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Aedes Mosquitoes Abundance In Relation To Some Climatic Factors In Banda Aceh City, Indonesia

Farida Athaillah[1], Muhammad Hambal[1], Yudha Fahrimal[1], Muttaqien Bakri[1], Ellyawardani[1], Henni Vanda[1], Abu Hassan Ahmad[2]

[1] *Faculty of Veterinary Medicine, Syiah Kuala University*
[2] *School of Biological Sciences, Universiti Sains Malaysia, Pulau Pinang, Malaysia*

Abstract

Dengue viruses and their mosquito vectors as an endemic disease in Indonesia are sensitive to their environment. The rising incidence of dengue is influenced by many factors, climate is one of them. Temperature, rainfall and humidity have well-defined roles in the transmission cycle. Changes in these conditions may contribute to increasing incidence. The purpose of this research was to determine the correlation between the dengue vector abundance and some climatic factors (temperature, rainfall and humidity) in Banda Aceh city after the tsunami. We also examined the potential effects of climate variations on dengue epidemiological pattern in indoor and outdoor of tsunami affected areas in Banda Aceh City during January – December 2010. Data processing was performed using SPSS and will be presented in tabular form. Pearson correlation test for parametric test and Spearman correlation coefficients for non-parametric test were performed to investigate the overall correlation between *Aedes* eggs abundance rates and some meteorological variables such as temperatures (^{0}C), relative humidity (RH), and rainfall (RR). The result showed that the total egg populations in indoor and outdoor of tsunami affected areas are not significantly different among those factors. There was a positive correlation between eggs abundance and rainfall, but negatively correlated with temperature and relative humidity. From this result we can conclude that the abundance of *Aedes* eggs is not significantly correlated to temperature and humidity in indoor and outdoor of tsunami affected areas in Banda Aceh City.

Key words : Mulberry, production, chemical compositions

Background

Banda Aceh is one of dengue endemic areas of Aceh Province, Indonesia. Based on data from Aceh Provincial Health Office in 2008, there were 74 villages out of 90 villages in Banda Aceh positive with dengue and 53 villages of which were endemic with dengue. During the same year there were 593 cases and five people reported died. It is alarming that the number of dengue cases in Banda Aceh is increasing from year to year. The earthquake and tsunami on 26th December 2004 in Aceh Province had a further devastating effect throughout the area and shore line. The condition of stagnant water created condition for mosquito vectors to multiply and potentially caused severe public health problems and endemic for dengue fever.

In general insects are exceedingly sensitive to temperature and rainfall regimens, and tropical and temperate species frequently show great variations in seasonal abundance (Vezzani et al., 2004). Reproduction of *Ae. aegypti* populations in tropical and subtropical zones occurs all year round and their abundance either be associated with rainfall regimens (Chadee, 1991, Micielli & Campos, 2003) or otherwise (Sheppard et al., 1969). Temperature and rainfall can have a profound impact on transmission cycles by influencing the availability of vector breeding sites, extending vector longevity, altering host breeding or migrating patterns, and maintaining aggregations of vectors and hosts around water bodies.

Many epidemiological studies of mosquito-borne arboviruses have shown that there are relationships between environmental factors, mosquito densities and disease epidemics (Russel, 1986). The seasonal changes in oviposition are a consequence of seasonal changes in weather conditions, and availbility of sites for egg laying (Micielli & Campos, 2003). Therefore by using climatologic indicators, escalation of vector population could than be predicted earlier by routine surveillance, thus increasing the time for planning and conducting control operations (Moore, 1985). Dengue viruses and their mosquito vectors are sensitive to their environment. Some climate variables can affect the transmission of disease. However, there are four main variables considered the most important factors in affecting disease: temperature, rainfall, humidity and wind (Parham and Michael, 2010).

Temperature, rainfall and humidity have well-defined roles in the transmission cycle. Therefore changes in these conditions may contribute to increasing incidence (Youngjo Choi *et al*., 2013). Global trends of unplanned urbanization; rising populations; increasing travel and trade; and changes to the physical environment and climate have led to a dramatic resurgence of dengue throughout the regions where suitable vectors are present. In the past five decades the global incidence has increased 30-fold and it will likely continue to escalate (World Health Organization, 2012). A study conducted by Foo et al. (1985) in Malaysia, found that heavy rain had an immediate negative impact on the *Aedes* house index since the larvae would be washed away during heavy downpours. They also claimed that a closer relationship might be anticipated between rainfall and numbers of *Ae. albopictus* rather than between rainfall and *Ae. Aegypti*, because *Ae. albopictus* is found commonly outdoors. Therefore, if the greenhouse effect increases rainfall and temperature, it might influence the seasonal and geographical abundance of mosquitoes.

