# Mapping of the Oviposition Ability, Survival Rate, and Distribution of Dengue Vector in Bengkulu City, Indonesia

*Lala* Foresta Valentine Gunasari[1], *Tsaniyah* Pasandra[2], *Nikki* Aldi Massardi[3], and *Dessy* Triana[1*]

[1]Department of Parasitology, Faculty of Medicine and Health Sciences, University of Bengkulu, Bengkulu, Indonesia
[2]Medical Program, Faculty of Medicine and Health Sciences, University of Bengkulu, Bengkulu, Indonesia
[3]Department of Anatomical Pathology, Faculty of Medicine and Health Sciences, University of Bengkulu, Bengkulu, Indonesia

**Abstract.** Vector surveillance is pivotal for dengue prevalence. The oviposition ability, survival rate, and distribution of dengue vector species can indicate the population density and are components of mosquito survival strategies. The density of dengue vectors is influenced by altitude, population density, water sources, and vegetation characteristics in their breeding habitats. This study aims to determine the oviposition ability, survival rate, and distribution of dengue vectors in Bengkulu City. This study employed a quantitative method with a descriptive observational design. Data were obtained by collecting *Aedes spp*. eggs from 67 urban villages in Bengkulu City. The survival rate was determined through colonization, and the distribution of mosquito species was analyzed based on the mosquitoes resulting from colonization. Beringin Raya was identified as the urban village with the highest oviposition ability, while Kandang was identified as the lowest. The highest survival rate of dengue vectors was found in Jalan Gedang, while the lowest was found in Sumber Jaya, Muara Dua, Padang Jati, and Tengah Padang. *Aedes aegypti* dominated 36 urban villages, while *Aedes albopictus* dominated 26 urban villages. In conclusion, dengue vectors were distributed across all urban villages in Bengkulu City, with *Aedes aegypti* being the dominant species.

## 1 Introduction

Dengue is one of the most common tropical diseases that affects humans, posing a global public health issue in recent decades. The World Health Organization (WHO) has reported an upward trend in the incidence of dengue hemorrhagic fever (DHF) worldwide. In 2000, 500,403 cases were reported, increasing to more than 2.4 million in 2010, and 5.2 million in 2019 [1]. In Indonesia, dengue cases increased from 65,602 in 2018 to 138,127 in 2019. However, the number of cases decreased to 108,303 in 2020 and 73,518 in 2021 [2–4]. In

* Corresponding author: dessy.triana@unib.aci.id

Bengkulu Province, 1,276 DHF cases were reported in 2020, with an incidence rate (IR) of 62.3 per 100,000 population [5]. This rate did not meet the government's target of fewer than 49 per 100,000 population [6]. Furthermore, 10 deaths were reported in 2020, with a case fatality rate (CFR) of 1% [5]. This CFR is classified as high and still did not meet the government's target of less than 1% [4]. A higher CFR indicates a greater severity of the disease [7].

Dengue is caused by infection with the dengue virus (DENV), a single-stranded RNA flavivirus that belongs to the Flaviviridae family. DENV has four main serotypes, namely DENV-1, DENV-2, DENV-3, and DENV-4. These four serotypes can lead to dengue infections with various clinical manifestations, ranging from asymptomatic dengue infection, dengue fever (DF), dengue hemorrhagic fever (DHF), to dengue shock syndrome (DSS) [8].

Dengue infection remains a major cause of fever cases requiring hospitalization, primarily due to the absence of specific treatment [9]. Current treatment focuses on managing symptoms by addressing plasma fluid loss caused by increased capillary permeability. Although a dengue virus vaccine was approved for distribution from the Indonesian Food and Drug Supervisory Agency (*Badan Pengawas Obat dan Makanan*/BPOM) in 2017, it has not yet been integrated into the national immunization program as a strategy to prevent dengue infection [10]. Therefore, vector control is necessary for dengue prevention, particularly through vector surveillance systems. The primary vectors of the dengue virus are *Aedes aegypti* and *Aedes albopictus* [11]. The population density of dengue vectors in an area can be assessed through oviposition ability, survival rate, and distribution.

