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RESEARCH ARTICLE

Biology characteristics of *Aedes albopictus* (Diptera: Culicidae) in Central Zones of Shah Alam, Selangor

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Abstract

Aedes sp. mosquitoes are the known vectors of dengue fever. The factors influencing the continuous occurrence of dengue fever have not yet been studied or fully understood. Therefore, this study was designed to assess the demographic parameter of *Aedes albopictus* (Diptera: Culicidae) in terms of their development, survival, and reproduction in Central Zone of Shah Alam. The study was conducted through ovitrap surveillance and mosquito rearing method. A total of 570 ovitraps were placed in nineteen (n=19) localities in the Central Zone of Shah Alam. Positive Ovitrap Index (POI) and mean eggs per trap (MET) was used to identify the infestation profile of dengue vectors in a locality. The biology and demographic parameters of dengue vector, such as development rate, survivorship and mortality rate were observed for each locality. Section 18 (POI: 73.3, MET: 35.05) was one of the localities that has high distribution and abundance of dengue vector. It was found that Section 24 was the locality with high development rate, high survivorship, and low mortality rate. These parameters were then used to formulate a life table for *Aedes* species mosquitoes in Central Zone of Shah Alam. As a conclusion life table analysis can be used to estimate the life cycle of the dengue vector. However, in-depth studies on the life table analysis need to be done in order to gain more understanding and so that authorized parties could plan for proper action to be taken.

Keywords: *Aedes albopictus*, life table analysis, demographic parameter, Malaysia

INTRODUCTION

Surveillance of adult mosquitoes helps vector control technicians to understand the dynamic complexity in mosquito ecology and its relationship. Thus, the survival of a mosquito is the most important aspect that affects its ability as a pathogen transmitting vector, such as *Aedes albopictus*, which is a vector of chikungunya and dengue (Thanittha *et al.*, 2011). Knowledge of mosquito life demographics is important in providing a female foundation for a successful vector control programmed. The survival of the mosquito is the most crucial aspect that affects its ability as a pathogen to transmit the disease. The life parameter studies of *Aedes albopictus* are still limited compared to *Aedes aegypti*, especially in Malaysia. This parameter is important to understand the population dynamic. Therefore, knowledge of mosquito life demographic may provide a foundation for a successful vector control program.

Aedes albopictus had been occasionally implicated in dengue epidemics in many parts of Asia. In Penang, *Aedes albopictus* have been found indoors due to urbanization (Nur Aida *et al.*, 2011). The high population density of *Aedes albopictus* is translated to frequent biting activity creating public health concern (Serpa *et al.*, 2013). The ability to determine the age structure and the survival rate of *Aedes albopictus* is of paramount ecological importance because longevity affects the net reproduction rates and dispersal distance (Nur Aida *et al.*, 2008). The establishment of the demographic profile of the *Aedes* and its geographical distribution provides a basic foundation for developing effective control strategies. Studies have been done to study the *Aedes* life parameter swath various factor influencing their survival, fecundity, and mortality (Hamisu *et al.*, 2016; Lau *et al.*, 2014; Sowilem *et al.*, 2013; Maimusa, 2012; Nur Aida *et al.*, 2011; Costa *et al.*, 2010; Nur Aida *et al.*, 2008; Lowenberg *et al.*, 2004, Strickman *et al.*, 2004).

Table 1 showed the summary of the *Aedes* life table model which important in providing the based information on its different development aspects under specific understanding life strategies of each species including life span, reproductive potential and stage specific survivorship to proliferate, and its vectorial capacity for disease transmission. Most of the studies have used the laboratory data collection under controlled conditions, known to provide the maximal growth potential that may not occur in nature. To address this issue, the entomologists have attempted utilizing the field data for the development of the life tables of *Aedes* mosquitoes. In order to highlight the biology of *Aedes albopictus* such as development, survival, mortality, and fecundity, an experiment was conducted in order to determine some of the demographic life parameters of selected strains of the *Aedes albopictus* under laboratory condition.

The inability of the current vector control strategy to curb the dengue outbreak in Malaysia could be attribute to the lack of information on the dengue vectors itself. In a practical manner, the distribution and abundance pattern of the DVs population are the important factors to determine the appropriate control which is necessary to interrupt the pathogen transmission. The understanding of the vector capacity and their contributable habitat is needed to effectively model and map by using Geographical Information System (GIS) in order to develop the sustainable and cost-effective strategies in managing the vector control program. Thus, this study aimed to evaluate the relationship of environmental condition on the distribution

and abundance of *Aedes albopictus* and its survival in the dengue risk area.