Dengue fever is becoming a public importance disease in Aceh Province, since mid-october 2008, where by 13 residents died due to the virus. It was speculated that the large-scale change of environment as a result of tsunami might have produced new breeding sites for mosquitoes and influenced the ecology, including density and species composition. Hence, it is crucial to examine the mosquito breeding situation in areas affected by tsunami. However, the relative frequency of mosquito breeding sites around tsunami affected areas remains poorly understood in Banda Aceh. Therefore, this study was conducted in order to study the influence of climatic parameters (rainfall, temperature and relative humidity) on the abundance of dengue vectors, which is essential for the planning of an effective mosquito control programme in Banda Aceh city in the future.

Materials and Methods

Entomological surveys were carried out in the selected sites of tsunami affected areas in Kuta Alam sub district of Banda Aceh in 2010. Kuta Alam sub district was chosen for the implementation of this study because it has been an endemic dengue area since 2007 and it was one of eight districts in Banda Aceh that was affected by the earthquake and tsunami on 26 December 2004. Two villages in Kuta Alam sub district which are affected by tsunami are Gampong Lampulo (about 1 km off the sea) and Gampong Lambaro skep (about 1.6 km off the sea).

Entomological Surveillance

This study was conducted by ovitrap sampling carried out in Kuta Alam sub district which was affected by tsunami for a period of 12 months. In each location, a total of 80 ovitraps were set randomly on the ground around the residential area indoors and outdoors confined to the immediate vicinity of the houses as described by Lee (1992). In Gampong Lampulo, 20 ovitraps were set indoors and 20 ovitraps were set outdoors with different sites. The same procedure was applied for Gampong Lambaro skep. In each site, ten ovitraps were placed indoors and ten others outdoors. After the ovitraps had been placed for 5 days, they were inspected on the same day biweekly for 48 weeks. Inspection were conducted from 08.00 – 12.00 hours. The eggs were collected and counted on the same day every week, and then the ovitraps and paddles were replaced with new ones for the following week. Samples collected from an ovitrap were transferred into a bottle and the paddles were air-dried for 48 hours before the eggs were counted using a dissecting microscope with a counter. The number of eggs from each of the paddles was recorded.

Climatological data including rainfall, relative humidity and average temperature were obtained from The Banda Aceh Meteorological Station located at Sultan Iskandar Muda Airport, approximately 10 km from Banda Aceh. Data was provided from January to December 2010.

Statistical Analysis

Climatic parameters such as rainfall, temperature, and relative humidity were obtained from the Meteorological Department in Banda Aceh. The climatic parameters were catagorized as current month (the month when sampling was conducted). Independent variables are climatic parameters while dependent variables are the monthly average number of eggs in each area. The relationship between species abundance regarding ovitrap placement were tested using the Pearson correlation coefficients for parametric test or Spearman correlation coefficients for non-parametric test. The tests were also conducted to determine the relationship between eggs and species abundance with meteorological data (rainfall, temperature and humidity). Independent variables were meteorological data while dependent variables were the monthly average number of eggs. An independent t-test was employed to compare the abundance of eggs among various pairs of ovitrap locations.

Results and Discussion

High Growth of Plant

This experiment was carried out in order to investigate the correlation between egg abundance of *Aedes* mosquitoes and climatic factors in tsunami affected areas in Banda Aceh, Indonesia.The eggs were obtained from the ovitraps set in several sites indoor and outdoor of the area, and collected biweekly for 48 weeks. The eggs were counted using a dissecting microscope and analyzed using Pearson correlation coefficients for parametric test and Spearman correlation coefficients for non-parametric test. The relationship between the number of eggs from indoor and outdoor ovitraps with climatic parameters such as rainfall, average temperature and relative humidity was conducted using Pearson correlation test.

