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A SCOPING REVIEW OF RESEARCH ON FACTORS AFFECTING THE OVIPOSITION, DEVELOPMENT AND SURVIVAL OF *AEDES* MOSQUITOES

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ABSTRACT

Objective: This is a conceptual paper to identify the effects of artificial light on the oviposition preferences, development of the juveniles and survivals of the adult *Aedes aegypti*. **Method**: The studies selected were analyzed by using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and discussed throughout the paper in the context of implications towards the oviposition, development and survivals of this species which include identifying the effect of different type of artificial lights and sunlight with different photoperiod regimes and water depth. **Result:** Most of the studies on the variables were focused on effect of temperature on the development and survival which 52% and 28% respectively. While, for the oviposition most of studies were focus on the impact of chemical deterrent and attractant on the egg-laying activity with 36%. **Conclusion**: To conclude, there is a gap found as there are none studies artificial light exposure effects towards this species especially in terms of its oviposition preferences, juvenile development and survivals of this species.

Keywords: Artificial light, dengue vector, development, oviposition, survival

1. Introduction

Aedes aegypti, a vector of dengue, is widely distributed in the tropical and subtropical zones. About two-thirds of the world's population lives in areas infested with dengue vectors, mainly *Ae. aegypti*. Dengue viruses infect over 100 million people every year (Imam, et al., 2014). The cases of dengue infections are difficult to accurately establish because approximately 20% of those infected with dengue virus exhibit apparent clinical symptoms and many patients with milder manifestations never seek health care including confused with malaria and typhoid (Getachew et al., 2015; Ebi & Nealon, 2016).

The case of dengue fever and dengue hemorrhagic fever showed an inclined trend for the past few decades. Currently, it also the most serious arboviral disease that happened around the globe (Cheong et al., 2014; Liu-Helmersson et al., 2016). The first case of dengue fever in Malaysia occurred in 1901-1902 and since then has remained endemic in Malaysia and also other countries (Cheong et al., 2014). The dengue viruses and vectors have spreading rapidly across the urban and semi urban areas of the country which indicated a wake-up call.

According to Getachew et al. (2015), *Aedes* mosquito is a diurnal-type of mosquitos which are active during the day. This species has a medical importance since it is the vector for arboviruses and lymphatic filariasis which can transmit all these pathogens by biting on the human skin (Schmidt et al., 2011; Sarwar, 2015). There are two variance of the *Aedes* species; *Ae. Aegypti* (primarily vector that caused the most dengue epidemics) and *Ae. Albopictus* (less effective in transmitting DENV) (Sarwar, 2015; Liu-Helmersson et al., 2016). These two variances are usually seen in a huge number in Malaysia and was recently recorded in Selangor area (Cheong et al., 2014; Rozilawati et al., 2015; Madzlan et al., 2018; Dom et al., 2019). The distribution of dengue fever caused by adult mosquitoes are closely related to aquatic habitats as they are favourable to breed in artificial containers (Hiwat et al., 2013; Cheong et al., 2014; Getachew et al., 2015; Rahman and Dom

2017). After the mating phase, *Aedes* female mosquitoes become gravid; it goes through a period of site seeking (Dieng et al., 2011). The water depth and surface area are crucial factor in oviposition process to ensure the survival of the eggs since the female mosquito do not attend the offspring (Dom et al., 2017; Awang et al., 2019).

The life cycle of *Aedes* mosquito species begin with the oviposition phase resulting from the mating activity between male and female mosquitoes. Inside the wet wall of water holding containersm, a raft of eggs are laid and the larvae will hatch when the eggs is submerged in the water (Pinheiro et al., 2002; Ebi & Nealon., 2016). The larvae obtain food from particulate organic matter and microorganisms. To develop from the first to fourth instars, the larvae renewing it skins thrice and turn them into pupa. In the fourth instar, it will undergo metamorphosis and develop into the emerging adult mosquito (do not require food to survive). Then, an adult mosquito rises and flying from the surface of water. The mosquito life cycle takes about eight to ten days which also depending on their feeding.

Figure 1 shows the conceptual framework on the relationship between mosquito life cycle and environmental factors on both habitat and ecosystem. The straight-line arrow indicates the life cycle of mosquito that occurs in aquatic environment while the dotted line arrow occurs in the surrounding environment. The blue color and green color of blunt-edged rectangle indicate the aquatic and surround environment respectively.