Table 1 Summary of life tables of *Aedes* mosquitoes based on previous study retrieved from 2004 to 2016.

Study (Year)	Location	Study setting	Species	Mosquito life parameter						Setting
				Egg hatching	Developmental period	Fecundity	Longevity	Gonothropic	Mortality rate	
Hamisu et al., 2016	Penang, Malaysia	Surrounded area in USM	*Aedes aegypti & albopictus*	-	*Ae. albopictus* (9.47 days) *Ae. aegypti* (8.76 days)	-	*Ae. albopictus*: 19.01 days *Ae. aegypti* 19.94 days	-	-	Controlled laboratory (27+_2 ℃)
Lau et al., 2014	Kuala Lumpur, Malaysia	Hotspot of DBKL	*Ae. aegypti*	80.1%	10–12 days	77 by 1 ♀	♀: 32 days ♂: 26 days	-	-	Controlled laboratory (29.0 ℃)
Sowilem et al., 2013	Makkah Saudi Arabia	Urban residential area	*Ae. aegypti*	72%	11 days	62 by 1 ♀	♀: 37 days ♂: 26 days	5-9 cycles	0.15	Controlled laboratory (25+_ 2 ℃)
Maimusa, 2012	Ac Park, UPM	Laboratory strain	*Ae. albopictus*		10–12 days	-	-	-	-	Controlled laboratory (29.4 ℃)
Nur Aida et al., 2011	Penang, Malaysia	Laboratory strain	*Ae. albopictus*	87.86%	5–7 days	774 eggs by 10 ♀	-	-	0.28	Uncontrolled laboratory
Costa et al., 2010	Sao Paolo. Brazil	Laboratory strain	*Ae. aegypti*	-	8 days	(35 ℃; 60%RH) 52 eggs by 1 ♀	-	-	-	Controlled laboratory (35 ℃; 60%RH) (25 ℃; 80%RH)
		Dengue hotspot area		-	11 days	(25 ℃; 80% RH) 75 eggs by 1 ♀	-	-	-	
Nur Aida et al., 2008	Penang, Malaysia	Laboratory strain	*Ae. albopictus*	-	-	221 eggs by 1 ♀	♀: 36 days ♂: 27 days	2 cycles	-	Uncontrolled condition
Lowenberg et al., 2004	Sao Paolo, Brazil	Randomly setting at 3 localities	*Ae. albopictus*	-	15 days (255oc) 10 days (27oc)		♀: 70 days ♂: 65 days	2 cycles	-	Controlled temperature (25 ℃ & 27 ℃)
Strickman and Kittayapong, 2002	Hua samrong, Thailand	Dengue hotspot area	*Aedes aegypti*	81.00%	-	30 eggs by 1 ♀	♀: 45 days ♂: 32 days	-	0.40	Uncontrolled condition (rural area)

**Symbol (♀) refers to female mosquitoes and (♂) male mosquitoes*

EXPERIMENTAL

Study population

Shah Alam is the capital state of Selangor with an area size of 290.3 km^2. It is located from 3°05'48.74"N 101°33'02.39"E to 2°58'22.93" N 101°44' 39.69"E. Shah Alam is located 25 kilometers of 45 minutes away from Kuala Lumpur, the capital of Malaysia. Shah Alam is surrounded by rapid development and has a high population density. Shah Alam is divided into four zones which are Northern (NZ), Southern zone (SZ), Central zone (CZ), and Town Centre (TC) with a total population of 763,416 in 2014. Fig. 1 shows the location of the study area.

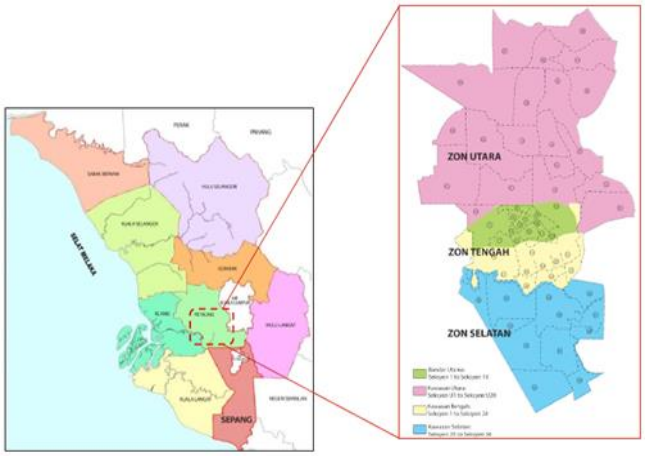

Fig. 1 Schematic diagram of the map shows the area of interest of this study, which is Shah Alam, Selangor. The red color indicates the Northern zone of Shah Alam, green indicates the town centre, yellow color indicates the central zone, and blue color indicates the Southern zone.

