Spatial distribution of dengue vector mosquitoes in Malang City, East Java, Indonesia (case study: Jatimulyo Village, Lowokwaru Sub-district)

Z P Gama¹, R J Salsabila¹

¹ Biology Department, Faculty of Mathematics and Science, Universitas Brawijaya, Malang, Indonesia

Corresponding author’s e-mail address: gama@ub.ac.id

Abstract. Jatimulyo Sub-district is one of the highest areas of DHF sufferers in Malang City. Dengue Hemorrhagic Fever (DHF) is transmitted through the Ae. aegypti and Ae. albopictus (the mosquito vectors). This study aims to identify diurnal mosquitoes at in-door and out-door place and to analyse the distribution of DHF vector mosquitoes in Jatimulyo Village, Lowokwaru Sub-district, Malang City. This research conducted in November 2019 until May 2020. Sampling of mosquito and larvae was carried out in 1 house/hamlet, there was determined using purposive sampling method and it carried out within active mosquito biting hours (7.00 a.m - 5.00 p.m). Larvae and imago were captured at in-door and out-door places then there were identified using Guidelines book for DHF entomology surveys and the identification book of Aedes (in bahasa). The survey of larvae & mosquito predators on container, and population mobility were carried out by interviewing homeowners. Abiotic factors measured include of temperature, light intensity, humidity, and wind speed. The location coordinates were recorded with GPS. Data analysis using Microsoft Excel 2010, SPSS 16.0 and QGIS 3.12.1. The results showed that there were 2 mosquitoes Ae. albopictus at the first hamlet outdoor sampling point and one Ae. aegypti at the ninth hamlet outdoor. Larvae Ae. albopictus was found in the sampling points of the sixth and eighth hamlet (in-door place), whereas Ae. aegypti was found at the sampling point in the seventh hamlet (in-door place). The distribution of Ae. aegypti and Ae. albopictus mosquitoes can be influenced by mosquito abundance value, Larva Index value, number of predators, number of container, age population of resident, and mobility of resident.

Keywords: Ae. aegypti, Ae. albopictus, distribution, mobilization, spatial

1. Introduction
Dengue is a major public health problem in several countries including Indonesia [1]. Tropical areas such as Indonesia are mosquito-prone areas. East Java is one of the parts of Indonesia located in the eastern part of Java. The result of diseases transmitted by mosquitoes in East Java Province is still a health problem for the community, both in urban and rural areas, one of which is DHF. Malang City is one of the cities in East Java Province that is attacked by diseases due to vectors from mosquitoes. Based on data from the Malang City Health Office, in 2017 in Jatimulyo Village, Lowokwaru District, 7 cases were recorded without any deaths, the number of DHF sufferers in the area was the highest in Lowokwaru District [2]. High the number of DHF sufferers in Jatimulyo Village, Lowokwaru District,
Malang is one of the reasons the researchers chose this area to analyze the distribution of the dengue vector mosquito. The increasing spread and number of DHF cases can be caused by several factors, namely population density, increasing urbanization and population mobility and the lack of community behavior towards cleaning mosquito nests. In addition, the mosquito that transmits dengue fever is still widespread in almost all corners of Indonesia so that dengue transmission can occur in all areas where the mosquito breeds. There is no cure for dengue fever cases, so we still rely on vector control. The habitat of the Aedes spp. that are transmitters of dengue disease, which is close to where they live increases the possibility of contact with humans [3]. DHF control depends on controlling the main vector, the Aedes aegypti and Aedes albopictus [4]. Increased public awareness about health and safety can be maximized by understanding the distribution of mosquitoes, in order to help prevent the spread of dengue and reduce the number of dengue sufferers in an area [5]. The presence of information of mapping the spread of the Ae. aegypti and Ae. albopictus can help in obtaining data quickly and accurately regarding the distribution of dengue vector mosquitoes in an area. Therefore, this study was conducted to identify type of mosquitoes in-door and out-door place and also to determine the distribution of dengue vector mosquitoes in Jatimulyo Village, Lowokwaru District, Malang City.