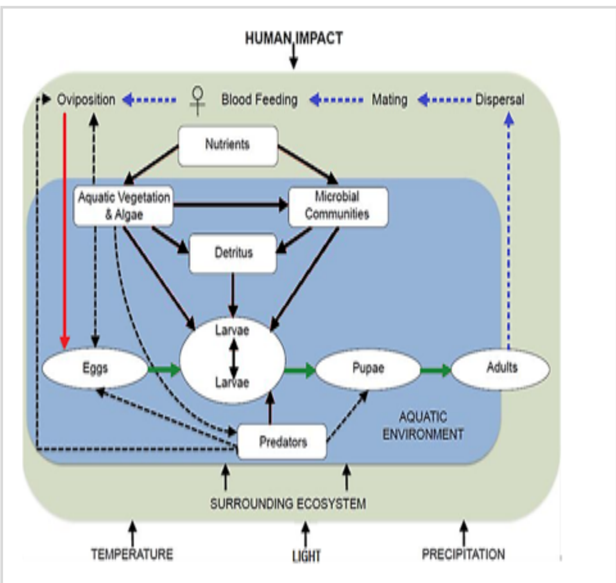

Figure 1: Relationship between mosquito life cycle and environmental factors on both habitat and ecosystem adopted from study conducted by Rejmánková et al., (2013). * Note: Red arrow represent oviposition phase, the green arrow represents the development phase and blue-dotted arrow represent the survival phase of mosquito.

2. Materials and Method

Several studies were included for literature review by using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The literatures were searched through the selected electronic databases which are BioMed, Bio One, Scopus, PubMed, PloS ONE, and Science Direct. The combinations of search keywords used are including "*Aedes*", "oviposition", "development", "survival", "light", and "depth of water level".

A total of 126 articles were retrieved from six of the electronic databases (*n*=126). From the total article, 15 articles were duplicates and hence excluded. After removal, the rest of the articles (*n*=111) subjected to screening phase prior to inclusion. Firstly, the remaining articles were grouped by title only (*n*=102) and followed by reading the abstract (*n*=81) were included. The inclusion criteria are i) environmental factor influence to the oviposition, development and survival of mosquito ii) the research design used. About 15 full articles from the total of 81 full articles were excluded because the articles were review articles (*n*=15). Finally, 66 full articles were included in this study and critically reviewed as in Figure 2.

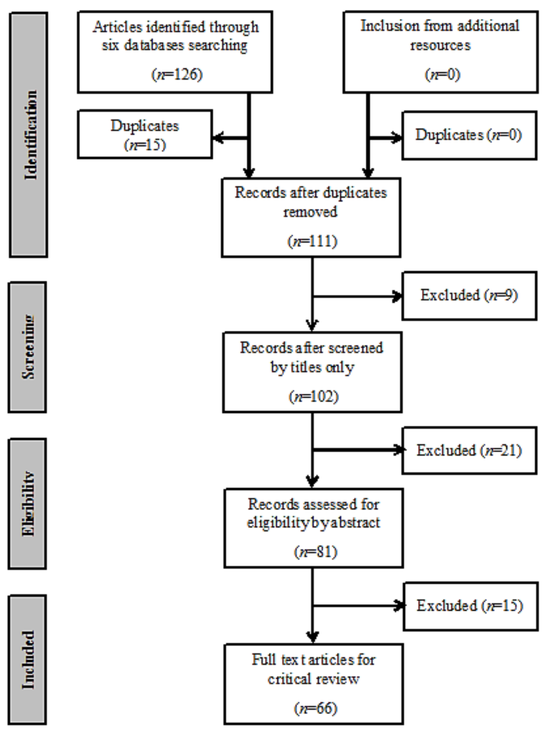

Figure 2: Flow diagram on process of selecting articles reviewed according to PRISMA guidelines.

3. Results

From the bar graph in Figure 3 (A) shows that there is an increment of interest in conducting study on the three important elements in the mosquito life cycle which are the oviposition, development and survival of mosquito. The reviewed articles were in the range started from the year 1963 until 2018. Moreover, most of the studies were conducted in the regions that have high number of dengue cases such as in North America and Asia with 32% and 33 % respectively. Moreover, can be noticed that in Figure 3 (C1), (C2) and (C3) shows the common variables that been studied by researchers. From the reviewed studies, there are various variables can affect the three vital elements in the life cycle of mosquito which are the oviposition, development of immature and survival of adult mosquito.

Most of the studies on the variables were focused on effect of temperature on the development and survival which 52% and 28% respectively. While, for the oviposition most of studies were focus on the impact of chemical deterrent and attractant on the egg-laying activity with 36%. From the Figure 3 shows that there is limited study conducted on the impact of light to the oviposition, development and survival of *Aedes* mosquito especially in local strain.

4. Discussion

All the causal factors for oviposition, development and survival were illustrated in this section. Figure 4 shows three different color coding of fishbone diagrams which are red, green and blue, where each of the colors is representing three different elements in mosquito life cycle which are gravid female adult oviposition, immature development and adult survival components respectively.