Figure1. shows the monthly mean temperature and relative humidity from January 2010 to December 2010 during the survey in Banda Aceh City. The average temperature for the 12 month sampling period was 27.4°C ± 0,68. The highest mean temperature was 28.4ºC obtained in May 2010 during the dry period, and the lowest was 26.1ºC in November 2010 during the wet period. The average relative humidity was 81.10 ± 3.42 %. The highest value of mean relative humidity was 87% occured in November 2010 during the wet period and the lowest was 76% occured in October during the dry period.

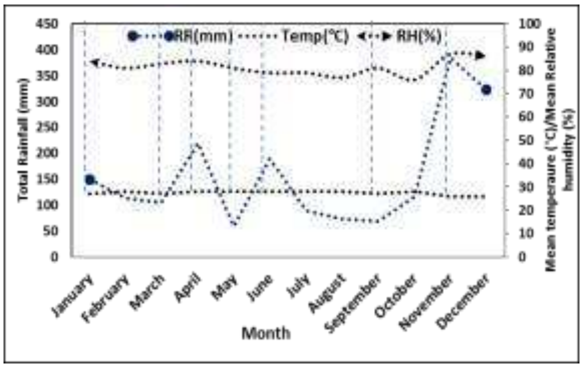

Figure 1: Monthly total rainfall (mm), mean temperature (°C) and mean relative humidity (%) during the survey in Banda Aceh in 2010. (Source: Blang Bintang Banda Aceh Meteorological Service).

Spearman test showed significant negative correlations between monthly temperature and rainfall ($r = -0.884$, $P<0.05$) and RH ($r = -0.434$, $P<0.05$) which means that the alteration of temperature will give no effect on rainfall. On the other hand, the mean relative humidity was highly correlated with rainfall ($r = 0.885$, $P<0.01$). Higher amount of rainfall is related to the increase of relative humidity value.

Egg abundance in indoor of tsunami affected area

The relationship between monthly mean eggs from indoor ovitraps with rainfall, temperature and relative humidity was conducted using Pearson correlation test. Figure 2. shows the monthly mean eggs abundance from indoor ovitraps during 12 months of study and their relationship with rainfall, temperature and relative humidity in the area. A total mean number of 459.45 eggs were collected from 12 months of indoor ovitrap sampling.

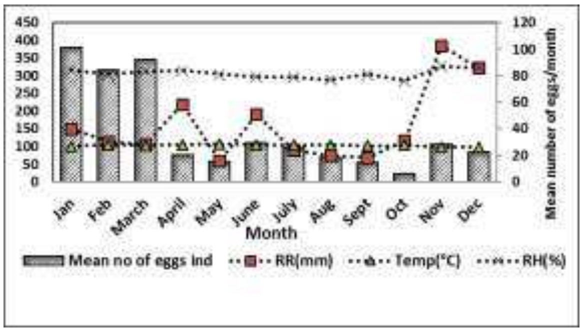

Figure 2. Total mean number of eggs collected from indoor ovitraps during 12 months of study and their relationship with rainfall, temperature and relative humidity in tsunami affected area in Banda Aceh in 2010.

The highest egg deposition was recorded in January 2010, while the lowest number of eggs was in October 2010. The higher number of eggs were observed in January, February and March, they were (101.50 ± 151.76; 84.50 ± 123.76 and 92.50 ± 100.16 respectively), and then decreased in April 2010 (20.15 ± 26.01) until October 2010 as the lowest number of eggs (5.95 ± 9.29).

Table 1 shows the abundance of eggs collected from indoor ovitraps in tsunami affected area assessed by counting the average number of eggs collected from January until December 2010. Pearson correlation test indicating that mean temperature (r= -0.443, p= 0.160) and mean relative humidity (r= -0.421, p= 0.173) have negatively correlated with the number of eggs collected from indoor ovitraps in that area. However, rainfall has positive correlation with the number of eggs obtained (r= 0.357, p= 0.255). Regardless the ovitrap location (indoor) and sampling time (month), the increase and decrease in the number of eggs collected from indoor ovitraps were correlated with rainfall

Table 1. Relationship of the average number of eggs collected from indoor ovitrap in tsunami affected area with climatological parameters