The density of vectors in an area is influenced by population density and altitude. Closer proximity of houses facilitates mosquito spread, while higher altitude makes it more challenging for *Aedes* mosquitoes to survive [12, 13]. Population density of dengue vectors can also be assessed by examining the survival rate of eggs to adulthood. These eggs can be used to estimate the number of adult female mosquito populations [14]. The survival rate of Aedes mosquitoes is influenced by temperature. On average, *Aedes* eggs can hatch and develop into adults at temperatures between 16°C and 35°C [15]. Additionally, the density of vectors can be determined based on their species distribution, which is influenced by their breeding habitats. In their development, *Aedes aegypti* and *Aedes albopictus* live in different habitats. *Aedes aegypti* typically lives close to human environments, while *Aedes albopictus* typically lives in gardens, swamps, and forests [16].

The analysis of oviposition ability, survival rate, and distribution of dengue vector species is crucial, as it can indicate the vector population density and is a key component in the mosquito's survival and life cycle, making it a particular focus for interrupting dengue virus transmission by breaking the mosquito's life cycle. Therefore, this study aims to analyze the oviposition ability, survival rate, and distribution of dengue vector species across urban villages in Bengkulu city.

## 2 Methods

This study employed a quantitative method with a descriptive observational design. This study was conducted in 67 urban villages in Bengkulu City. The variables in this study included oviposition ability, survival rate, and distribution of dengue vectors. Data collection involved the following process: collection and counting of mosquito eggs, colonization of mosquito eggs, and identification of vector species. Cluster random sampling was used as the sampling technique. A sample of 50 houses per urban village was selected [17], with the houses randomly selected with a minimum distance of 100 meters between each house. Two ovitraps were installed in each house, placed both outdoors and indoors. In total, 3,350 houses were sampled across 67 urban villages in Bengkulu City, with a total of 6700 ovitraps being installed. The ovitraps were left in place for five days. After five days, the ovistrips with

mosquito eggs from each household were collected and dried. The mosquito eggs on the ovistrips were counted individually using a loupe and categorized based on their respective urban villages. The ovistrips with mosquito eggs were then soaked in plastic trays filled with water to allow the eggs to hatch into larvae within 1-2 days. The larvae were fed with dried chicken liver, and the water in the plastic trays was replaced 2-3 times a week to ensure their survival. After 6-8 days, the larvae transformed into pupa, which were subsequently transferred to containers covered with a mosquito net or placed in a mosquito cage. Within 1-2 days, the pupa emerged as adult mosquitos. The adult mosquitoes were kept indoors with a temperature of 27 ± 2 $^{o}$C, air humidity of 75 ± 10%, and a 12-hour light and dark cycle. The adult mosquitoes were fed with a 10% sugar solution. The percentage of successfully hatched eggs developing into adult mosquitoes was calculated. All data were tabulated based on each urban village. Adult mosquitoes were identified according to Rueda's pictorial keys for the identification of mosquitoes to distinguish between *Aedes aegypti* and *Aedes albopictus* [18]. Identification was carried out through morphological observations using a stereo microscope.

# 3 Results

## 3.1 Oviposition Ability of Dengue Vectors in Bengkulu City

A total of 21,818 mosquito eggs were collected from the 6,700 ovitraps installed in 3,350 houses across 67 urban villages in Bengkulu City. The urban village with the highest number of mosquito eggs was Beringin Raya, with a total of 1,538 eggs, while the urban village with the lowest number of mosquito eggs was Kandang, with only six eggs. The oviposition ability of dengue vectors across 67 urban villages is illustrated in Figure 1.