The red fishbone diagram describes various amounts of studies on different regulating factors experimenting on the oviposition life cycle component of the *Aedes aegypti* mosquito. The different depth, diet, conspecific, attractant or deterrent and light are the regulating factors found to be conducted by the previous studies. The green fishbone diagram illustrates several amounts of studies found conducted on different regulating factors on the immature development of larvae of *Aedes aegypti*. The regulating factors are different diet regime, containers, temperature, density as well as natural or artificial lights. The blue fishbone explains different amount of studies experimented on regulating factors towards the survivorships of the adult *Aedes aegypti* in the life cycle component. Different range of temperatures, diet regime, types of attractant or deterrents, types of light and any others were experimented on the life traits of the adult *Aedes aegypti*.

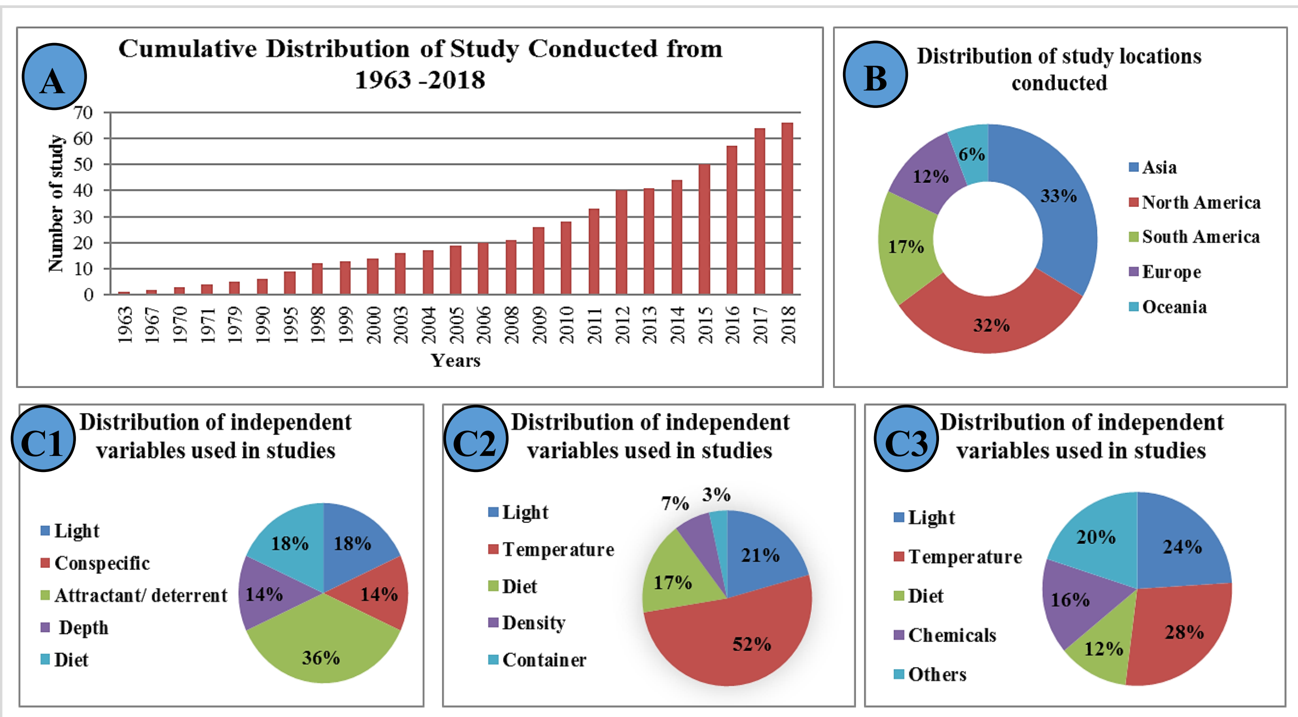

Figure 3: Distribution of studies during search period (A) cumulative studies conducted (B) and study location (C1) variables use in oviposition studies, (C2) variables used in development studies, (C3) variable in survival studies of mosquito.

4.1 Study on oviposition of mosquitoes

All the independent variables Mosquito of gravid female choice in oviposition site is a critical factor which influenced by several regular factors such as the present of attractant or deterrent chemical compositions (Autran et al., 2009; Seenivasagan et al., 2009; Reegan et al., 2015; Rajaganesh et al., 2016), the availability of diet (Canyon et al., 1999; Yoshioka et al., 2012; Zeller & Koella, 2016), conspecific larvae presence (Yoshioka et al., 2012; Zahiri & Rau, 1998) and last but not least water surface depth (Reiskind & Zarrabi, 2012; Binckley, 2017; Lester & Pike, 2003).