2. Experimental details

2.1. Time and location
This research was conducted in November 2019 to May 2020 in the Jatimulyo village, Lowokwaru Sub-district. The description of the research location is presented in the figure 1.

![Figure 1](image_url)

*Figure 1. Study site in Jatimulyo Village, Lowokwaru Sub-district, Malang City, Indonesia*

Jatimulyo Village as one of area in the Lowokwaru Sub-District, Malang City is located at latitude 7° 56’35.28 "S and longitude 112° 37’06.15" E. An area of Jatimulyo village about 211.38 ha, and it has a population of 22,606 people [6]. Mosquito sampling was carried out in Jatimulyo Village,
because the village is surrounded by the Brantas river, so it can be assumed that this location can increase the mosquito population in their area.

2.2. Data collection
The capture of diurnal mosquitoes (imago phase) has been carried out in door sequences according to a predetermined schedule. The capture of the imago phase was carried out using standard methods from the WHO. The time for catching mosquitoes was during the active hours to suck blood by mosquitoes, which was 7 a.m. to 5 p.m. Mosquito catching were carried out in-door and out-door places. In door capture of mosquitoes were carried out using a mosquito trap (Black Hole, Bio-trap Inc., Seoul, Korea) which emits UV light and there was turned on for 30 minutes [7]. Mosquito traps already installed in dark rooms such as bedrooms, warehouses, garages, and other dark places. The mosquito sample was obtained then inserted into the plastic sample.

Out-door catching of mosquitoes was carried out using the human baited trap method with an aspirator for 30 minutes at each location. This tool allows the user to suck and catch the specimen without swallowing it. Aspirators can be used to collect mosquitoes [8]. The initial step is that the catcher sits at a predetermined location, by opening the feet to the knees. The mosquitoes that have landed can be caught with an aspirator and put into the plastic sample.

![Mosquito trap (a) and Aspirator (b)](image)

Figure 2. Mosquito trap (a) and Aspirator (b)

The collection of mosquito larvae has been carried out according to the standards of the Health Ministry of Indonesia (2017) concerning a survey of mosquito larvae. The collection of larvae has been carried out by taking one mosquito larvae found in each container in the yard and inside of the house such as flower pots, water plant pots, pot placemats, and used items that can hold water, bathroom tubs. The mosquito larvae samples were obtained then inserted into the plastic sample. Some of the abiotic factors measured include air temperature and relative humidity with a psychrometer, wind speed measured with an anemometer while light intensity was measured using a lux meter. The coordinates of the sampling location have been recorded with GPS (Global Positioning System). Mosquito predator surveys have also been carried out in addition to observing population mobility through interviews with home owners.

2.3 Data analysis

2.3.1 Analysis of the Larva Index (LI), the House Index (HI), the Container Index (CI), the Breteaux Index (BI), and the Mosquito Larva Free Rate (ABJ) [9] were calculated using the following formula:

- **House index (HI)** = percentage of houses infested with larvae and/or pupae.
- **Container index (CI)** = percentage of water-holding containers infested with larvae or pupae.
- **Breteaux index (BI)** = number of positive containers per 100 houses inspected.
Table 1. The size of the density of mosquitoes (Larvae Index)

| Density Figure (DF) | House Index (HI) | Container Index (CI) | Breatteaux Index (BI) |
|---------------------|------------------|----------------------|-----------------------|
| 1                   | 1-3              | 1-2                  | 1-4                   |
| 2                   | 4-7              | 3-5                  | 5-9                   |
| 3                   | 8-17             | 6-9                  | 10-19                 |
| 4                   | 18-28            | 10-14                | 20-34                 |
| 5                   | 29-37            | 15-20                | 35-49                 |
| 6                   | 38-49            | 21-27                | 50-74                 |
| 7                   | 50-59            | 28-31                | 75-99                 |
| 8                   | 60-76            | 32-40                | 100-199               |
| 9                   | ≥ 77             | ≥ 41                 | ≥ 200                 |

2.3.2 The Man Hour Density (MHD) of each species of mosquitoes were calculated (MHD = Total no. of mosquitoes collected / No. of person x Time spent in hours).