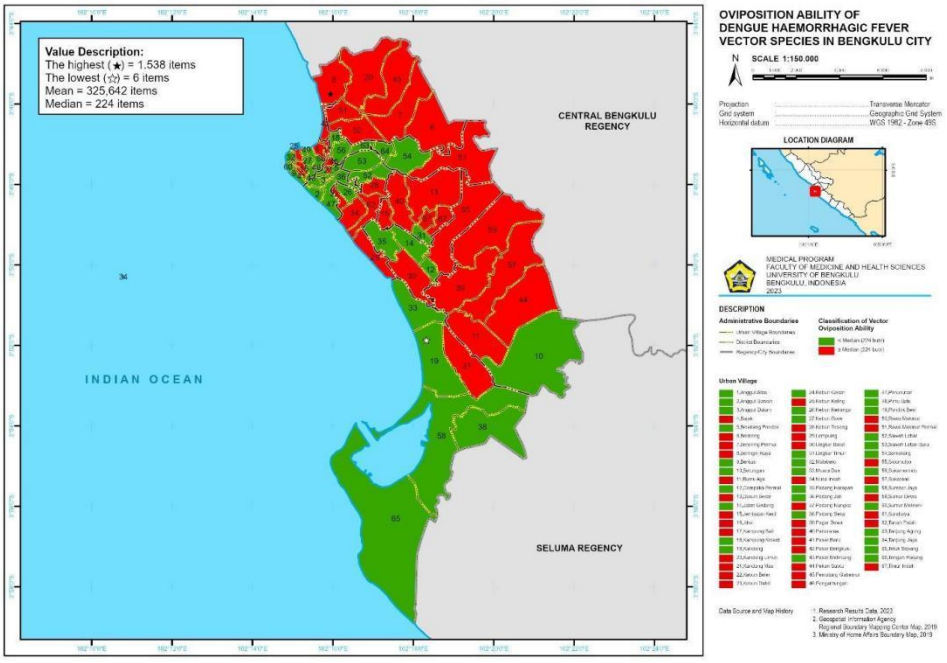


**Figure 1. Oviposition Ability of Dengue Vectors in Bengkulu City**

### 3.2 Survival Rate of Dengue Vectors in Bengkulu City

Out of the 21,818 eggs collected, 7,504 developed into adult mosquitoes, resulting in an overall survival rate of 34.39%, calculated as $\frac{7.504}{21.818} \times 100\% = 34.39\%$. The survival rate varied across urban villages, ranging from 0.00% to 81.35%. The highest survival rate was found in Jalan Gedang at 81.35%, while the lowest survival rate was found in Sumber Jaya, Muara Dua, Padang Jati, and Tengah Padang, all having a survival rate of 0.00%. A survival rate map for Bengkulu City is presented in Figure 2.

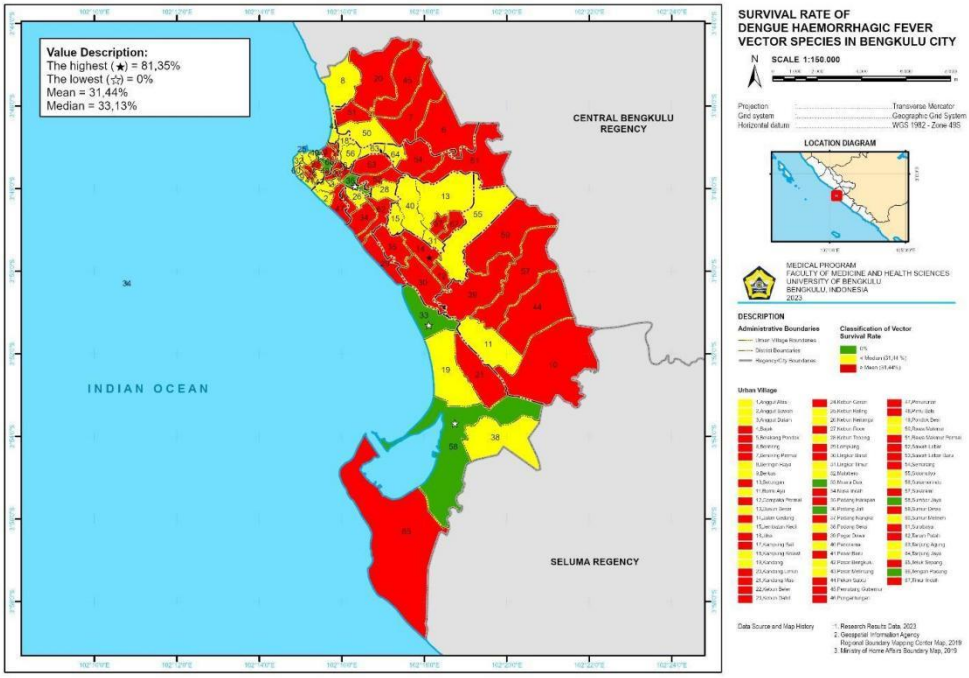


**Figure 2. Survival Rate of Dengue Vectors in Bengkulu City**

### 3.3 Distribution of Dengue Vectors in Bengkulu City

In the identification process, *Aedes aegypti* was the most frequently identified mosquito species, accounting for 4,238 (56.48%) mosquitoes, while *Aedes albopictus* accounted for 3,266 (43.52%) mosquitoes. Among urban villages, 36 were dominated by *Aedes aegypti*, 26 urban villages by *Aedes albopictus*, and one urban village had an equal proportion of both species.