The presence of chemical composition in the habitat can result in either to attract or to deter the mosquito in oviposition site selection. According to Autran et al. (2009) and Rajaganesh et al. (2016) the presence of chemical composition in the oviposition substrates can affect the oviposition activity of gravid *Ae. aegypti* female by deterring the mosquito from laying eggs to the oviposition site. While, Allan & Kline (1995) and Seenivasagan et al. (2009) stated that the presence of cheimcal in the oviposition substrate can influence *Aedes* mosquitoe to lay eggs in the oviposition site resulting more eggs deposition. Chemical compunds especially that attract the gravid *Ae. aegypti* female to the oviposition sites is a critical factor that should be taken into consideration for both populations monitoring and control (Allan & Kline, 1995).

Aedes aegypti has been widely studied in respond to the variation in diet availability towards its oviposition, development (Yoshioka et al., 2012; Zeller & Koella, 2016) and survival (Canyon et al., 1999). As studied by Yoshioka et al (2012) gravid female mosquitoes select for oviposition site was not only influenced by the conspecific and larval density but also the availability of food. Later, Zeller & Koella (2016) stated that the variability of food conditions has strong effects on the oviposition of gravid *Ae. aegypti* female by which highest total number of eggs were counted for mosquitoes that had been nurtured on high food compared to the low food condition. Thus, availability of food in the oviposition substrate is a critical factor in driving selection for oviposition sites.

According to Zahiri & Rau (1998) the oviposition attraction or repellency of gravid *Ae. aegypti* female is influenced by the presence of conspecific larvae in the oviposition substrate or water. They discovered that oviposition attraction to this oviposition substrate to conspecific, gravid *Ae. aegypti* female initially rose to a peak and then declined as further increase in biomass of conspecific larvae present in the oviposition substrate. Moreover, Yoshioka et al (2012) also stated that gravid female mosquitoes select for oviposition site was influenced by the conspecific and larval density.

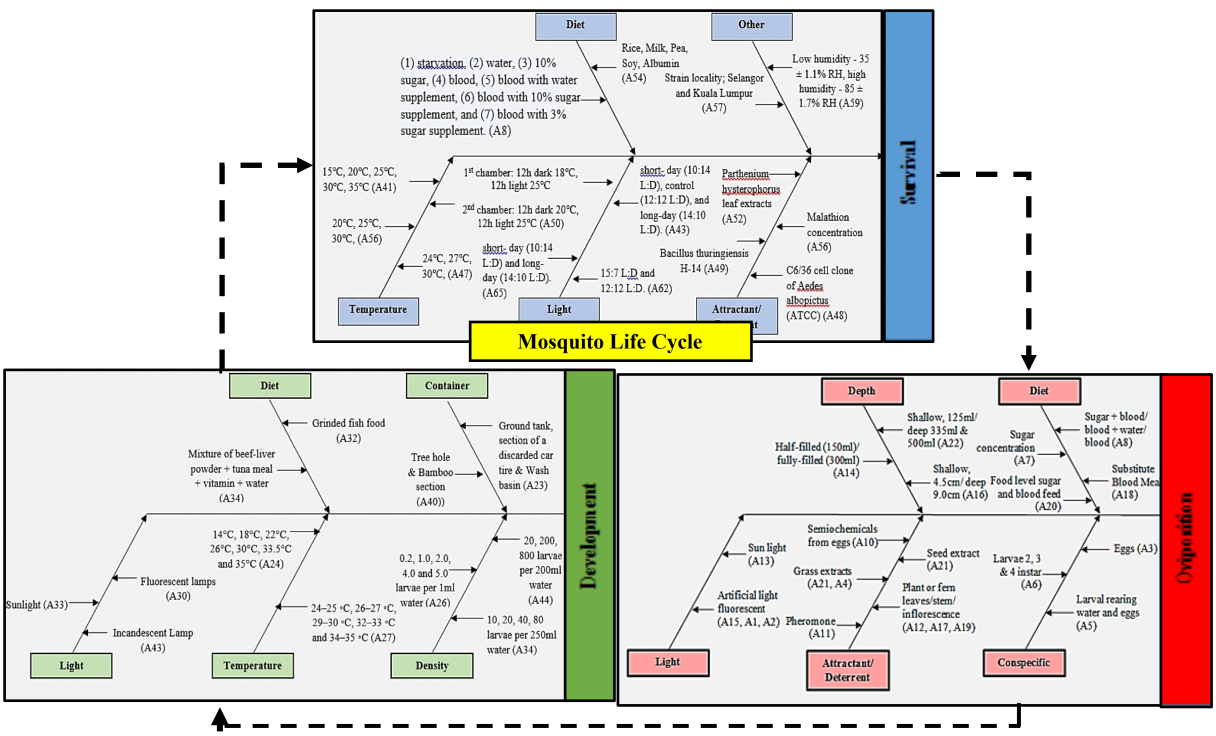

Figure 2.4: Depicted the several factors that influence the oviposition, development and survival of mosquito. *Notes: The shortest arrow show the regime in each study, intermediate arrow connects every regulating factor towards the longest arrow represent the components of the mosquito life phases and dotted line indicates the mosquito life cycle flow.

