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Efficacy of Intelligent Mosquito System (I.M.O.S) with Xmos Mini Aerosol Against *Aedes* in 17th College, Universiti Putra Malaysia

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ABSTRACT

This study reports the efficacy of I.M.O.S (Intelligent Mosquito System) by using Xmos mini aerosol in reducing *Aedes* mosquito population in 17th College, Universiti Putra Malaysia (UPM). Prior to the experiment, the *Aedes* mosquito population was determined in all blocks of the 17th College, UPM. The I.M.O.S. was installed above the entrance door of the hall and two rooms and was set to automatically spray at 6.30 am and 4.00 pm every day. No intervention was used in the control house. Adult efficacy study was conducted by placing 20 *Aedes* mosquitoes in each cage and was hung at a distance of 10 feet from the I.M.O.S. The mortality caused by I.M.O.S throughout the exposed two hours and after 24 hours of exposure was recorded. The number mosquito eggs population were calculated throughout the installation of I.M.O.S. Data were analysed using two-way ANOVA and paired T-test, respectively. The mean number of *Aedes* mosquito eggs and ovitraps index showed no significant difference ($p>0.05$) between control and treatment blocks. There were significant differences ($p<0.05$) in the percentage of knockdown of adult *Aedes* mosquitoes (10, 20, 30, 60 and 120 minutes after exposure) and the mortality of adult *Aedes* mosquitoes

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after 24 hours exposure. Nano and slow-release technology of the I.M.O.S with Xmos mini aerosol proved that this type of intervention can kill adult *Aedes* mosquitoes. Thus, it is a potential intervention for vector control and management.

Keywords: Aedes mosquito; aerosol; dengue fever; dengue virus; intelligent mosquito system; Ovitraps

INTRODUCTION

Dengue fever (DF) is an endemic disease that critically affects the subtropical and tropical regions of the world. Female *Aedes* mosquitoes are the only known vector that can transmit dengue virus (DENV) and cause DF. DENV is transmitted and spread specifically by *Aedes aegypti* and *Aedes albopictus* (Medeiros et al., 2018). DENV is a single stranded RNA virus of Flaviviridae family. The flavivirus circulates in the blood of infected person for two to three days and develops symptoms such as sudden onset fever, severe flu, severe headache, nausea, vomiting, swollen glands, retro orbital pain, muscle, and joint pains (Ratini, 2019). People with a second or subsequent dengue infection as well as those with weakened immune systems are at higher risk for developing severe form of viral illness which are dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) (Ratini, 2019).

According to the research that was done before 1970, there were only total of nine countries that was affected with dengue epidemics. But the disease today is widespread in over 100 countries including Western Pacific, South East Asia, Eastern Mediterranean, America and Africa. However, the most affected countries are in South East Asia and Western Pacific. Dengue cases in Malaysia has risen since the first major epidemic in 1973 (Wallace et al., 1980). In Malaysia, iDenggi (2019) reported 57,920 dengue cases from 29 December 2019 until 9 July 2020.To add, the cumulative number of death due to dengue infection from January until July were 94 deaths (iDengue, 2019). It clearly showed that demographic and social developments such as population development, urbanization and modern transportation significantly affected the increase in number of dengue cases. Higher infectious incidence due to different virus serotypes raised the rate of genetic modification in viruses. As a result, it will increase the chances of DENV genotypes with higher severity of the DF (Gubler, 2002).

Due to the failure of vector management, the increasing intensity of dengue has given more opportunity for scientist to develop the dengue vaccines, hence making it effective tetravalent dengue vaccine for global public health. For several decades, the dengue vaccine development has been in progress but the complex pathology of the illness, the importance to control four virus serotypes and low in investment by vaccine developers have inhibited the process (Guzman et al., 2010). While waiting for a treatment or cure for this disease in terms of new tools of vaccines, antiviral drugs, and improved diagnostic to be found, it is of utmost importance that the spread of dengue is well-controlled and well-managed.

