



Aedes aegypti Entomology Index and Environmental Determinants as the Basis for Dengue Fever Control in Bengkulu City

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DOI:

<https://doi.org/10.47134/phms.v3i1.520>

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Received: 05-09-2025

Accepted: 12-10-2025

Published: 26-11-2025



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Abstract: Dengue fever continues to be a significant public health issue in Indonesia, with Bengkulu City classified as an endemic area. The transmission of dengue is highly influenced by the density of *Aedes aegypti* vectors and environmental factors that support their breeding and survival. This study aimed to evaluate the level of *Aedes aegypti* larval infestation and adult mosquito density as the basis for assessing dengue transmission risk and to analyze the relationship between environmental factors and larval presence in the working area of Sawah Lebar Public Health Center, Bengkulu City. An entomological survey with a descriptive-analytic approach was conducted from January to March 2023 across five neighborhoods (RTs). A total of 100 houses and 189 water containers were examined using the House Index (HI), Container Index (CI), Breteau Index (BI), and Larval Free Index (ABJ). Adult mosquitoes were collected using resting collection and human landing catch methods. The relationship between environmental factors and larval presence was analyzed using the chi-square test ($p < 0.05$). Of the 100 houses examined, 73 (73%) were positive for larvae, and 148 of 189 containers (78.3%) contained *Aedes aegypti* larvae. The highest infestation was recorded in RT 23, with HI 93.3%, CI 89.3%, BI 223.3%, and ABJ 6.7%, indicating a very high transmission risk. *Aedes aegypti* dominated adult mosquito collections (73.8%) compared to *Aedes albopictus* (26.2%). Statistical analysis showed significant associations between larval presence and uncovered water containers ($p = 0.004$), poor waste disposal ($p = 0.021$), and the absence of regular source reduction activities ($p = 0.001$). The Sawah Lebar area exhibited high larval infestation and

adult *Aedes aegypti* density, indicating a substantial risk of dengue transmission. Vector control should be strengthened through the implementation of Integrated Vector Management (IVM), emphasizing community participation in “3M Plus” practices, regular larval surveillance, environmental sanitation improvement, and intersectoral collaboration to ensure sustainable dengue prevention.

Keywords: *Aedes Aegypti*, Entomological Indices, Dengue Fever, Environmental Factors, Vector Control, Bengkulu.

Introduction

Dengue fever (DF) is one of the infectious diseases that remains a global public health problem. In the last two decades, the number of DF cases has shown a significant upward trend in various countries. According to a report by the Centers for Disease Control and

Prevention (CDC, 2023), as of December 20, 2023, there were more than five million DF cases in more than 80 countries and regions [1]. The Americas ranked highest with more than three million cases in 2023, surpassing 2.8 million cases in 2022. Various factors contributed to this increase, including climate change, urbanization, and the expansion of the habitat of the main vectors, namely *Aedes aegypti* and *Aedes albopictus* [2].

In Indonesia, dengue fever remains a serious challenge to the public health system. In 2021, there were 73,518 reported cases with 705 deaths. This number increased to 143,266 cases in 2022, although there was a slight decrease in 2023 with 114,720 cases. The provinces of West Java, East Java, and Central Java were reported as the areas with the highest number of cases. High population density, environmental conditions conducive to vector breeding, and mosquito resistance to insecticides are factors that exacerbate the situation [3]. DHF is caused by the dengue virus, which belongs to the *arbovirus* group. The clinical manifestations of this disease vary, ranging from *dengue fever* to a more severe form, namely *dengue shock syndrome*. Transmission occurs through the bite of *Aedes* mosquitoes, especially *Aedes aegypti* and *Aedes albopictus* [4].

Bengkulu Province is one of the dengue endemic areas in Indonesia with a high public health risk in ten districts/cities. In 2021, there were 823 cases, increasing to 1,235 cases in 2022 with 11 deaths. In 2023, the number of cases increased to 1,339 with 14 deaths and an *incidence rate* of 34 per 100,000 population [5]. The Sawah Lebar Community Health Center was reported as one of the health centers with the highest number of cases, namely 12 cases in 2021, increasing to 38 cases in 2022, and decreasing to seven cases in 2023 [8].

