8.06%	Flooded floor (5,7), Drain (4), Elevator shaft (0), Water drum (2)
14	35	3	8.57%	Flooded floor (0), Drain (0,3)
15	27	4	14.81%	Flooded floor (2), Drain (6), Water drum (1), Pail (1)
16	43	3	6.98%	Flooded floor (12), Drain (6), Elevator shaft (0)
17	31	3	9.68%	Flooded floor (5,8) Drain (3)
18	19	3	15.79%	Flooded floor (4), Water drum (1), Pail (1)
19	17	3	17.65%	Flooded floor (2), Plastic container (0), Pail (0)
Total	742	76	10.24%	Flooded floor (0,1,2,3,4,5,6,7,8,11,12,13), Drain (0,1,2,3,4,5,6,7,9,10,11), Plastic container (0,1), Elevator shaft (0), Water drum (1,2), Pail (0,1)

Table 4: The dispersal of immature mosquitoes according to floor level

Floor level	Approximate Height (m)	*Ae. aegypti*		*Ae. albopictus*		*Cx. quinquefasciatus*	
		Larvae	Pupae	Larvae	Pupae	Larvae	Pupae
0	0.0–3.0	94	25	74	8	163	63
1	3.1–6.0	103	26	0	0	49	16
2	6.1–9.0	150	47	0	0	17	2
3	9.1–12.0	115	30	0	0	0	0
4	12.1–15.0	87	22	0	0	0	0
5	15.1–18.0	119	31	0	0	0	0
6	18.1–21.0	68	10	0	0	0	0
7	21.1–24.0	110	31	0	0	0	0
8	24.1–27.0	56	20	0	0	0	0
9	27.1–30.0	5	2	0	0	0	0
10	30.1–33.0	14	3	0	0	0	0
11	33.1–36.0	25	12	0	0	0	0
12	36.1–39.0	12	0	0	0	0	0
13	39.1–42.0	26	8	0	0	0	0
Total		984	267	74	8	229	81

The results of the commonly used larval index are described in Table 3. Container Index ranged between 5.56% and 21.43%, at different construction sites. The average of the Container Index was 10.24%, which is higher than the threshold index (CI < 10%). Eight construction sites found CI higher than the threshold index (CI value > 10%). The breeding sites were found from the ground floor to the thirteenth floor, with an abundance of breeding sites from the ground floor to the second floor (Table 4).

According to the Kruskal-Wallis Test result, significant differences (H = 28.60, df = 2, P = 0.00) were found among the floor categories. Further pairwise comparisons using the post hoc Bonferroni test indicated that floor category one and two was significantly difference with a p-value of 0.006. In addition, floor category one and three was also significantly different with a p-value of 0.000. However, there was no significant difference observed for floor categories two and three with a p-value of 0.072.

4. Discussion

The findings of this study indicate that the construction site has proven to be a suitable habitat for both dengue vectors *Ae. aegypti* and *Ae. albopictus,* as well as *Cx. quinquefasciatus*. We discovered that, *Ae. aegypti* was the predominant species with their immature found at all construction sites with 76% of the total immature mosquitoes collected. The dominance of *Ae. aegypti* is equivalent to the results of previous studies conducted in urban high-rise residences (Lau et al., 2013; Wan Norafikah, 2010). While *Ae. albopictus* recorded the lowest number with 5% of immature mosquitoes collected. *Ae. albopictus* immature was found in only six construction sites with its breeding sites found in the uncovered place and outdoor environments of the construction sites, which corroborates with previous studies (Rahim, 2021; Estrada-Franco JG and Craig GB, 1995). In addition, the behaviour of *Ae albopictus* itself has contributed to the lower number of immatures found at all study sites. *Ae. albopictus* prefers to breed in natural water-holding containers such as leaf axils and tree holes then rest in places where vegetation is abundant (Estrada-Franco JG and Craig GB, 1995). The immature stage of *Cx. quinquefasciatus* was found in 19% of immature mosquitoes collected and it was more dominant at two construction sites than *Ae. aegypti*.