Shah Alam was selected as a research site because it has suffered a high epidemic period of dengue outbreak in Malaysia. Rozilawati *et al.* (2015) defined a dengue hotspot area when the dengue outbreak at a locality reaches 30 days and beyond the day of the outbreak started. Shah Alam is one of the localities that have a lot of dengue outbreak. Furthermore, Shah Alam is selected for the case study due to its diverse population distribution with a variety of rural and urban areas and has a significant public health implication in relation to control and prevention of dengue. The central zone (CZ) of Shah Alam is chosen as the study sites to set the ovitrap due to the distribution pattern of dengue cases concentrated in this area as compared to other zones.

Collection and colonization of *Aedes albopictus*

The entomological surveillance for the purpose of mosquito collection was conducted in several localities in central zones of Shah Alam. The eggs were collected using oviposition trap. Oviposition trap or ovitrap are made up from a black plastic container filled with a 150 ml distilled water or dechlorinated water with a paddle made of wooden hardboard (8cm x 2cm) as the damp site for the mosquito oviposition. The paddle was labeled with the code, data, and sampling locality.

A total of 60 ovitraps were deployed in each locality and placed in suitable habitat for the presence of mosquito (Fig. 2). Each trap was positioned in each site at a distance of 100 to 150 meters from each other's. After four consecutive days of exposed, the ovitraps were recollected. The paddles were transferred into an airtight plastic (13cm x 6cm). Meanwhile, the ovitraps were tightly covered with its container cap. This process cautiously carried to avoid the water spills occur and resulting in the loss of the water. This is because it was expected that the water may contain the *Aedes* eggs. The paddles were then dry in advance at room temperature of 29 ˚C to facilitate the process of eggs identification. The numbers of eggs in the water also will be taking into account as the eggs might be in the water. The eggs in the ovitraps were filtered using the filter paper and dried the same as the paddle. Both paddles and the filter paper with the presence of *Aedes* eggs were examined under the stereomicroscope at the Vector Control Research

Laboratory of Faculty of Health Science, Universiti Teknologi MARA for the purpose of eggs count.

Fig. 2 Examples of suitable habitats for the presence of mosquitoes with

considering the factors of; (i) near adult resting sites (ii) in complete shade which is out of weather and human interference (iii) in direct line of sight (iv)near to other breeding containers (v) close to the ground.

After the identification, all the *Aedes albopictus* eggs that have been collected in the field were colonized in the Vector Control Research Laboratory using standard protocol adopted from "Manual for the Mosquitoes Rearing and Experimental Technique". The diet and culture density were optimized in order to get the best colonization condition. The eggs were allowed to hatch in dechlorinated water until it reaches the pupal stage. Then the pupae will be transferred into the cage before transform into an adult. During the adult stage, the mosquito was supplied with enough nutrient for their development using sucrose solution and blood meal as the oviposition purpose. This procedure was repeated until the mosquito reached their F2 generations. Therefore, F2 generations were employed for the experiment. Emerged virgin males and females were allowed to mate, and their progeny are recorded. The F2 colonies were maintained in the specific laboratory condition. The diet provided accordingly to the life stages. The life demographic parameters including hatching rates of eggs, survival, mortality, and fecundity of the mosquitoes were recorded accordingly.

The life demographic evaluation of *Aedes albopictus*

The adult F2 mosquitoes were reared in the specific temperature of 29 ˚C. The field strain of collected *Aedes* eggs was immersed in the water and the hatching rate was recorded. The eggs were taken out of the water for every five days and dried for another 48 hours before submerging again in water for the same period. This procedure was repeated three times (Delatte *et al.*, 2009). Any unhatched eggs were considered as nonviable/sterile (Irvin *et al.*, 2004; Delatte *et al.*, 2009; Lee *et al.*, 2009). The larvae were culture in the sterile container with dechlorinated water with 0.2 mg food per L1 and L2 and 0.5 mg food per L3 and L4 per day.