If the MHD value is less than 2 mosquitoes/hour /person, the risk of dengue transmission is low, whereas if the MHD value is more than 2 mosquitoes/hour/person, the risk of dengue transmission is high. The MHD value can be used as a reference for determining the level of risk of dengue spread [9][10].

3. Results and Discussion

3.1 Identification of mosquitoes in Jatimulyo village

The results of the sampling at ten houses were obtained 3 larvae of Aedes spp. and 3 of Aedes spp. adult at the sixth hamlet and the eighth hamlet. The three of larvae were found in a water reservoir (in the bath). The identification results of mosquitoes showed that the larvae found were Ae. albopictus (see in Figure 3), characterized by a ventral brush consisting of 10 tufts or less [10]. Another characteristic of the larvae found with the Aedes albopictus type is the shape of the head that was more rounded than the Ae. aegypti larvae, thus affecting the position and angle of the antenna is presenting in figure 4 [10]. Larva Ae. albopictus found in the sixth hamlet area was not in perfect condition when observed. The possibility that what happened was that the larvae were found to have entered the IV instar stage, so that during the process of storing samples in water, lysis occurred in their cells, because they did not get enough nutrition and space to enter the next phase, namely becoming pupae.

Figure 3. Larva Ae. albopictus, (a) identification results (magnification 10x), (b) ventral brush (c) head
Figure 4. Larva *Ae. aegypti*, (a) identification results (magnification 10x), (b) ventral brush (c) head

The larvae found in the seventh hamlet area were identified as *Ae. aegypti* (Figure 5a), characterized by the antenna rod without spreading small spines (Figure 5b) [10]. Additionally, the head shape of *Ae. aegypti* is more elliptical to the side and affects the position and angle of the antenna (Figure 5c) [10]. The identification results of the two mosquitoes that found in the ninth hamlet were *Ae. aegypti* and one mosquito found in the first hamlet was *Ae. albopictus*. Identification of the *Ae. aegypti* was done by observing the mesonotum which has a lyre-like line with two curved lines and two white straight lines (See in Figure 6a and 6b). Besides, *Ae. aegypti* in the femur of the middle leg there was a long white stripe (Figure 6b) [11].

Figure 5. *Ae. aegypti* adult (a) identification results (magnification 10x), (b) mesonotum (c) femur

Figure 6. *Ae. albopictus* adult (a) identification results (magnification 10x), (b) mesonotum (c) femur

3.2. Distribution of mosquitoes at Jatimulyo village

Sampling was carried out in Jatimulyo Village by determining 10 sampling points (houses) and provided that one house in each hamlet. The data was implemented in the form of a distribution map (Figure 7) with information on the type and number of larvae and adult mosquitoes. Larvae and adult mosquitoes of *Ae. aegypti* and *Ae. albopictus* were not found at the sampling points 2, 3, 4, 5, and 10.
The distribution of dengue mosquitoes can be influenced by several factors, namely habitat, food, predators, and population mobility.

![Distribution Maps of Aedes aegypti and Aedes albopictus in Jatimulyo Village, Malang City](image)

**Figure 7.** The distribution maps of mosquitoes in Jatimulyo village

*Ae. aegypti* and *Ae. albopictus* were found outside the house. Table 2 showed that the abundance of *Ae. aegypti* was 0.27 individuals/m² lower than *Ae. albopictus* with a value of 0.5 individuals/m². These reasons could be assumed that the *Ae. aegypti* was not be able to adapt to the environment [12].

| Type of mosquitoes | The number of mosquito (individu) | Abundance of mosquitoes (individu/m²) |
|--------------------|----------------------------------|---------------------------------------|
| *Aedes aegypti*     | 1                                | 0.27                                  |
| *Aedes albopictus*  | 2                                | 0.5                                   |

Abundance value for *Ae. albopictus* was higher than *Ae. aegypti* because of *Ae. albopictus* is a species of mosquito that was often found in plantation or forest areas and tends to seek outside the home [13]. Other studies report that all *Ae. albopictus* was found in outdoor environments, this can be caused by *Ae. albopictus* is better able to adapt to the environment for life and development than *Ae. aegypti* [12].