According to their study gravid female tends to lay eggs in oviposition substrate where the conspecific larvae were present as they hypothesized that the conspecific serve as a signal that the site has sufficient food, experiences infrequent water turnover and desiccation.

Gravid female mosquitoes also have well-studied in respond to the physical characteristic of aquatic media in term of depth towards oviposition behavior for surveillance and control purposes. According to Lester & Pike (2003) the depth of water has lack of significant effects towards the oviposition selection by gravid female over the container size. This was explained by the habitats in their experiment did not experience dry out which can affect the preference of the female mosquitoes for oviposition sites. However, Reiskind & Zarrabi (2012) stated that physical qualities of habitat such depth of water plays a significant role in oviposition selection. Water could include a wider variety of depths in the container which possible that mosquitoes to avoids or selects for oviposition. *Ae. albopictus* female were preferring habitats that held deeper water than shallower water (Reiskind & Zarrabi, 2012).

All the independent variables findings from the reviewed articles within this period (1963-2017) of studies on the oviposition were tabulated in Table 2.1 and all the causal factors were illustrated in the red fishbone diagram. The diagram describes various amounts of studies on different regulating factors experimenting on the oviposition life cycle component of the *Aedes aegypti* mosquito. The different depth, diet, conspecific, attractant or deterrent and light are the regulating factors found to be conducted by the previous studies.

4.2 Study on development of mosquitoes

Mosquito are adaptable to various environment conditions to survive. Conditions like temperature, containers types density, diet, sunlight exposure, photoperiod, competitions between other mosquito and other species as well as prerequisite for breeding sites could affect the evolvement and juvenile continuity (Kappus & Venard, 1967; Swain et al., 2008; Farjana et al., 2012; Costanzo et al., 2016; De Majo et al., 2017; Jong et al., 2017; Overgaard et al., 2017). Based on Figure 2.4 adopted from Rejmánková et al. (2013), it is summarizing the prime factors and interaction mechanism between mosquitoes and their habitat in ecosystem. Humans can affect habitat availability and quality through surrounding environment and human activity such as ecosystem and landscape change such deforestation or reforestation, desertification, irrigation and other hydrological changes, and agricultural practices can affect development of immature mosquito until it becomes an adult. The surrounding environment such instances regional weather, greenery and water depth existences are factors that prompt to the water temperature (Farjana et al., 2012; Rozilawati et al., 2012)

One of the causes affecting mosquito development is the ambient changes in the breeding site area (Stresman, 2010). Precipitation provide more possible breeding area for mosquitoes. In addition, seasonal changes also may affects the water temperature in breeding area. For instance, wet and rainy seasons provide more breeding site particularly in area of poor solid waste management. Increase number of possible breeding container can influence the survivorship rate of mosquitoes.

Table 2.1. Studies included in the meta-analysis of oviposition behavior of mosquito

Articles ID	Author (Year)	Location	Species					Research Design		Independent Variables				
			Ae. albo	*Ae. aegy*	*Culex spp*	*Anop spp*	Others	Field	Lab	Light	Deterrent/ attractant	Diet	Conspecific	Depth
A1	O'Gower, (1963)	Oceania		•					•	•				
A2	Snow (1971)	Europe		•					•	•				
A3	Chadee *et. al.*,(1990)	Europe		•					•				•	
A4	Allan & Kline, (1995)	North America	•	•					•		•			
A5	Allan & Kline, (1998)	Europe		•					•				•	
A6	Zahiri & Rau, (1998)	North America		•					•				•	
A7	Canyon *et. al.*, (1998)	Oceania		•					•			•		
A8	Canyon *et. al.*, (1999)	Oceania		•					•			•		
A9	Santos *et al.*, (2003)	South America		•				•	•		•			
A10	Ganesan *et. al.*, (2006)	Asia		•					•		•			
A11	Seenivasagan *et. al.*, (2009)	Asia		•					•		•			
A12	Autran *et al.*, (2009)	South America		•					•		•			
A13	Wong *et. al.*, (2011)	North America		•				•		•				
A14	Dieng *et al.*, (2012)	Asia	•					•						•
A15	Bernáth *et. al.*, (2012)	Europe		•					•	•				
A16	Reiskind & Zarrabi, (2012)	North America	•						•					•
A17	Reegan *et al.*, (2015)	Asia		•	•				•		•			
A18	Talyuli *et. al.*, (2015)	South America		•					•			•		
A19	Rajaganesh *et. al.*, (2016)	Asia		•				•	•		•			
A20	Zeller & Koella, (2016)	Europe		•					•			•		
A21	Santos *et al.*, (2017)	South America		•					•		•			
A22	Binckley, (2017)	North America	•					•						•

Marks (●) indicate the studies have at least one value of the independent variable listed

This can be proven where to complete the immature stages, water and optimum temperature are needed for the immature mosquito to develop and survive (Bertram et al., 1970; Phanitchat et al., 2017; Rozilawati et al., 2012).