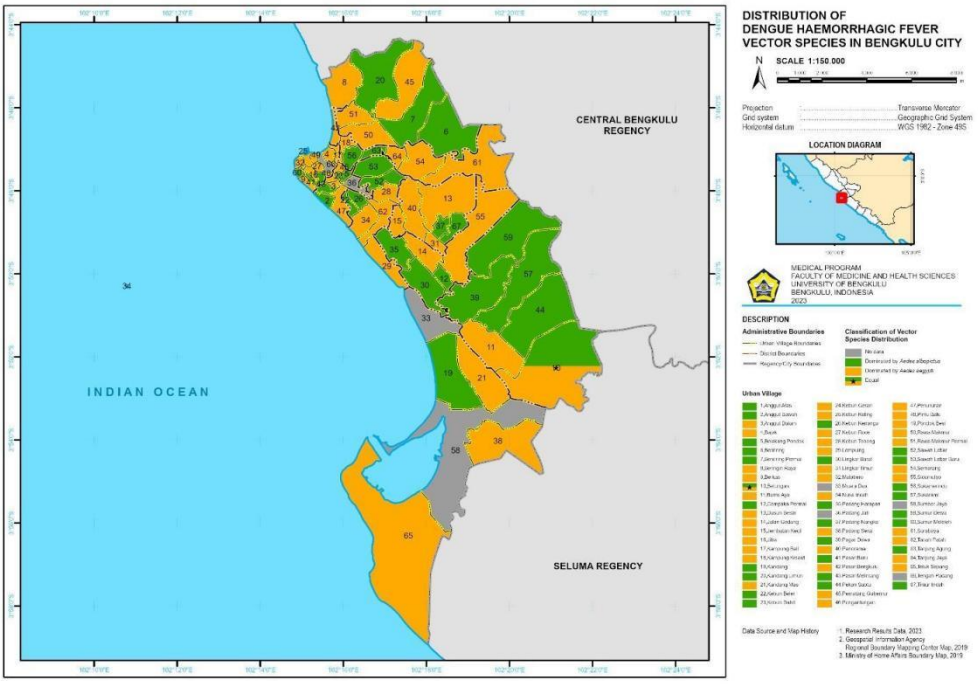


**Figure 3. Distribution of Dengue Haemorrhagic Fever Vector in Bengkulu City**

The detailed information regarding the oviposition ability, survival rate, and distribution of dengue vectors across the 67 urban villages in Bengkulu City is provided in the following table.

Table 1. Oviposition ability, survival rate, and distribution of dengue vectors in Bengkulu City, Indonesia

| Urban Villages | Number of Eggs | Number of Mosquitoes | Survival Rate (%) | Species Distribution | | | |
|---|---|---|---|---|---|---|---|
| | | | | *Ae. aegypti* | | *Ae. albopictus* | |
| | | | | N | % | N | % |
| Pagar Dewa | 744 | 292 | 39.25 | 113 | 38.70 | 179 | 61.30 |
| Sukarami | 847 | 439 | 51.83 | 72 | 16.40 | 367 | 83.60 |
| Pekan Sabtu | 270 | 85 | 31.48 | 40 | 47.06 | 45 | 52.94 |
| Bumi Ayu | 605 | 136 | 22.48 | 136 | 100.00 | 0 | 0.00 |
| Betungan | 84 | 28 | 33.33 | 14 | 50.00 | 14 | 50.00 |
| Sumur Dewa | 225 | 89 | 39.56 | 40 | 44.94 | 49 | 55.06 |
| Kandang | 6 | 1 | 16.67 | 0 | 0.00 | 1 | 100.00 |
| Kandang Mas | 793 | 336 | 42.37 | 215 | 63.99 | 121 | 36.01 |
| Teluk Sepang | 220 | 70 | 31.82 | 70 | 100.00 | 0 | 0.00 |
| Sumber Jaya | 42 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Padang Serai | 76 | 9 | 11.84 | 9 | 100.00 | 0 | 0.00 |