Generally, the most common vector management is categorised as physical, biological, chemical, and integrated vector management (combination of more than two interventions) (Bouzid et al., 2016). Physical controls consist of regular cleaning of mosquito breeding sites which are artificial containers, cover of the containers and ovitraps (Lima et al., 2015). Biological control involves the use natural predators such as Copepods (Lazora et al., 2015), single or multiple species larvivorous fish (Han et al., 2015) in mosquitoes' breeding sites. Furthermore, bacterium such as *Bacillus thuringiensis israelensis* (Bti) that develops toxic proteins resulting in high larval mortality after ingestion (Boyce et al., 2013). However, the practical side of this control remains highly questionable.

Insecticide spraying, insecticide treated curtains, nets, and screens, fogging and larvicide application are forms of chemical controls (Bouzid et al., 2016). Wilson and colleagues reported that materials treated with insecticide could minimize the spread of disease but recorded low *Ae. aegypti* mortality rates demonstrated substantial resistance to insecticides, which significantly reduces the efficacy of this form of control measure (Wilson et al., 2014).

Mosquito populations around the world are widespread and abundant despite decades of vector control programs (Marcondes & Ximenes, 2016). However, different types of interventions, resources, period of study will affect the effectiveness of any vector control program which may explain in part of varying degree of success between studies. On the other hand, due to poor reporting of the study design, observational methodologies, heterogeneity and indirect results, the quality of data falls within the range of low and very low (Bouzid et al., 2016).

As practiced in Malaysia, dengue vector control activities are strongly dependent on human resources. In fact, a strong and large human workforce is needed to carry out the numerous district-level activities of dengue vector management, surveillance, and prevention (Packierisamy et al., 2015). In addition, trained healthcare that performs inspections, fogging and larvaciding activities is one of the pillars of the national control activities in preventing the rise of dengue cases. Frontliners including medical doctors and entomologist provide technical support in this issue. As a result, human resources represent the most important community to combat against *Aedes* mosquitoes (Packierisamy et al., 2015). Fitzpatrick et al. (2017) reported six countries with middle-income economies and high number of dengue cases accounts for an estimated 15% of the global dengue burden.

Hence, there is a need for implementation of a new intervention which is less laborious to reduce the *Aedes* mosquito population. Intelligent mosquito system (I.M.O.S) with Xmos mini aerosol is a product developed by One Team Network Sdn. Bhd. as an alternative to combat this issue. I.M.O.S is an automatic system that releases the required amount of the aerosol content (Personal communication Mr. Lim Chee Hwa 30 June 2019) at the time where mosquitoes' activities are high during the early hours in the morning and in the evening before dusk (WHO, 2017). Xmos mini aerosol contains 0.76% of metofluthrin as active ingredient and is highly effective to kill adult mosquitoes. Metofluthrin is ideal to be used in numerous current source products such as coil of mosquito, as well as in modern products such as ventilator vaporizers and paper strips (Ujihara et al., 2004). Metofluthrin has higher vapor pressure and deliver macro-particles into air lasting up to eight hours (Personal communication Mr. Lim Chee Hwa 30 June 2019). Matsuo et al., (2005) explained that metofluthrin shows high effectiveness of knockdown especially towards mosquitoes as well as other insects. Moreover, this ingredient is highly volatile and has low toxicity towards mammals (Matsuo et al., 2005).

Therefore, this study was designed to investigate the effect of I.M.O.S with Xmos mini aerosol in reducing *Aedes* mosquito population in 17th College, Universiti Putra Malaysia (UPM) as well as the knockdown efficacy of adult *Aedes* mosquitoes.

MATERIALS AND METHOD

Study Area

The research was carried out at the 17th College of Universiti Putra Malaysia located in Serdang, Selangor as this study site records high number of dengue cases (Abdul et al., 2016). It consists of four residential blocks namely Block A, B, C and D. The accommodation design is 'Apartment Style' with four rooms per house and two students per room. Block A, B and C are accommodated by female students while Block D is for male students. There are four wings with five levels in each block. A Lake can be found about 50 meters from the entrance of the college. All blocks were used for the pre-treatment assessment. After ensuring the mosquito population in all blocks was similar, Block B and C were randomly selected as treatment block and control block, respectively.