The low number of mosquitoes that found in Jatimulyo village was influenced by the distance between the breeding places and human activities. The western, southwest, and southern parts of Jatimulyo Village are directly adjacent to the Brantas river, and the distance between the rivers and settlements varies considerably, around 5-15 meters. The distance between the river and the settlement was considered to affect the number of mosquitoes in the area, because the river has the potential to become a breeding place for *Aedes* spp.

Jatimulyo village with a population density of 107 people/ha with a minimal distance between one house and another is also one of the factors that support the high and low density of mosquitoes in a location. The closer of the distance between houses, it is can affect the mosquitoes to spread from house to house because of the *Aedes* spp. can fly for 40-50 meters [14]. There was also no correlation...
between temperature, relative humidity, light intensity, and wind speed because the significance value was p-value more than 0.05.

3.3. Analysis of water reservoirs at Jatimulyo Village

Ae. aegypti prefers to lay eggs in water collected in a container, there were not stagnant water on the ground. The potential mosquito breeding sites are water reservoirs that are used for daily purposes such as drums, bathtubs, buckets [11]. The type and number of containers during research were recorded. Based on the type, water reservoirs were divided into six types, namely bathtubs, buckets, fish ponds / aquariums, bird drinking places, water reservoirs and used tires. The types and numbers of water reservoirs have been interpreted in the following graph (Figure 8).

![Figure 8. The types and numbers of water reservoirs in Jatimulyo village](image)

Based on Figure 8, the most water reservoirs found were buckets (48%), and the least were fish ponds and used tires (3%). Buckets were available both inside and outside of the house, with or without lids. Most buckets were closed and turned over when not in use. This can reduce the breeding places for dengue mosquitoes because a landfill that is left open will be inundated with water and become a potential breeding places for dengue mosquitoes [10]. The most preferred breeding places were dark ones, wide open and protected from direct sunlight [11]. These results were consistent with observations, because all larvae found were in the open bath and they were in the house. Ae. aegypti and Ae. albopictus can live in clean waters because the Aedes mosquito was attracted to clean water conditions which contain chemical compounds and organic compounds (water plants) which can be used as mosquito food [12].

3.4. Analysis of Larvae Index at Jatimulyo Village

The larva index analysis includes the House Index (HI), the Container Index (CI), the Breteau Index (BI), and the Mosquito Larva Free Rate (ABJ) referring to Table 3. The HI value in the Jatimulyo Village area was 30%; CI 4.6%; BI 40%; and ABJ 70%, these values were compared with the Density Figure (DF). HI values were included in category 5 (medium density), CI was included in category 2 (medium density), and BI was included in category 5 (medium density). Based on the larva index, Jatimulyo Village is included in the category of moderate transmission.

HI describes the spread of mosquitoes in an area. The Ministry of Health stipulates that to prevent DHF transmission, HI should not be more than 10%, if it is greater than 10% then the area indicates a high-risk area for the incidence of DHF. The higher the HI value, the higher the risk of residents in the area to contact with dengue virus-carrying mosquitoes [15]. Based on this, the area of Jatimulyo Urban Village is at high risk of dengue fever because it has a HI value more than 10%.
Table 3. Type and number mosquitoes Larvae in Jatimulyo Village

| Hamlets | Number of larvae (Individu) | \(Ae. aegypti\) | \(Ae. albopictus\) |
|---------|-----------------------------|-----------------|-----------------|
| 1       | 0                           | 0               | 0               |
| 2       | 0                           | 0               | 0               |
| 3       | 0                           | 0               | 0               |
| 4       | 0                           | 0               | 0               |
| 5       | 0                           | 0               | 0               |
| 6       | 0                           | 1               | 0               |
| 7       | 1                           | 0               | 0               |
| 8       | 0                           | 1               | 0               |
| 9       | 0                           | 0               | 0               |
| 10      | 0                           | 0               | 0               |