| Urban Villages | Number of Eggs | Number of Mosquitoes | Survival Rate (%) | Species Distribution | | | |
|---|---|---|---|---|---|---|---|
| | | | | *Ae. aegypti* | | *Ae. albopictus* | |
| | | | | N | % | N | % |
| Muara Dua | 13 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Padang Harapan | 59 | 28 | 47.46 | 4 | 14.29 | 24 | 85.71 |
| Jalan Gedang | 193 | 157 | 81.35 | 89 | 56.69 | 68 | 43.31 |
| Sidomulyo | 1091 | 150 | 13.75 | 102 | 68.00 | 48 | 32.00 |
| Lingkar Barat | 269 | 194 | 72.12 | 89 | 45.88 | 105 | 54.12 |
| Cempaka Permai | 33 | 16 | 48.48 | 0 | 0.00 | 16 | 100.00 |
| Kebun Tebeng | 225 | 89 | 39.56 | 59 | 66.29 | 30 | 33.71 |
| Tanah Patah | 654 | 347 | 53.06 | 226 | 65.13 | 121 | 34.87 |
| Nusa Indah | 882 | 367 | 41.61 | 214 | 58.31 | 153 | 41.69 |
| Kebun Beler | 355 | 121 | 34.08 | 34 | 28.10 | 87 | 71.90 |
| Kebun Kenanga | 180 | 81 | 45.00 | 17 | 20.99 | 64 | 79.01 |
| Sawah Lebar | 177 | 114 | 64.41 | 49 | 42.98 | 65 | 57.02 |
| Sawah Lebar Baru | 177 | 118 | 66.67 | 3 | 2.54 | 115 | 97.46 |
| Lempuing | 450 | 154 | 34.22 | 91 | 59.09 | 63 | 40.91 |
| Padang Jati | 14 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Kebun Dahri | 224 | 93 | 41.52 | 10 | 10.75 | 83 | 89.25 |
| Belakang Pondok | 191 | 99 | 51.83 | 6 | 6.06 | 93 | 93.94 |
| Penurunan | 120 | 66 | 55.00 | 66 | 100.00 | 0 | 0.00 |
| Anggut Bawah | 69 | 14 | 20.29 | 1 | 7.14 | 13 | 92.86 |
| Anggut Atas | 119 | 10 | 8.40 | 0 | 0.00 | 10 | 100.00 |
| Anggut Dalam | 79 | 2 | 2.53 | 2 | 100.00 | 0 | 0.00 |
| Kebun Geran | 179 | 47 | 26.26 | 47 | 100.00 | 0 | 0.00 |
| Pengantungan | 272 | 111 | 40.81 | 100 | 90.09 | 11 | 9.91 |
| Panorama | 400 | 86 | 21.50 | 86 | 100.00 | 0 | 0.00 |
| Jembatan Kecil | 255 | 74 | 29.02 | 42 | 56.76 | 32 | 43.24 |
| Dusun Besar | 402 | 4 | 1.00 | 4 | 100.00 | 0 | 0.00 |
| Padang Nangka | 331 | 188 | 56.80 | 65 | 34.57 | 123 | 65.43 |
| Timur Indah | 343 | 139 | 40.52 | 50 | 35.97 | 89 | 64.03 |
| Lingkar Timur | 170 | 17 | 10.00 | 17 | 100.00 | 0 | 0.00 |
| Berkas | 38 | 10 | 26.32 | 10 | 100.00 | 0 | 0.00 |
| Pasar Baru | 240 | 110 | 45.83 | 9 | 8.18 | 101 | 91.82 |
| Jitra | 435 | 237 | 54.48 | 193 | 81.43 | 44 | 18.57 |