Sex separation was conducted during the pupal stage. At least 30 pupae were separated and placed into the glass tube (2.5 cm x 7.5 cm) cover with a net in order to obtain virgin mosquitoes. From this, a total of the first 30 adult pairs (aged ≤ 2 days) that emerged will be placed in pair in a small cage size (10 x 10 x 10 cm) and supply with a piece of cotton pad soaked with 10 % sucrose solution place in a small round container in 5 cm diameter. The mosquitoes could mate for 72 hours, and then the sucrose was removed before a mouse confined in a wire mesh will be introduced into the cage for one hour. Each mosquito that has a blood meal was recorded accordingly. Then a fresh sucrose solution, together with a small round container (d=5 cm, h=2.5 cm) containing wet filter paper will be placed in each cage.

The gonotrophic cycle (GC) completed by each female were also recorded. The duration of the completed GC, which refers to the period of blood feeding, including the succession of physiological phenomena of oocyte maturation and ending with oviposition (Clements, 1992) were also recorded. The survivorship for both males and females were recorded to determine the longevity of each sex.

RESULTS

Overall, 570 ovitraps were installed in nineteen (n=19) localities in central zones of Shah Alam. Each locality was set for 30 ovitrap. From 570 ovitrap installed, 531 (93.15%) were recovered while the other 39 are categorized missing or damage.

Profile of biological characteristics for larvae stage

Fig 3. presents the profile of the biological characteristics of larvae stage namely; (a) hatching rate, (b) development rate, and (c) larval survivorship of the collected eggs. Most of the localities in the study area have a high hatching rate with an average 73.24% hatching rate. The development rate from eggs to the emergence of an adult were taken from 7 to 17 days. The shortest period was identified in Section 24 which take only 7 days from eggs to adult. Section 7 and 18 recorded 10 days. In terms of survivorship of the larvae, Section 24 recorded the shortest period which takes 9 days for all of the larvae to develop to pupae. This indicates that the development of larvae to pupae is rather quick and that the transmission of DF could be relatively rapid in that locality.

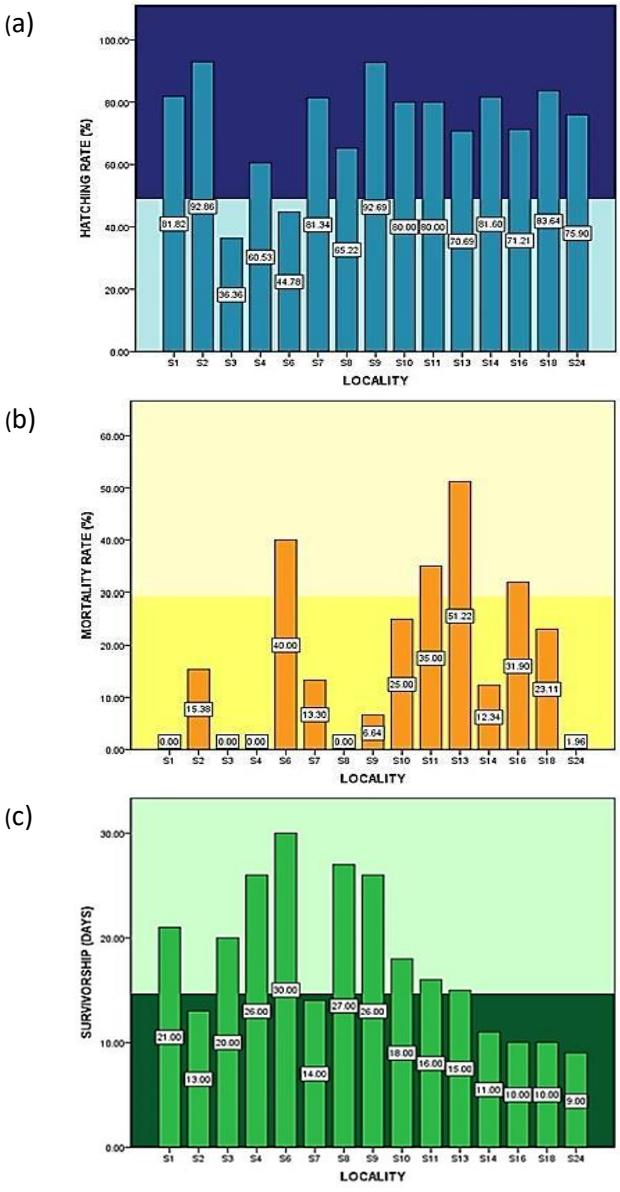

Fig. 3 Demographic profile of biological characteristics for larvae stage collected from nineteen localities in central zones of Shah Alam; (a) Hatching rate, (b) Mortality rate and (c) Survivorship of larvae.