Ae. aegypti immature was found in all positive breeding sites except in the elevator shaft, and it was preferred to breed on the flooded floors (61.5%), drains (24.8%), and water drums (10.7%), as compared to the others. Flooded floors and drains have become a common construction site problem due to uneven constructed concrete floor surfaces. The situation has created stagnant water which then retained water for a long period, hence becoming a favourable breeding site for the vector mosquitoes (Dia et al., 2012; Wilson and Sevarkodiyone, 2014). Meanwhile, the water drums found in workers' hostels located at the construction sites are also at risk of becoming a breeding site for mosquitoes. The condition of water drums that are not properly covered, contributes to the breeding site of the *Aedes* mosquito (Rahim, 2021; Duarte et al., 2013). From our study, the breeding sites of *Ae. aegypti* were located indoors, shaded, and less exposed to sunlight, and these findings were supported by several studies (Hassan et al., 2005; WHO, 1986). On the other hand, *Ae. albopictus* immature was greatly bred in the water-holding plastic containers located outdoors and uncovered at the construction sites. *Ae. albopictus* is known to be a container breeder in both natural and man-made containers and it is mostly found in outdoor areas (Rahim, 2021; Rao, 2010). In another situation, the elevator shaft was found completely invaded by *Cx. quinquefasciatus* immature at all surveyed construction sites. Their immature also found in flooded floors but a lower number. *Cx. quinquefasciatus* are commonly bred in filthy waters and their existence in various types of breeding sites is a possible indication that the mosquito may adapt easily to various conditions in the water (Burke, 2010).

The discovery of *Ae. aegypti* immature on each floor level suggested that the dispersal of this mosquito species was from the ground floor to the highest floor level, supporting the survival of the *Aedes* mosquito. Mosquitoes could be involved in close-range dispersal through human transportation using elevators or stairs (Lau et al., 2013; Wan Norafikah, 2010). Mosquitoes may disperse to find their food sources which are blood and nectar, mates, breeding sites, and resting sites (Service, 1997). Although *Ae. aegypti* immature dispersal seemed extensive (up to 42.0-meters height), our study demonstrated the abundance of *Ae. aegypti* immature was on the seventh-floor level and below, with most abundant on the second-floor level (up to 9.0-meters height). A previous study found that the dispersal of *Ae. aegypti* was up to 63.0 meters in height, with most abundant on the ground floor level (Ab Hamid et al., 2020). Meanwhile, *Ae. albopictus* immature was only found breeding on the ground floor level, with a maximum height of up to 3.0 meters. Our findings suggest that, *Ae. albopictus* preferred elevations closer to the ground floor, probably due to the outdoor environment with scattered plastic containers, pails, and vegetation around for breeding and resting. Although *Cx. quinquefasciatus* immature were found dispersed up to 9.0 meters in height, they were most abundantly found on the ground floor. We discovered the preferred breeding site of *Cx. quinquefasciatus* which is the elevator shaft was only found on the ground floor level of the construction sites. The breeding sites closer to the ground may create a complete ecosystem and ecology suitable for mosquitoes' infestation (Ab Hamid et al., 2020). These results emphasized that the lower floor level requires additional efforts during vector preventive and control measures. The availability of biotic (including plants, humans, and pets) and abiotic components (including building structure, wind speed, humidity, and temperature) and ecological system in our study sites may have provided adequate food sources, breeding sites, and resting places for the mosquitoes (Vijayakumar et al., 2014).

The average Container Index (CI) found in this survey was consistent with a relatively moderately high dengue sensitivity and dengue transmission risk (Rosenberg et al., 2018). All the positive containers were found in common places at the construction sites, making it accessible for workers to do the elimination process. Furthermore, construction workers are particularly exposed to mosquito bites since they spend most of the day working outdoors. Lack of knowledge among workers regarding mosquito breeding sites and indifferent behaviour about cleanliness at construction site areas will possibly increase the risk of getting a mosquito-borne infection (Wilke et al., 2018). Changes in construction phases, weather conditions, or human behaviour may significantly influence mosquito abundance. Therefore, controlling vector mosquito populations is recognized as the most effective and efficient strategy for preventing vector-borne disease outbreaks (Ajelli, 2017). Safety guidelines for construction sites must take into account the presence of vector mosquitoes, building features that influence the distribution of their breeding sites, and their interactions with construction workers. Specific vector mosquito control strategies may be required for different construction phases, since the efficiency of standard vector mosquito preventive and control strategies may be drastically reduced for different phases of the construction site (Wilke et al., 2018).

Our study possesses several limitations. Firstly, the study sites have various building sizes and designs that may have influenced the results. The larger size of construction sites required additional manpower to conduct mosquito breeding habitats inspections. Therefore, due to time constraints and lack of manpower, overlooked situations may occur when the inspections are carried out in some areas. Secondly, all construction sites surveyed were only carried out near dengue outbreak localities. Further surveys may include more construction sites in non-dengue outbreak areas as well so that the findings will be more valuable.

5. Conclusion

Despite these limitations, this study has the importance of providing the first baseline data on the presence of mosquito species, their preferred breeding habitats, and their vertical distribution at construction site areas in the Federal Territory of Kuala Lumpur. This study revealed that immature vector mosquitoes can be found in high numbers at construction sites and construction sites display sheltering exclusively for *Ae. aegypti*, which led to a high risk of dengue transmission. These evidence-based findings are essential for the health department to facilitate vector mosquito preventive and control activities in the construction site areas. Thus, the search and destroy activities should be focused on the productive vector mosquitoes' breeding habitats so that the outcomes will be more effective and efficient which could save time and manpower.