Variable	Correlation Coficient (r)	N	Sig (2 tailed)
Temperature	-0.443	12	0.160
Relative humidity	-0.421	12	0.173
Rainfall	0.357	12	0.255

Egg abundace in outdoor of tsunami affected area

The abundance of eggs from outdoor collection and their relationship with rainfall, temperature and relative humidity in tsunami affected area of Banda Aceh in 2010 was studied. A total average number of 450.15 eggs was obtained. The highest egg deposition was recorded in March 2010, while the lowest number of eggs was in October 2010. In January 2010, the average number of eggs was 94.10 ± 133.16, and then decreased in February to 62.25 ± 79.32. In March it reached the first peak (119.50 ± 111.93), then decreased again in April (32.05 ± 41.29), and in October it has the lowest number (3.15 ± 10.81). Later onwards there was no increase in eggs number collected in ovitraps until December 2010 (Figure 3).

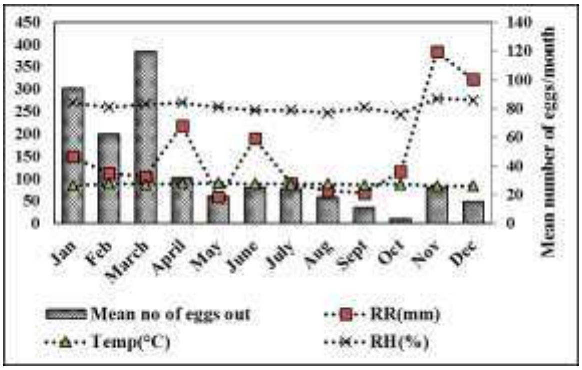

Figure 3. Total mean number of eggs collected from outdoor ovitraps during 12

months of study and their relationship with rainfall, temperature and relative humidity in the tsunami affected area in Banda Aceh in 2010.

The mean number of eggs collected from outdoor collection in tsunami affected area was related to climatological parameters, analyzed by Pearson correlation test (Table 2).

Table 2. Relationship of the mean number of eggs collected from outdoor ovitrap in tsunami affected area with climatological parameters

Variable	Correlation Cooficient (r)	N	Sig (2 tailed)
Temperature	-0.149	12	0.643
Relative humidity	-0.427	12	0.167
Rainfall	0.235	12	0.463

Pearson correlation test indicating that the average number of eggs collected from outdoor collection was negatively correllated with temperature (r = -0.149, p =0.643) and relative humidity (r = -0.427, p = 0.167), but it was positively correlated with rainfall (r = 0.235, p =0.463). Regardless of the ovitrap position (outdoor) and sampling time (month), the increase and decrease in the number of eggs collected from outdoor ovitraps were not correlated with the climatological factors except rainfall.

Discussion

Climate can influence the pattern of infectious diseases caused by viruses, bacteria or parasites. These diseases can be spread out by vectors that are sensitive to temperature, humidity, and other ambient environmental conditions (Sitorus, 2003). In addition, WHO (1999) also stated that mosquito-borne diseases such as dengue is associated with warm weather conditions.

Rainfall is known as one of the main factors that regulates the abundance of outdoor breeding mosquito populations such as *Aedes*. Rainfall patterns can influence the long-term abundance of insect populations (Speight et al. 1999). Besides rainfall, relative humidity is an important factor that influences the mosquito oviposition activity (Micieli and Campos 2003, Saifur et al. 2010). Temperature changes is another meteorological factor that may affect *Ae. albopictus* population dynamics by altering reproductive and mortality rates (Alto and Juliano, 2001). The seasonal changes in oviposition are caused by changes in weather conditions and the availability of sites for oviposition. The low abundance might be due to drought and low relative humidity (Micieli and Campos, 2003).

The fluctuations of rainfall recorded in Banda Aceh showed two distinct peaks in the year of sampling, that was in March during the dry period and in November during the wet period. Normally, the increase of rainfall will enhanced the reproductive potential of *Aedes* mosquitoes in wet season. A high frequency of rainfall would ensure that small artificial containers used as immature mosquito habitats would remain flooded, thereby expanding adult populations (Patz and Reisen, 2001). However, in this study the number of eggs collected from each study sites showed fluctuated results. The amount of eggs was slightly higher in dry season (March) compared to wet season (November). This might be due to the amount of rainfall was quite high in March compared to November, although March belongs to dry season. In tropical region, it is common to have heavy rain even in dry season, thus will also influence the growth rate of *Aedes* mosquitoes during dry season. Sandosham (1962) also reported that the abundance of *An. maculatus* very closely related to rainfall which is correspond to our findings. The same results were also obtained by Jaal (1990), Rao (1984) and Mangin et al. (2008) who discovered that *Anopheles* mosquito abundance is closely related to rainfall.