**The temperature was controlled to room temperature at 29 ºC and relative humidity 30 %.*

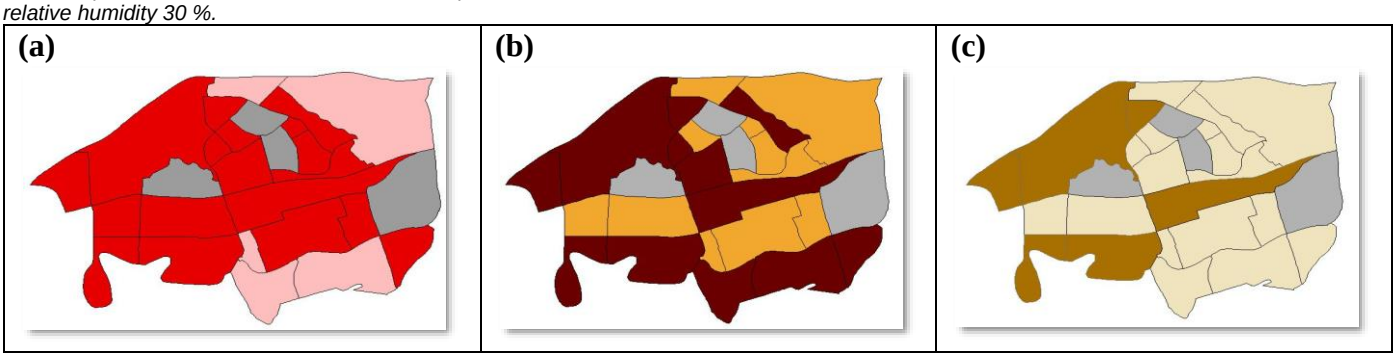

Fig. 4 Population parameter of *Aedes albopictus* (adult stages); (a) Developmental time, (b) Adult longevity and (c) Eggs density produced by *Aedes albopictus*. Note: The developmental time: Dark red (6 to 9 days); light red (10 to 12 days). Adult longevity: Dark orange (>54 days); light orange (<54 days). Eggs density produces by *Aedes albopictus*: Dark brown (<77.4 eggs per ♀) and light brown (>77.4 eggs per ♀).

Table 2 Fecundity, gonotrophic cycle, and generation of offspring (25 males: 25 females).

Locality	Gonotrophic cycle of F_0 (Total eggs produced)									Total eggs (n)	No. eggs per ♀	Total cycle	Mean eggs per cycle
	G1	G2	G3	G4	G5	G6	G7	G8	G9				
S2	125	368	214	117	32	14	0	0	0	870	34.80	6	145.00
S3	41	186	100	332	147	123	50	39	25	1043	41.72	9	115.89
S4	127	350	317	108	30	21	0	0	0	953	38.12	6	158.83
S6	56	437	625	546	324	89	39	21	29	2166	86.64	9	240.67
S7	71	1050	813	651	318	95	77	45	0	3120	124.8	8	390.00
S8	108	435	516	238	94	31	19	0	0	1441	57.64	6	205.86
S9	388	547	101	63	58	21	0	0	0	1178	47.12	7	196.33
S10	100	174	235	214	157	42	18	0	0	940	37.60	6	134.29
S11	200	325	204	175	87	32	0	0	0	1023	40.92	6	170.50
S12	97	201	189	116	25	39	0	0	0	667	26.68	7	111.17
S13	108	186	201	219	133	56	18	0	0	921	36.84	6	131.57
S15	100	432	475	387	358	104	109	32	25	2022	80.88	7	224.67
S16	70	300	357	270	210	199	40	0	0	1446	57.84	7	206.57
S17	71	1250	854	600	318	187	77	45	0	3402	136.08	8	425.25
S18	10	87	332	368	120	88	25	0	0	1030	41.2	7	147.14
S19	64	142	589	432	129	78	63	25	0	1522	60.88	8	190.25
S20	100	430	515	226	80	32	24	0	0	1407	56.28	7	201.00
S22	100	175	265	217	125	36	12	0	0	930	37.20	7	132.86
S23	114	1007	108	116	30	15	0	0	0	1390	55.60	6	231.67
S24	207	289	299	346	265	104	50	35	0	1595	63.80	8	199.38

Population parameter of *Aedes albopictus* in central zone of Shah Alam (adult stage)