Acknowledgments

The authors thank the Director-General of Health, Malaysia for his permission to publish this article. The authors also thank the staff of the Entomology and Pest Unit, Federal Territory of Kuala Lumpur & Putrajaya Health Department for assistance in the field.

References

Ab Hamid N, Mohd Noor SN, Isa NR, Md Rodzay R, Bachtiar Effendi AM, Hafisool AA, Azman FA, Abdullah SF, Kamarul Zaman MK, Mohd Norsham MI, Amanzuri NH. 2020. Vertical infestation profile of Aedes in selected urban high-rise residences in Malaysia. Tropical medicine and infectious disease 5(3): 114. doi: 10.3390/tropicalmed5030114.

Ajelli M. 2017. Modeling mosquito-borne diseases in complex urban environments. Acta tropica 176: 332-4. doi: 10.1016/j.actatropica.2017.08.026.

Atique S, Chan TC, Chen CC, Hsu CY, Iqtidar S, Louis VR, Shabbir SA, Chuang TW. 2018. Investigating spatio-temporal distribution and diffusion patterns of the dengue outbreak in Swat, Pakistan. Journal of infection and public health 11(4):550-7. doi: 10.1016/j.jiph.2017.12.003.

Burke R, Barrera R, Lewis M, Kluchinsky T, Claborn D. 2010. Septic tanks as larval habitats for the mosquitoes Aedes aegypti and Culex quinquefasciatus in Playa-Playita, Puerto Rico. Medical and veterinary entomology 24(2): 117-23. doi: 10.1111/j.1365-2915.2010.00864.x.

Dia I, Diagne CT, Ba Y, Diallo D, Konate L, Diallo M. 2012. Insecticide susceptibility of Aedes aegypti populations from Senegal and Cape Verde Archipelago. Parasites & vectors 5(1): 1-4. doi: 10.1186/1756-3305-5-238.

Duarte EH, Pereira J, Oliveira HD, Lima HS, Perez A, Pile E. 2013. Aedes (Stegomyia) aegypti (Diptera: Culicidae) in some islands of Cape Verde: types of breeding sites and their relationship with larval presence. Arquivos do Instituto Biológico 80: 359-62.

El Badri AM. 1999. Aedes in construction sites on Penang, Malaysia: A study on its breeding habitats, distribution and control. MSc thesis. Universiti Sains Malaysia, Penang, Malaysia.

Estrada-Franco JG, Craig GB. 1995. Biology, Disease Relationships, and Control of Aedes Albopictus; Pan American Health Organization: Washington, DC, USA.

Fernandez BJ. 2016. Aedes and construction sites. Website https://www.thestar.com.my/opinion/letters/2016/01/08/aedes-and-construction-sites/ [accessed 22 November 2021].

Hammond SN, Gordon AL, Lugo ED, Moreno G, Kuan GM, López MM, López JD, Delgado MA, Valle SI, Espinoza PM, Harris E. 2007. Characterization of Aedes aegypti (Diptera: Culcidae) production sites in urban Nicaragua. Journal of medical entomology 44(5): 851-60. doi: 10.1093/jmedent/44.5.851.

Hassan AA, Salmah MR, Ngumbang J, Ramli SA, El-Badri AM. 2005. Mosquitoes of urban areas of Penang: abundance and control. In Proceedings of the Fifth International Conference on Urban Pests, pp. 257-263.

Knop E. 2016. Biotic homogenization of three insect groups due to urbanization. Global Change Biology 1: 228-36. doi: 10.1111/gcb.13091.

Kraemer MU, Sinka ME, Duda KA, Mylne AQ, Shearer FM, Barker CM, Moore CG, Carvalho RG, Coelho GE, Van Bortel W, Hendrickx G. 2015. The global distribution of the arbovirus vectors Aedes aegypti and Ae. albopictus. Elife 4, e08347. doi: 10.7554/eLife.08347.001.

Lau KW, Chen CD, Lee HL, Izzul AA, Asri-Isa M, Zulfadli M, Sofian Azirun M. 2013. Vertical distribution of Aedes mosquitoes in multiple storey buildings in Selangor and Kuala Lumpur, Malaysia. Tropical biomedicine 30(1): 36-45.

McKinney ML. 2002. Urbanization, Biodiversity, and Conservation The impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. Bioscience 52(10): 883-90. doi: 10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2.

Ministry of Health (MOH), Malaysia. 2014. New direction guidelines on dengue control: Ministry of Health Malaysia, pp. 17.

Montgomery MR, Stren R, Cohen B, Reed HE. 2013. Cities transformed: Demographic change and its implications in the developing world. 1st ed. London: Routledge. doi: 10.4324/9781315065700.