In addition, larval density may be the main factors contributing to mosquito survival during the immature or juvenile stages of mosquitoes. High density at the breeding site will affect the larvae and other live aquatic competition. Previous study focused on the density effect on immature mosquito development. The researcher summarizes that the body mass of immature mosquito is affected by high density (Couret et al. 2014; Zapletal et al. 2018). Aquatic plant is one of the food sources used for larvae in the natural environment. Food that acts as a nutritional supply for the development of immature mosquitoes will affect the rate of development in the larval or juvenile stages in particular. According to Couret et al. (2014) and Jong et al. (2017), mosquito's larvae require enough nutrition to transform into the pupa.

Factors such as size, depth of water and organic content are important for selection of mosquito habitat (Washburn, 1995; Couret et al., 2014; Overgaard et al., 2017; Phanitchat et al., 2017). It also stated that in artificial and natural containers the dengue vector was able to breed and develop. According to past study by Rao et al. (2011), during the juvenile stages, they are very sensitive with the changes of diet resource. Competition and the limitation of diets affecting their survival rate and development. For example, coconut shell contains rich organic content, low lighting and small orifice, making it a preferred mosquito breeding site selection (Rao et al., 2011). In this situation, containers or breeding sites that have richer resources of organic matter will supply enough nutrition during the juvenile stage and larger number of mosquitoes will be able to survive.

According to the study conducted by (Gomes, 1994), time taken from the hatching of eggs to the emergence of adults in the tree hole requires only nineteen days. It was also noted in the study that other container forms such as bamboo and tyre required more time to complete immature development of mosquitoes (Gomes et al., 1994). From 1995 to 2016, several studies on preferred containers conclude that tire, plastic container, glass container as well as coconut shell are by far the most preferable container for juvenile growth (Nazri et al., 2016; Gomes et al., 1994).

There are some species occurring mostly in sun-exposed environments such as *An. gambiae s.s.*, *An. Albimanus* and *An. pseudopunctipennis*, members of the *An. sundaicus* complex, *An. Sinensis* and *An. Aconitus*, while others seem to prefer shaded water bodies such as *An. Funestus* and *An. vestitipennis*. Despite some laboratory experiments seem to show that light is not a crucial direct factor (Chahad-Ehlers et al., 2007). In natural habitats, the aquatic larvae are basically surrounded by vegetation and emergent plants shading. Dense vegetation usually supports mosquito rapid growth. According to Munga et al., (2006), land cover may also affect survival of larvae and adult productivity as penetration of light and temperature are reduced minimally under such natural conditions. It is some possible that in some examples, larvae are positively correlated with shaded environment only because shade of trees minimized drying speed of the pools (Obsomer et al., 2007). The effects of darkness on larval development in *Anopheles* species are really known.

In a past study by Howland (2017), has found a significant reduction for the development of adult *An. stephensi* when the larvae were breed in the dark area. Approximately only 60% of pupae developed into adults. Nevertheless, limited study has been done to assess the association of light toward the development of immature mosquito. Most of the study focus on the effect of other environment factors such as temperature, density, seasonal change, larval diet, and breeding container. The effect of different type of light exposure on the development of immature mosquito is often ignored in the study.

4.3. Study on survival of mosquitoes

According to Dyde (1968), Costanzo in his study stated that, comprehending the mechanism of how environment affects the life traits and population dynamics is very important since these traits can impact the transmission of disease. The association of mosquitoes with biotic and abiotic factors of the environment may influence the mosquito life history traits such as adult size, gonotrophic cycles, lifespan which then affect their survival rate and population level (Costanzo et al., 2015). The most commonly conducted studies on environmental factors in terms of survival of mosquito include temperature, climate changes, and chemicals (Delatte et al., 2009; Tran et al., 2013; Dutra et al., 2017).

The temperature reported by Grech (2015) in his study is one of the major extrinsic factors affecting many insect population parameters including mosquitoes. In designing vector control strategy models, information on the relationship between temperature and growth rates as well as the development and survival of various stages is useful (Grech et al., 2015). A study conducted by Delatte found that i) female longevity at all temperatures was longer than male longevity. (ii) the average length of each gonotrophic cycle was nearly identical for each female temperature, and (iii) the average number of eggs did not differ significantly between females and temperatures. For several days, females have also been found to lay their eggs; this behavior suggests that eggs from a single gonotrophic cycle are laid at more than one site of oviposition.