Ovitrap

Ovitraps were provided by One Team Networks Sdn Bhd. A total of 160 of ovitraps with QR code were installed along the front and back staircase of each level of Block A, B, C and D for the pre-treatment assessment. Non-woven tissue (17.5 cm x 7.3 cm) was placed in each ovitrap for six days to allow the mosquitoes to oviposit. All the tissues were collected, and the eggs deposited on the tissues were counted to determine the mosquito population for every block. This procedure was carried out every month for two months (referred hereafter as Intervention 1 and 2) at the required blocks.

Intelligent Mosquito System (I.M.O.S) with Xmos Mini Aerosol

I.M.O.S with Xmos mini aerosol was kindly sponsored by One Team Networks Sdn Bhd (Figure 1). A total of fifteen I.M.O.S and 45 cans of Xmos mini aerosol were used in five selected houses during the intervention. Each house contains three I.M.O.S installed at three different areas which are hall, room 1 and room 2. Before the trial, all the Xmos mini aerosol were pre-weighed and the weight loss was recorded after assessment and a new Xmos mini aerosol was replaced after 45 days.

Figure 1: I.M.O.S with Xmos mini aerosol

Pre-treatment Assessment

During the pre-treatment assessment, 160 ovitraps were installed at the front and back staircase of each level. The ovitraps were attached to the stairs by using cable tie (8 inches). The mosquito population was determined by counting the eggs of mosquito on the substrate inside the ovitrap after six days. All the substrates from the ovitrap were air-dried at room temperature before placing them under a magnifying glass to manually calculate the number of mosquito eggs. Two blocks with the highest population were chosen for the treatment. The mean number of eggs and ovitrap index (OI) were calculated by using the following formulas.

$$\text{Mean number of eggs} = \frac{Total\ number\ of\ eggs\ in\ ovitraps}{Total\ number\ ovitraps\ examined} \times 100$$

$$\text{Ovitrap index, OI} = \frac{No.of\ positive\ ovitrap\ (with\ eggs)}{No.of\ ovitrap\ deployed} \times 100\%$$

Intervention Study

The size of the hall was 20.4 m^2 while room 1 and room 2 were 13.7 m^2 as shown in Figure 2. For the intervention study, Block B was chosen as treatment block while Block C was the control block. A total of fifteen I.M.O.S with Xmos mini aerosol were placed inside the five selected houses in Block B. In each of the treated house, three I.M.O.S with Xmos mini aerosol were installed separately in the hall, room 1 and room 2. Xmos mini aerosol was set to spray at two time points, 6.30 am and 4.00 pm. At each spraying time, six sprays were released in room 1 and 2 while nine sprays were released in the hall. There was no instalment of I.M.O.S in the control houses.