Based on the Pearson test conducted on the number of eggs obtained from indoor and outdoor ovitraps, the abundance of eggs showed positive correlation with rainfall, while negatively correlated with temperature and humidity. The result is indicating that no meteorological factor effect on the average number of eggs collected indoor and outdoor in tsunami affected areas except the rainfall. According to Lee (2008), high rainfall will increase efforts by vectors to lay eggs and will increase the number of mosquito population in an area. He also stated that the increase of rainfall will increase the incidence of disease in the population in the region.

Overall, number of *Aedes* eggs collected was not significantly related to climatic parameters. This is supported by Sheppard et al. (1969), which found that in Bangkok, where artificial containers filled with water constantly available, no seasonal fluctuations of *Aedes* populations were observed. Whereas, the opposite result was found by Nur Aida (2013) which showed a significant relationship between climatic factors with the mean number of eggs collected in Pulau Pinang, Malaysia. The differences in the average number of eggs found were probably due to the different number of breeding sites that existed in the areas next to where the ovitraps were installed. It also depends on water quality, water management around the areas and also local meteorological conditions, such as rainfall, temperature and relative humidity (Sulaiman and Jeffery 1986; Yang et al, 2008).

Other previous studies also reported the importance of rainfall data to the abundance of *Aedes* immature. Khan (1980) found that the number of outdoor container infested with *Ae. albopictus* in Bangladesh was correlated with rainfall over an eleven months period. The result of this study showed that the abundance of eggs collected from each study sites was related with rainfall, temperature and relative humidity, and it applies to both areas. Therefore the similarity found in the seasonal pattern of eggs abundance in the present study could be due to the availability of other habitats for laying eggs apart from ovitraps.

According to Saifur et al. (2010), humidity plays a major role in the dynamics of mosquito populations, especially those breeding in container habitats. High-moisture substrates provided better environments for egg laying and the numbers of eggs laid were much lower in the drier environment. The decline in relative humidity induced the gonoactive female to rest, thus leading to a decrease in mosquito oviposition. The same outcome was reported by Goma (1966) who discovered that mosquitoes are normally found in places where the humidity is high and the air is relatively statics as described in the eggs collected from indoor ovitraps in tsunami are. Therefore this location with high-moisture substrates provided better environments for egg laying and the numbers of eggs laid in this area.

The abundance and distribution of *Aedes* egg populations obtained in this study showed that *Aedes* species are able to adapt in human-habitations. Based on the positive collections of each ovitrap during the sampling, it can be seen that *Aedes* vector has a widespread breeding location in indoor and outdoor of the tsunami affected areas. The reproductive activity of *Aedes* female mosquitoes was successfully detected by ovitraps placed in each study areas. Knowledge on *Aedes* population fluctuations can assist to develop an early warning system for dengue outbreaks and the right time to initiate control programmes for the concerned areas. Since vector abundance closely relates to dengue outbreaks, the ability to estimate and forecast the real vector population will prepare the community for early control of the vector before outbreaks occur.

Conclusion

The total egg populations in indoor and outdoor of tsunami affected areas are not significantly different among those factors. There was a positive correlation between eggs abundance and rainfall, but negatively correlated with temperature and relative humidity. From this result we can conclude that the abundance of *Aedes* eggs is not significantly correlated to temperature and humidity in indoor and outdoor of tsunami affected areas in Banda Aceh City. Overall it is concluded that the tsunami has not negatively influenced the *Aedes* eggs abundance in Banda Aceh City. It turns out that the ecological damage caused by tsunami five years ago has reverted to its normal condition.

The increasing or decreasing of temperature and relative humidity do not have effect on the fluctuation of eggs collected in indoor and outdoor of tsunami affected areas. Of all climatological parameters tested for the correlation, only rainfall has the positive influence on the number of eggs collected in the study area.

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