A Mala (2014) study found that climate and seasonal changes have an impact on the mosquito's life cycle. Precipitation creates more potential breeding area for mosquito such as at improper solid waste management area. It also influence the temperature of water in the breeding site. High number of potential breeding sites with optimum water temperature will increase the mosquito survival level. Roiz et al. (2010) suggest that variations in human water supply may influence the seasonal pattern of Aedes mosquito population dynamics more than changes in precipitation.

Chemicals especially pesticides and larvicides are widely used as a restraint tool for vector control. Vontas (2012) in his study mentioned the growing of resistance of *Aedes* mosquito toward the insecticides that are frequently being used for its control measure and also reported in different countries. According to Ministry of Health Malaysia (2008) stated that, Temephos in which the only approved chemical larvicide for vector control, *Aedes* mosquito has been found to be resistant to this chemical. Feng et al., (2011) in his study found that these actions when compared with their susceptible counterparts are costly to resistant insects in terms of reduction in fecundity, survival time, body size and increase in development time. All the independent variables findings from the reviewed articles within this period (1963-2017) of studies on the development and survival were tabulated in Table 2.2 (A) and (B) respectively.

Table 2.2: Studies included in the meta-analysis of development of immature stage of mosquito

Articles ID	Author (Year)	Location	Species					Research Design		Independent Variables							
			Ae. albo	*Ae. aegy*	*Culex spp*	*Anop spp*	Others	Field	Lab	Light	Seasonal Changes	Diet	Salinity	Temperature	Container	Density
A23	Overgaard *et al.,* (2017)	North America		•				•							•	
A24	Joshi, D. S. (1995)	Asia					•		•					•		
A25	Costanzo *et al.,* (2016)	North America		•					•	•						
A26	Grech *et al.,* (2015)	South America		•	•				•					•		
A27	Mohammed & Chadee *et al.* (2011)	North America		•					•					•		
A28	Joseph *et al.,* (2009)	North America		•					•					•		•
A29	Zapletal *et al.,* (2018)	North America					•		•	•				•		
A30	Kappus & Venard (1967)	Asia		•					•					•		
A31	Carrington *et al.,* (2013)	South America				•			•			•				
A32	Araújo *et al.,* (2012)	Asia			•				•	•				•		
A33	Swain *et al.,* (2018)	North America		•					•			•		•		•
A34	Couret *et al.,* (2014)	Asia	•					•				•				
A35	Jong *et al.,* (2017)	Asia	•						•					•		
A36	Thipruethai *et al.,* (2017)	Oceania		•					•	•				•		
A37	Bayoh & Lindsay (2003)	Europe				•			•					•		
A38	Rozilawati *et al.,* (2016)	Asia	•						•					•		
A39	Farjana *et al.,* (2012)	Asia	•	•					•			•		•		•
A40	Gomes *et al.,* (1995)	South America	•						•						•	
A41	H. Delatte *et al.,* (2009)	Asia	•						•					•		
A42	Trimble & Smith (1979)	North America					•		•	•						
A43	Constanzo *et al.,* (2015)	North America	•	•					•	•						
A44	Teng & Apperson (2000)	South America	•				•		•			•				•
A45	Bertram *et al.,* (1970)	Europe					•		•	•						

(A)

Articles ID	Author (Year)	Location	Species					Research Design		Independent Variables						
			Ae. albo	*Ae. aegy*	*Culex spp*	*Anop spp*	Others	Field	Lab	Light	Seasonal Changes	Diet	Salinity	Temperature	Container	Others
A46	Ephantus J. Muturi *et al.,* (2011)	North America	•		•				•					•		
A47	Albert O. Mala *et al.,* (2014)	Asia				•			•					•		
A48	R. Maciel-de-Freitas *et al.,* (2010)	South America		•					•				•			
A49	L.Y. Wang (2005)	Asia		•					•				•			
A50	Peter Löwenberg Neto *et al.,* (2004)	South America		•					•	•						
A51	Caitlin A. van Dodewaard (2015)	Asia	•	•					•			•				
A52	Sarita Kumar *et al.,* (2010)	Asia		•					•				•			
A53	Daniella Goindin *et al.,* (2015)	Europe		•					•					•		
A54	Heverton Leandro Carneiro Dutra *et al.,* (2017)	South America		•					•			•				
A55	Lauren B. Carrington *et al.,* (2011)	Asia		•					•					•		
A56	K. S. Costanzo *et al.,* (2014)	North America	•	•					•	•						
A57	Rozilawati H *et al.,* (2017)	Asia	•						•		•					
A58	W. A. Hawley (2011)	North America					•	•	•					•		
A59	C. C. Murdock *et al.,* (2016)	North America	•								•					
A60	Junaid Rahim *et al.,* (2016)	Asia	•						•				•			
A61	Muhammad Salman Hameed *et al.,* (2016)	Asia	•						•					•		
A62	Doughlas A. Burkett *et al.,* (2005)	North America	•	•	•	•	•		•	•						
A63	Ebony G. Murrell (2008)	North America	•	•				•	•						•	
A64	Steven A. Juliano (2012)	North America	•	•				•	•						•	
A65	D. A. Yee *et al.,* (2012)	North America	•						•	•						
A66	H.L Lee *et al.,* (2009)	Asia		•					•		•					

(B)

Marks (●) indicate the studies have at least one value of the independent variable listed.