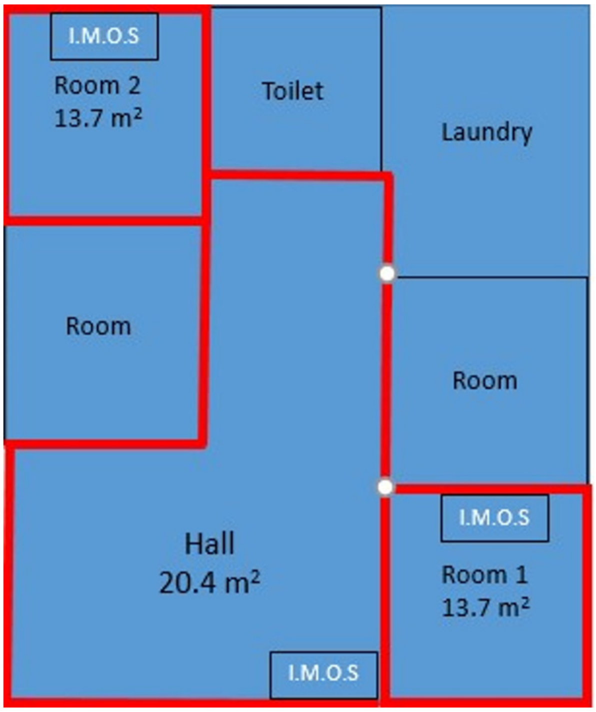

Figure 2: The size of hall, room 1 and room 2 at 17th College, UPM

Adult Efficacy Study

A total of 980 females non-gravid and non-blood fed, laboratory susceptible strain of *Ae. aegypti* were supplied in three batches of 360 mosquitoes each batch by Sumitomo Chemical Enviro- Agro Asia Pacific Sdn. Bhd. located in Senawang, Negeri Sembilan. Twenty *Ae. aegypti* adult female mosquitoes were placed in one net (10 cm x 17 cm x 32 cm). The nets were hung 10 feet (approximately 3.08 m) away from I.M.O.S in the five treatment houses and control houses, with a total of three cages in each house (one in the hall, room 1 and room 2). Starting from 4:30 pm to 6:30 pm, the knockdown efficacy was calculated by measuring the number of knockdown mosquitoes in the net. After that, all nets were moved to the laboratory. The percentage of mortality after 24 hours of exposure was then calculated. This adult efficacy study was conducted thrice at an interval of 30 days during the intervention phase. The percentage of knockdown efficacy was calculated using the following formula:

$$Percentage\ of\ knockdown\ efficacy$$
$$: \frac{Number\ of\ mosquito\ knockdown}{Total\ number\ of\ mosquito\ in\ net} x100$$

Temperature and Humidity

Three sets of humidity and temperature data logger from Temperature Technology of Australia (Model number: DS1921G) were used. The device was placed in the living room, room 1 and room 2 in the selected houses for hourly temperature and humidity recordings.

Data Analysis

Data were presented as mean ± SE. Data were analyzed by using Statistical Package for Social Science (SPSS) Version 15. The number of mosquito eggs and ovitraps index data were compared among Block B and C using the Paired Sample T-test. Two-way ANOVA was used to compare the means on knockdown of adult *Aedes* mosquitoes between control and treatment blocks at different time points. The percentage of adult knockdown between room and hall and the percentage of adult *Aedes* mosquitoes after 24 hours were analysed by using unpaired T- test. A value was considered significant at $p \leq 0.05$.

RESULTS

The population of *Aedes* mosquito eggs (Figure 3) collected in 17th College during pre-treatment, intervention 1 and intervention 2 between control and treatment blocks were not significantly different ($p= 0.166$) with each other during the pre-treatment. During day 30 and 60 indicated as intervention 1 and 2, respectively, the mosquito population was not significantly ($p=0.098$) different between the control and treatment blocks. The OI shows similar pattern with the mean number of eggs indicating that there was no significant difference ($p=0.213$) between control and treatment blocks during pre-treatment, intervention 1 and intervention 2 as shown in Figure 4. The knockdown percentage of adult *Aedes* mosquitoes in the treatment block was significantly higher ($p<0.05$) than the control block at all time points which were 10, 20, 30, 60 and 120 minutes of exposure (Figure 5). The mortality of adult *Aedes* mosquitoes after 24 hours of exposure was significantly higher (*p=0.0383*) in the treatment group compared to the control block as represented in Figure 6. The percentage of knockdown of adult *Aedes* mosquitoes between room and hall at the treated areas in 17th College, UPM showed no difference (*p=0.705*) (Figure 7).