Further information on the population parameter of *Aedes albopictus* for the adult stage was also been analyzed. Fig. 4 shows the spatial temporal pattern of biology and demographic parameters of adult *Aedes albopictus* based on; (a) developmental time, (b) adult longevity and (c) eggs density produced by female mosquitoes in each locality in the central zone of Shah Alam. Based on the outcome from Fig. 4A, eighteen localities (78.2%) in the central zone show a developmental time between 6 to 9 days. In term of adult longevity, eleven localities (47.8%) was observed to have longer longevity which the adult can survive more than 54 days. The fecundity, gonotrophic cycle, and generation produced are also observed in order to determine the biology and demographic parameters of DF. As shown in Table 2, Section 7 recorded has the highest fecundity with the total eggs of 3120 eggs and seven gonotrophic cycles until the adult mosquito died. The locality with the lowest fecundity is Section 12 with the total number of 667 eggs and only 6 gonotrophic cycles.

A life table is a convenient and fundamental population model that can be constructed to understand the population dynamics of a species including the life demography and general biology which include the survival, development and reproductive system of a population under various conditions. Through life table, prediction on population growth can also be done. Fig. 5 shows the estimation of *Aedes* species mosquito life table for overall Central Zone, Shah Alam. The cycle begins from the hatching of F1 eggs until the death of F1 adults. Note that the value stated in the table are mean values.

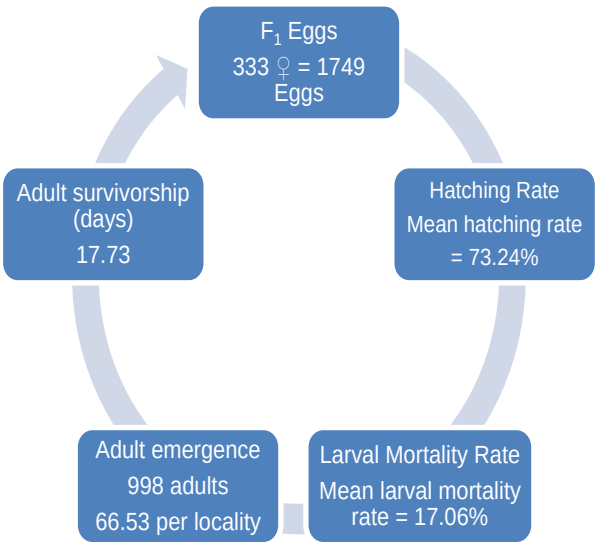

Fig. 5 Life table of *Aedes albopictus* in central zone of Shah Alam.

DISCUSSION

The population of *Aedes albopictus* is widely distributed within the central zone of Shah Alam. The distribution pattern can be related to the incidence rate of dengue fever within the study area. Solari *et al.* (2006), stated that environmental factors may influence the survival of the dengue vector in localities He also stated that the egg deposition could enhance the quality and reliability of the life table model. In contrast to that, other factors that have not been clearly assimilated in the life table model is the effects of lack of food or nutrients or the starvation of larvae as this factor may be a relevant too for the study of mosquito populations (Solari *et al.*, 2006; Arrivillaga and Barrera, 2004).

Survival is an important parameter when estimating the vectorial capacity of these arthropods' vectors of pathogens (Dye, 1992; Nur Aida *et al.*, 2008). A study on a life parameter such as developmental period or rate, survival and mortality rate and reproduction of mosquito are important to understand the population. The physical and biological mechanism affecting the population can be understood and all data obtained can be used as a basic foundation for developing efficient and effective vector control strategy (Ríos-Velásquez *et al.*, 2007). A study done by Nur Aida *et al.* (2013) supported that a critical analysis of the age composition of a population is also crucial in epidemiological studies. Furthermore, knowledge of survival rates can help in assessing the impact of vector control measures. They also agreed that the determination of the population increase from the reproductive capacity is another crucial component in the study of insect populations. Population increase can be described by a fertility table presenting the potential reproductive ability of female at different times. From this study, some patterns of biology and demographic parameters were observed. This result shows that the infestation of *Aedes* vectors in this study is related to the human population and human activities due to some factor such as low relative shaded area at human settlement.

A life table is a convenient and fundamental population model that can be constructed to understand the population dynamics of a species including the life demography and general biology which include the survival, development and reproductive system of a population under various conditions. Through life table, prediction on population growth can also be done.

CONCLUSION

Based on the results obtained, different localities show different rates of population performance for each locality in the central zone of Shah Alam. These characteristics; infestation profile, development rate, survivorship and fecundity of *Aedes albopictus* can be used as a baseline to properly plan for a more efficient practices to eradicate dengue fever outbreaks.

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