| Urban Villages | Number of Eggs | Number of Mosquitoes | Survival Rate (%) | Species Distribution | | | |
|---|---|---|---|---|---|---|---|
| | | | | *Ae. aegypti* | | *Ae. albopictus* | |
| | | | | N | % | N | % |
| Pasar Melintang | 151 | 13 | 8.61 | 2 | 15.38 | 11 | 84.62 |
| Kebun Roos | 109 | 11 | 10.09 | 10 | 90.91 | 1 | 9.09 |
| Tengah Padang | 86 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Bajak | 923 | 301 | 32.61 | 202 | 67.11 | 99 | 32.89 |
| Pondok Besi | 76 | 11 | 14.47 | 10 | 90.91 | 1 | 9.09 |
| Kebun Keling | 265 | 17 | 6.42 | 17 | 100.00 | 0 | 0.00 |
| Sumur Meleleh | 47 | 2 | 4.26 | 0 | 0.00 | 2 | 100.00 |
| Malabero | 67 | 6 | 8.96 | 6 | 100.00 | 0 | 0.00 |
| Pintu Batu | 213 | 75 | 35.21 | 73 | 97.33 | 2 | 2.67 |
| Kampung Bali | 833 | 337 | 40.46 | 327 | 97.03 | 10 | 2.97 |
| Kampung Kelawi | 109 | 14 | 12.84 | 14 | 100.00 | 0 | 0.00 |
| Sukamerindu | 205 | 26 | 12.68 | 12 | 46.15 | 14 | 53.85 |
| Semarang | 94 | 53 | 56.38 | 53 | 100.00 | 0 | 0.00 |
| Tanjung Agung | 75 | 14 | 18.67 | 0 | 0.00 | 14 | 100.00 |
| Tanjung Jaya | 88 | 9 | 10.23 | 9 | 100,00 | 0 | 0.00 |
| Surabaya | 225 | 132 | 58.67 | 82 | 62.12 | 50 | 37.88 |
| Pasar Bengkulu | 745 | 220 | 29.53 | 126 | 57.27 | 94 | 42.73 |
| Kandang Limun | 258 | 122 | 47.29 | 50 | 40.98 | 72 | 59.02 |
| Bentiring | 690 | 237 | 34.35 | 22 | 9.28 | 215 | 90.72 |
| Pematang Gubernur | 750 | 275 | 36.67 | 182 | 66.18 | 93 | 33.82 |
| Rawa Makmur | 682 | 142 | 20.82 | 141 | 99.30 | 1 | 0.70 |
| Beringin Raya | 1538 | 313 | 20.35 | 308 | 98.40 | 5 | 1.60 |
| Bentiring Permai | 646 | 214 | 33.13 | 11 | 5.14 | 203 | 94.86 |
| Rawa Makmur Permai | 392 | 232 | 59.18 | 187 | 80.60 | 45 | 19.40 |
| Total | 21818 | 7504 | 34.39 | 4238 | 56.48 | 3266 | 43.52 |

## 4 Discussion

**Oviposition.** A total of 21,818 mosquito eggs were collected from 67 urban villages in Bengkulu City. The oviposition ability of mosquitoes is influenced by various factors, including humidity and temperature. According to previous research, optimal conditions for the development of *Aedes sp.* include humidity levels between 70% and 90% and temperatures ranging from 25°C to 30°C [19]. During the study period from July to December 2022, recorded average humidity levels of 82.6%-86.9% and temperatures of

26.2°C-27.1°C, both of which are conducive to the survival and development of *Aedes sp.* [20].

Altitude also plays a role in the presence of *Aedes sp.* Previous research has shown that *Aedes sp.* were found in areas with altitudes ranging from 0 to 736 meters above sea level, with fewer mosquitoes at higher altitudes [13]. The average altitude in Bengkulu City is less than 500 meters above sea level [21], which further supports the favorable conditions for the growth and development of *Aedes sp.* in Bengkulu City.

Environmental conditions in each urban village also contributed to the number of mosquito eggs collected. Beringin Raya recorded the higher number of *Aedes sp.* Eggs, accounting for 1,538 eggs. Previous studies have shown that these mosquitoes tend to breed in places with stagnant water that does not directly touch the ground, such as unused plastic buckets, drums, and old tires [22]. In addition, breeding sites can include used cans, coconut shells, and bamboo pieces [23]. *Aedes sp.* mosquitoes are often most abundant in residential areas with ample vegetation and water reservoirs [24]. Improperly managed waste can accumulate water during rainfall, providing ideal breeding sites for mosquitoes. This study found a significant amount of solid waste and discarded items containing stagnant water in Beringin Raya. Moreover, the residential area in Beringin Raya is characterized by a high density of trees. The abundance of breeding sites and residential conditions in this urban village likely contribute to the high number of mosquito eggs collected from Beringin Raya.