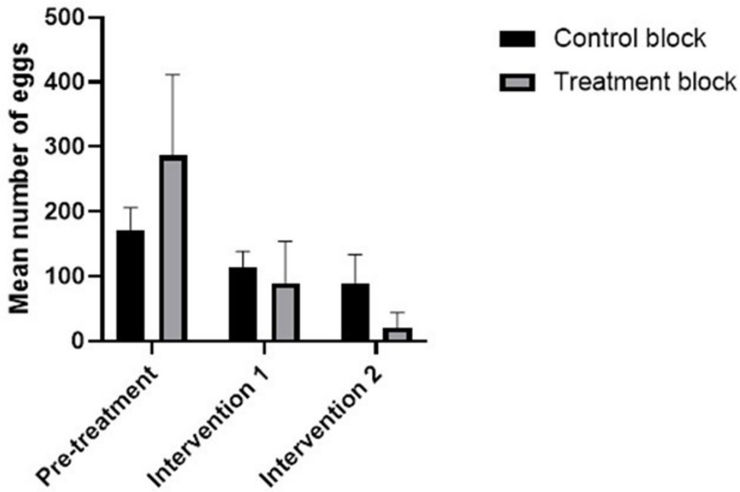

Figure 3: Number of eggs during pre-treatment, intervention 1 and intervention 2 between control and treatment blocks

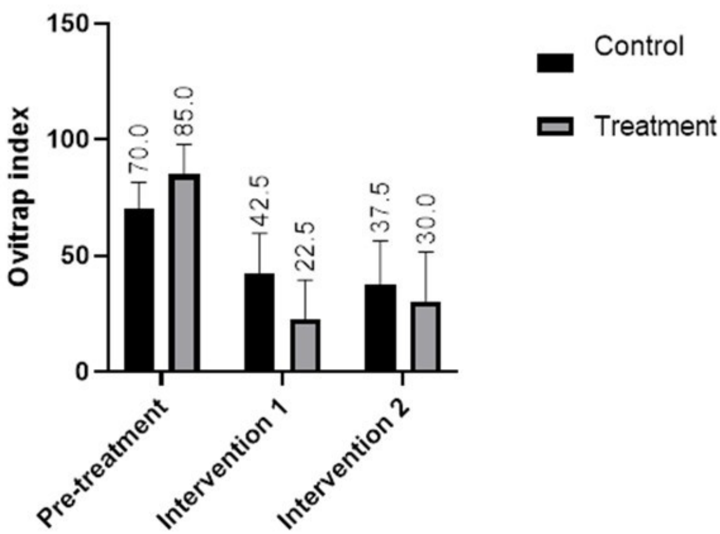

Figure 4: Ovitrap index (OI) during pre-treatment, intervention 1 and intervention 2 between control and treatment blocks

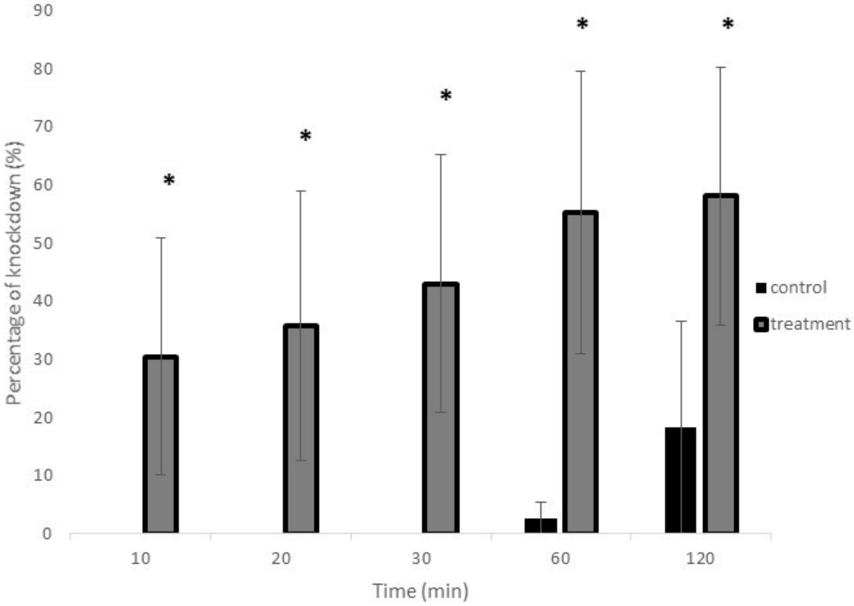

Figure 5: Percentage of knockdown at (10, 20, 30, 60 and 120 min) between control and treatment blocks. * significantly different at p<0.05