Moore KJ, Qualls W, Brennan V, Yang X, Caban-Martinez AJ. 2017. Mosquito control practices and Zika knowledge among outdoor construction workers in Miami-Dade County, Florida. J Occup Environ Med 59: 7–19. doi: 10.1097/JOM.0000000000000960

Mudin RN. 2015. Dengue incidence and the prevention and control program in Malaysia. IIUM Medical Journal Malaysia 14(1). doi: doi.org/10.31436/imjm.v14i1.447.

Mutebi JP, Hughes HR, Burkhalter KL, Kothera L, Vasquez C, Kenney JL. 2018. Zika virus MB16-23 in mosquitoes, Miami-Dade County, Florida, USA, 2016. Emerg Infect Dis 24: 808–810. doi: 10.3201/eid2404.171919.

Rahim FA, Mahmud MA, Yatim MF. 2021. Key Breeding Containers of Dengue Vectors in Outbreak Localities in Federal Territory of Kuala Lumpur. Journal of Diseases 8(1), 1-8. doi: 10.18488/journal.99.2021.81.1.8.

Rao BB. 2010. Larval habitats of Aedes albopictus (Skuse) in rural areas of Calicut, Kerala, India. Journal of vector borne diseases 47(3): 175.

Rohani A, Azahary AA, Malinda M, Zurainee MN, Rozilawati H, Najdah WW, Lee HL. 2014. Eco-virological survey of Aedes mosquito larvae in selected dengue outbreak areas in Malaysia. Journal of vector borne diseases 51(4): 327.

Rosenberg R, Lindsey NP, Fischer M, Gregory CJ, Hinckley AF, Mead PS, Paz-Bailey G, Waterman SH, Drexler NA, Kersh GJ, Hooks H. 2018. Vital signs: trends in reported vectorborne disease cases—United States and Territories, 2004–2016. Morbidity and Mortality Weekly Report 67(17): 496. doi: 10.15585/mmwr.mm6717e1.

Sampaio AMM, Kligerman DC, Ju´nior SF. 2009. Dengue, related to rubble and building construction in Brazil. Waste Manag. 29: 2867–2873. doi: 10.1016/j.wasman.2009.06.017.

Samy AM, Elaagip AH, Kenawy MA, Ayres CF, Peterson AT, Soliman DE. 2016. Climate change influences on the global potential distribution of the mosquito Culex quinquefasciatus, vector of West Nile virus and lymphatic filariasis. PloS one. 11(10): e0163863. doi: 10.1371/journal.pone.0163863.

Sang S, Yin W, Bi P, Zhang H, Wang C, Liu X, Chen B, Yang W, Liu Q. 2014. Predicting local dengue transmission in Guangzhou, China, through the influence of imported cases, mosquito density and climate variability. PloS one 9(7): e102755. doi: 10.1371/journal.pone.0102755.

Service MW. 1997. Mosquito (Diptera: Culicidae) dispersal—the long and short of it. Journal of medical entomology 34(6): 579-88.

Vijayakumar K, Kumar TS, Nujum ZT, Umarul F, Kuriakose A. 2014. A study on container breeding mosquitoes with special reference to Aedes (Stegomyia) aegypti and Aedes albopictus in Thiruvananthapuram district, India. Journal of vector borne diseases 51(1): 27.

Wan Norafikah O, Nazni WA, Noramiza S, Shafa'ar Ko'ohar S, Azirol Hisham A, Nor Hafizah R, Sumarni MG, Mohd Hasrul H, Sofian Azirun M, Lee HL. 2010. Vertical dispersal of Aedes (Stegomyia) spp. in high-rise apartments in Putrajaya, Malaysia. Tropical biomedicine 27(3): 662-7.

Wilke AB, Vasquez C, Petrie W, Caban-Martinez AJ, Beier JC. 2018. Construction sites in Miami-Dade County, Florida are highly favorable environments for vector mosquitoes. PLoS One 13(12): e0209625. doi: 10.1371/journal.pone.0209625.

Wilson JJ, Sevarkodiyone SP. 2014. Breeding preference ratio of dengue and chikungunya vectors in certain rural villages of Virudhunagar district, Tamil Nadu, South India. Wld. Appl. Sci. J. 30:787-91. doi: 10.5829/idosi.wasj.2014.30.06.82347.

World Health Organization. 1986. Aedes aegypti: biology and control. Geneva.

Cite the Article: Faizul Akmal Abdul Rahim, Mohd Amierul Fikri Mahmud, Mohd Farihan Md Yatim, Mohd Hatta Abdul Mutalip, Hanipah Shahar (2022). The Construction Site Provides a Suitable Environment for Vector Mosquitoes in The Federal Territory of Kuala Lumpur, Malaysia. *Environment & Ecosystem Science, 6(2): 65-70.*