The CI value in Jatimulyo Village showed that it was higher than the WHO standard (<5%). These showed that the Jatimulyo Village area did not have many containers that have the potential for breeding \(Aedes\) spp. larvae, but the 4.6% CI needs to be lowered because it was closed to the WHO standard value. The BI value based on the larval index parameter was lower than the WHO standard (50%), with moderate DF category. The BI value can be lowered by increasing \(Aedes\) population control efforts. According to the Ministry of Health's Minimum Service Standards [10], the minimum ABJ value to limit the spread of DHF is 95%. The free rate of larvae is said to be high if there are no larvae found in the surveyed area, and it is said to be low if many larvae are found. The area of Jatimulyo Village has a low ABJ score (70%) because it is less than 95%. The low ABJ value can be caused by the low number of sampling points at the time of the study, so it is necessary to carry out surveys repeatedly and regularly. ABJ has no effect on the incidence of DHF, the low number of ABJ does not affect the high incidence of DHF, but can be an indicator of successful fogging and early prevention of DHF [16].

The presence of \(Ae. aegypti\) and \(Ae. albopictus\) can also be analyzed by the presence of predators. The most common type of predator was the long-legged spider (Arachnida: Pholcidae), 28% of the total 43 predators were found. The house spider (Arachnida) was found 26%, birds were found 21%, lizards were found 16%, cleaning / ornamental fish was found in 7%, and the least was found were geckos as much as 2%. Long-legged spiders become predators of adult mosquitoes by making spider webs and mosquitoes will be trapped in the web. When conducting the research, lizards were not visible in all houses, but according to residents of Jatimulyo Village, lizards were found in almost every house and had the potential to be mosquito predators. Birds were effective for eating mosquito larvae that were likely to be in the drinking area, while ornamental fish will eat mosquito eggs & larvae that were in the fish pond.

3.5. Analysis of Population mobility at Jatimulyo Village

The spread of DHF by the \(Ae. aegypti\) and \(Ae. albopictus\) was influenced by several things, one of which was population activity. Population activities such as mobility were analyzed into mobility distances and mobility intensity, which were assumed to be influenced by the age of the population. The mobility distance is categorized as low (only around Malang city, 0-15 km), medium (around Malang City to Malang Regency, 16-80 km), and high (around Malang City, Malang Regency, to out of town, more than 80 km). The mobility intensity was also categorized into 3, consisting of low (0-2 times a week), moderate (3-5 times a week), and high (6-7 times a week). The age of the population (respondents) is categorized into the age of children (1 year to more than 15 years), productive age (15 - 64 years), and non-productive age (more than 64 years).
The low category distance has the highest percentage because most of the population can fulfill their needs and carry out activities around the city of Malang. The low range of mobility can reduce the risk of dengue transmission, because the narrow scope of activities will facilitate environmental maintenance to prevent the reproduction of dengue vector mosquitoes. The respondents who go outside the city have a 17 times greater risk of getting dengue compared to residents who do not leave the city [17].

The MHD value which is categorized as having a high risk of DHF transmission if more than 2 mosquitoes/hour/person, while the MHD value less than 2 mosquitoes/hour/person is categorized as a low risk of dengue transmission. Based on the MHD value of species *Ae. aegypti* and *Ae. albopictus*, the area of Jatimulyo Urban Village is in the low risk category of dengue transmission.

4. Summary
The type of diurnal mosquito that is found in Jatimulyo is *Ae. albopictus* at sampling point 1 and one *Ae. aegypti* at the sampling point 9. The three mosquitoes were found outside the house (out door). Larvae of *Ae. albopictus* was found at sampling points 1 and 8, while larvae *Ae. aegypti* found at sampling point 7. The spatial distribution of *Aedes* spp. can be influenced by mosquito abundance, LI value, number of predators, number of landfills, and population mobility. Abundance *Ae. aegypti* is lower than *Ae. albopictus* in outdoor places. Based on the Larvae Index value, Jatimulyo sub-district was an area with a moderate risk of dengue spread, with a high probability of spreading dengue based on the ABJ score. As many as 6 types of predators were found with different predation rates at each stage of the life of mosquitoes which can reduce the risk of dengue transmission. There are 64 containers, 3 of which contain larvae. The low intensity and distance of population mobility will reduce the risk of dengue transmission in the Jatimulyo Village area.

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