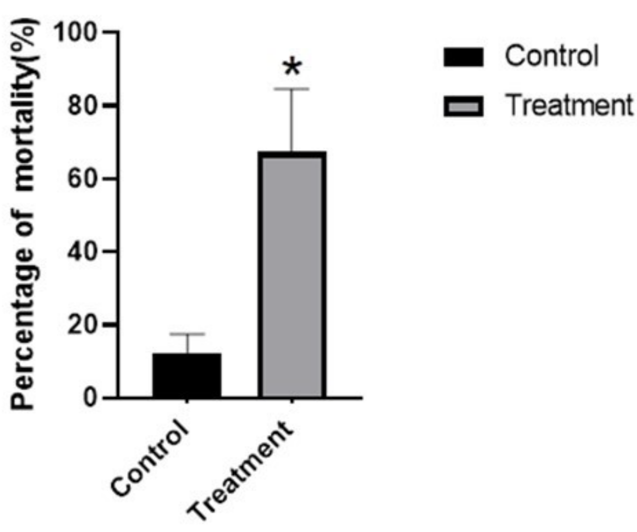

Figure 6: Percentage of mortality between control and treatment blocks after 24 hours of exposure. * significantly different at p<0.05

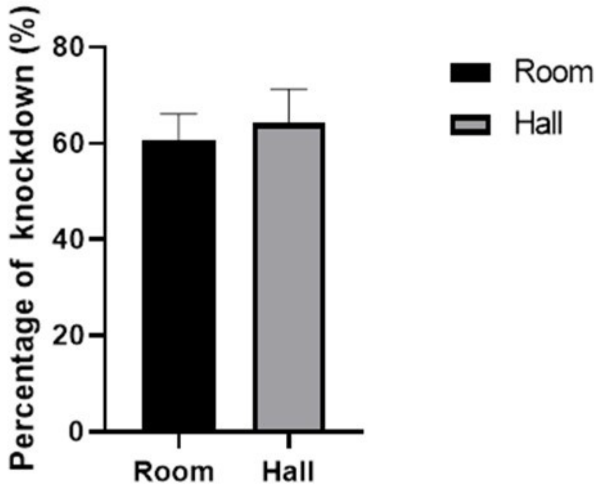

Figure 7: Percentage of knockdown of adult *Aedes* mosquitoes in the room hall area in the treatment block

DISCUSSION

Malaysia records frequent and consistent dengue cases throughout the years whereby the state of Selangor has the highest number of cases among all other states (iDenggi, 2019). Despite the intensive and extensive efforts by health and government-funded integrated vector control agencies, the outcome is still unsatisfactory as many new cases are still being reported. Therefore, this study focused on the use of insecticide, specifically I.M.O.S with Xmos mini aerosol as one possible method for vector control and management of *Aedes* mosquitoes.

The high population of *Aedes* mosquitoes and OI is consistent with our previous report by Latifah et al. (2020). This might be due to the presence of lakes in front of the 17th College and the presence of various containers, bottles, drains and students' pails in the study area that might provide ideal mosquito breeding sites. The use of I.M.O.S however did not effectively reduce the mosquito population, as the number and OI during the treatment months were still high. This is probably because the insecticide spraying was carried out inside the house repelling or killing mosquitoes that are present inside the house. Bibbs & Xue (2016) reported that the impact on mosquitoes was only at a very close proximity of approximately 0.3 m from the metofluthrin delivery system. The population of mosquitoes outside houses where ovitraps were installed were still high. We need to consider how long the efficacy of the treatment formulation lasts in the air when exposed against *Aedes* mosquitoes. *Ae. aegypti* shows an ability to escape from an open windows and doors (Moore et al., 2007). If this escape occurs, it will cause female *Aedes* mosquitoes to be able to oviposit as well as increases the eggs population.