In contrast, Kandang recorded the fewest *Aedes sp.* mosquito eggs, with only six eggs collected. One possible explanation for this low number is the amount of rainfall during the sampling period. This is in line with a study that states that there is a decrease in the abundance of *Aedes sp.* eggs during increased rainfall. Study have shown that increased rainfall can lead to a reduction in the number of *Aedes sp.* eggs, as excessive rainfall may cause breeding sites to overflow, disrupting mosquito reproduction and reducing available egg-laying sites. Additionally, heavy and prolonged rainfall can wash away pre-adult mosquito stages, leading to a decline in the mosquito population [25, 26]. However, other studies suggested that the number of mosquito eggs is higher during months with high rainfall, as the rain provides breeding and egg-laying sites for Aedes mosquitoes [27]. Therefore, the impact of rainfall on mosquito populations varies depending on factors, such rainfall duration and the surrounding environmental conditions.

**Survival Rate.** During the colonization process, not all eggs developed into adult mosquitos, resulting in varying mosquito survival rates across villages. The hatchability of *Aedes sp.* eggs is influenced by storage duration. Previous research has shown that the hatching rate of Aedes eggs decreased with longer storage times: 63.17% after one month, 10% after five months, and no hatching after six months due to drought leading to egg embryo death [28]. In this study, ovistrips with eggs were collected from different villages and stored at room temperature before colonization, resulting in differences in egg storage time across villages. This is suspected to be the cause of differences in survival rates in each village.

Other factors that affect the survival rate of *Aedes sp.* are temperature and humidity. The optimal temperature for hatching *Aedes sp.* is between 25°C and 27°C [29], while hatching does not occur at water temperatures above 33°C [30]. The average room temperature in this study ranged from 27°C to 30°C. Humidity is also important, with the air humidity in this study ranging from 75% to 89%. The optimal humidity for the life cycle of *Aedes sp.* mosquitoes is around 81.5%-89.5%, while lower humidity can shorten their lifespan [31].

In addition, the survival rate of *Aedes sp.* mosquitoes is influenced by external factors, such as the condition of the breeding medium. Previous studies have demonstrated that the survival rate from eggs to adults is influenced by the organic content of the breeding medium, which serves as a food source for larvae [32]. For instance, stagnant and clear water drain has been shown to support better survival rates compared to clean well water, with a

survival rate of 100% in drain water due to its higher plankton content [33]. Similarly, another study found that the hatchability of *Aedes sp.* eggs is higher in gutter water compared to rainwater and well water [34]. In this study, the survival rate in Bengkulu City was 34.39%. The use of clean water from the laboratory as a breeding medium is suspected to be the cause of the low mosquito survival rate in this study.

### 4.1 Distribution of Dengue Vector Species in Bengkulu City

Based on the identification of mosquitoes successfully colonized from 67 urban villages in Bengkulu City, two mosquito species were found, namely *Aedes aegypti* and *Aedes albopictus*. *Aedes aegypti* had a higher percentage, accounting for 56.48%, while *Aedes albopictus* accounted for 43.52%. *Aedes aegypti* is known to thrive in urban environments [35], which explains its predominance in Bengkulu City as an area with high human mobility. Although *Aedes albopictus* is commonly found in areas with dense vegetation, studies from Taiwan and Malaysia have demonstrated that *Aedes albopictus* can also be found in urban or suburban areas with high population density [36, 37]. Similarly, in Indonesia, *Aedes aegypti* and *Aedes albopictus* have been found to coexist in suburban areas in the provinces of East Nusa Tenggara, West Nusa Tenggara, Bali, East Kalimantan, and Central Java [38,39]. However, the rapid expansion of urban areas has disrupted natural ecology, causing *Aedes albopictus* to inhabit anthropophilic areas [40, 41, 42]. (1,2) This may explain the continued prevalence of *Aedes albopictus* in Bengkulu City.

## 5 Conclusion

In this study, a total of 21,818 mosquito eggs were collected, with a survival rate of 34.39%. The most abundant mosquito species was *Aedes aegypti* with 4,238 individuals (56.48%) and *Aedes albopictus* with 3,266 individuals (43.52%). Beringin Raya had the highest vector oviposition ability, while Jalan Geda had the highest dengue vector survival rate. Among the urban villages, 36 were dominated by *Aedes aegypti*, 26 by *Aedes albopictus*, and one urban village had an equal proportion of both species. Further research could investigate the relationship between egg storage time and egg hatching. Further research could also focus on factors influencing oviposition ability in Beringin Raya as the urban village with the highest oviposition ability.

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