4.2. Effect of light towards oviposition, development and survival of *Aedes* mosquito

The effect of photoperiod and artificial lights on the life cycle of *Aedes* mosquito in terms of oviposition, development of immature and survival of adult *Aedes* mosquito in terms of different artificial lights and photoperiod regime were compared; (a) natural sunlight, (b) various colour artificial light (c) ultraviolet light. However, most of the studies were conducted by using artificial lights on oviposition, development of juvenile *Aedes* mosquito and survival of adult *Aedes* mosquito (Kappus & Venard, 1967; Harwood & Halfhill, 1964; Bertram et al., 1970; Neto & Navarro-Silva, 2004; Burkett & Butler, 2005).

In *Aedes* mosquito species, gravid female choice in oviposition site is a critical factor which influenced by several factors. Reiskind & Zarabbi (2012) stated that oviposition choice is a well-studied aspect of the mosquito life cycle which can be utilized for potential method for species-specific surveillance and control. Studies by Muir et al. (1992) and Chatterjee et al. (2015) stated that gravid female *Aedes* mosquito follow visual cues to domestic and semi-domestic artificial container as well as with both chemical and physical cues in the water for oviposition preference.

According to Bernáth et al. (2012), optical characteristics of water surfaces have influence to the oviposition site selection by mosquitoes in the field. Besides, under unnatural or in urbanized area *Ae. aegypti* breed in container with water surfaces are generally covered or low light intensity (Bernáth et al., 2012). However, according to O'Gower (1963) and Wong et. al. (2011) the selection of an oviposition site by gravid female is related to the illumination and background reflectance of the breeding site. This was supported by Snow (1971) that explained that the relationship of these factors can affect its spectral sensitivity. Table 2.4 shows four included articles that study on light regime on the oviposition of *Aedes* mosquitoes.

Study conduct by Burkett & Butler (2005) had used artificial white light in a chamber with different wavelength of light, the results from this study showed that none of the mosquito species tested were highly attracted to both 350 and 550 nm and over the other wavelengths tested. Peak spectral sensitivities of approximately 350 and 550 nm may serve to allow discrimination in an environment dominated by greens and blues. Hence, the relatively small numbers of *Ae. Aegypti* and *albopictus* captured in light traps indicates that transmitted light is relatively unimportant in host choice. Indeed, the duration of feeding times for *Ae. aegypti* did not differ significantly among wavelengths tested. Duration of feeding times for *Aedes albopictus* was significantly greater for 600 nm, 500 nm, broad spectrum white, 450 nm and 400 nm. Field trials with light emitting diodes or other sources of monochromatic light might result in similar attractive colours.

A study conducted by Neto & Navarro-Silva (2004) bad used artificial light under a chamber with different cyclic temperature. From this study, it is found that the longetivity of both male and female mosquitoes are quite the same. Furthermore, the study also has found that the gonotrophic cycle of *Aedes* mosquito has increase. This is verified by other study conducted by Briegel & Timmermann (2001) with increased temperatures all the gonotrophic cycles became faster. Adult longevity was very similar under cyclic temperatures and constant temperature of 20 ºC, and this suggests that the lowest temperature of the cyclic regime is a limiting factor for survival and distribution. This fact may determinate the probable areas where *Ae. albopictus* can inhabit. Male and female's longevity did not differ under cyclic temperature condition of 27/20ºC. The mortality rate of adults was constant through the time. It is believed that the changes of temperature have affected the reproduction activity by elongating the gonotrophic cycles. There are major gaps in the study of artificial light's influence on Aedes mosquito's oviposition, development, and survival. In this country, data on the effect of artificial light on Aedes mosquito's life development is still limited. In order to understand the biology of mosquitoes, it is very important to study the effect of artificial light on the development of this vector mosquito in the local environment

5. Conclusion

In conclusion, there are knowledge gaps on the study of the influence of artificial light as there are limited study on the effects of artificial light exposure towards *Aedes* mosquito especially in terms of its oviposition preferences, juvenile development and survivals of this species has been conducted. This paper also has revealed that there are several factors that can influence the life development of mosquitoes. It is recommended to conduct more research in the future to study the relationship between artificial light toward the development of the mosquito by using local strain since there are very limited data on this study.This is very important to be considered in order to understand further the biology of mosquito and for better understanding in dengue surveillance and control practice plus contributing for better understanding in the mosquito life cycle.

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