I.M.O.S with Xmos mini aerosol is a chemical vector control that can kill adult mosquitoes where it contains 76% of metofluthrin as active ingredient (Matsuo et al., 2005). Previous study by Kawada et al. (2004) and Ujihara et al. (2004) reported multilayer paper strips impregnated with metofluthrin gave positive result as repellent against mosquitoes whether in field application or laboratory. Metofluthrin can reduce the biting activity of *Ae. aegypti* (Darbro et al., 2017). When the mosquitoes fly in the zone of metofluthrin, they will experience confusion leading to eventual knockdown of the mosquito (Buhagiar et al., 2017). Furthermore, metofluthrin mechanism of action focuses on causing disorientation affecting its biting activity, knockdown and killing the mosquitoes rather than exhibiting a repellent effect (Buhagiar et al., 2017).

Metofluthrin is highly lethal to *Ae. aegypti* in the confined space of an apartment at Queensland, Australia (Rapley et al., 2009). Shono (2004) reported that the use of metofluthrin coils effectively caused reduction in landing counts of *Ae. aegypti*. One Team Network Sdn Bhd claimed metofluthrin had high vapor pressure and deliver macro-particles into air and provided up to eight hours of protection. This statement was supported by Kawada et al., (2006) where metofluthrin had greater vapor pressure than d-allethrin and permethrin. Due to its characteristic, metofluthrin can vaporize at normal temperature while other pyrethroid are not able to vaporize due to their inability to evaporate effectively and require heating source for evaporation (Kawada et al., 2006).

Our outcome from the adult efficacy study shows that Xmos was able to cause knockdown at 10, 20, 30, 60 and 120 min and high mortality after 24 hours of exposure towards adult *Aedes* mosquitoes. We also analysed the mortality rate in two different size of spaces which were hall (20.4 m^2) and room (13. 7 m^2) giving us the advantage to determine if the spray was effective at different space volumes. Our outcome was like Dabro et al. (2017) who reported that significant knockdown was reported as early as 10 min after exposure at a distance of 3 m. They also reported that the mosquito knockdown at 3 m was lower than the exposure at 1 m. The knockdown rates ranged from 20-90% when the mosquitoes were exposed at 1 m and 0-70% at 3 m indicating partial dependency of mosquito knockdown rates on the room volume. In our study when we placed the spray 3 m away from the mosquitoes resulted in a 67% of knockdown.

The advantage of this study is that it is carried out at the site of a hotspot area and therefore represents the actual scenario rather than testing the effectiveness of a product in an experimental setting with controlled environment. The ideal range of *Ae. aegypti* female's survival and ability to travel is between 15°C and 32°C with an optimal temperature of 27°C (Rowley & Graham, 1968). The temperature in this study fell within 27.3-30.3°C, which is ideal for the mosquitoes' optimum activity. In terms of relative humidity, it has little impact towards the activity of female *Ae. aegypti* and their flight activity if it still falls within 30 to 90% with an optimal relative humidity of 80% (Rowley & Graham, 1968).

The relative humidity of our study area was 67.3-80.2% also ideal for the survival of *Aedes* mosquitoes. This indicates that metofluthrin caused the mortality of the mosquitoes and the possibility of mosquitoes' knockdown due to unfavourable or harsh surrounding temperature is cancelled out.

CONCLUSION

I.M.O.S with Xmos mini aerosol was effective in killing adult *Aedes* mosquitoes following direct exposure and after 24 hours after withdrawal in 17th College, Universiti Putra Malaysia. I.M.O.S with Xmos mini aerosol was however not effective in reducing the number of mosquito eggs and ovitraps index.

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