Vector control efforts continue to face challenges. *Aedes aegypti* can breed in almost all regions of Indonesia, especially in containers that allow water to accumulate, such as discarded items and unmanaged water storage. Community participation in mosquito breeding site eradication is relatively low, so increased involvement in routine and continuous larval inspection activities is needed [6]. Entomological indices, such as the *Container Index* (CI), *House Index* (HI), *Breteau Index* (BI), and *Larvae-Free Rate* (LFR), are used to assess vector density and the risk of DHF transmission [7]. Based on these conditions, a study is needed on the distribution of vectors and environmental factors that influence their population in endemic areas, so that control strategies can be designed more effectively and contextually.

Materials and Methods

This research activity used an entomological survey design with a descriptive analytical approach aimed at evaluating the entomological index of *Aedes aegypti* and analyzing the environmental determinants that influence the risk of dengue hemorrhagic fever (DHF) transmission. This design was chosen because it provides an overview of vector

density while testing the relationship between environmental factors and the presence of larvae in the field [6,7].

The research location was set in the working area of the Sawah Lebar Community Health Center, Bengkulu City, which was reported as one of the areas with the highest number of dengue fever cases in the province [5,8]. The survey was conducted from January to March 2023, during the rainy season when the availability of mosquito breeding habitats generally increases. The study population included all households in the health center's working area, while the sample was selected *purposively*, taking into account households with a history of dengue fever cases and the availability of household water containers. Unoccupied houses were excluded from the study. Sample size was based on WHO entomological survey guidelines, with 100 households selected to ensure representative calculations of entomological indices. [7].

Data collection was conducted through larval surveys, adult mosquito surveys, and environmental factor observations. Larval surveys used the *single larva survey* method according to WHO guidelines [7], examining all water containers inside and around the house. Larvae found were collected and identified in the laboratory to confirm the vector species. The results of the examination were used to calculate several entomological indices, namely the House Index (HI), *Container Index* (CI), *Breteau Index* (BI), and Larva-Free Index (LFI). Adult mosquito surveys were conducted using aspirators inside houses with the *resting collection* method as recommended by the WHO and used in similar studies in Southeast Asia [6,9]. Each house was inspected for 10–15 minutes, and the mosquitoes caught were identified to the species level.

In addition, environmental factors were recorded through direct observation using a pre-designed *checklist*. The variables observed included the physical condition of the house, the presence of water containers, environmental sanitation, the presence of used items, and the practice of mosquito breeding site elimination (MBSE) by the occupants of the house. The collected data were analyzed descriptively to calculate the entomological index and adult mosquito density, then compared with the WHO's DHF transmission risk threshold standard [7]. Subsequently, a *chi-square* test with a 95% confidence level was used to analyze the relationship between environmental factors and the presence of larvae.

Results and Discussion

This study was conducted to evaluate the level of *Aedes aegypti* larvae infestation and adult mosquito density as a basis for determining the risk of dengue hemorrhagic fever (DHF) transmission and the effectiveness of vector control in the community. Larvae and adult mosquito surveys were conducted in five neighborhoods within the working area of the Sawah Lebar Community Health Center, with the aim of determining the distribution of larvae, the dominant mosquito species, and the relationship with physical environmental

factors and community social behavior. The analysis was conducted using HI, CI, BI, ABJ, Man Biting Rate (MBR), and *Resting Rate* (RR) indicators to assess the risk of vector-borne disease transmission and plan targeted control interventions. The larval survey results obtained from the five RTs are presented in Table 1, which shows the number of houses and containers inspected, the number of positive larvae, and the HI, CI, BI, and ABJ values as indicators of DHF transmission risk in the Sawah Lebar Community Health Center working area.

Table 1. Distribution of *Aedes aegypti* Larval Infestation in the Sawah Lebar Health Center Work Area, Bengkulu

Location (RT/RW)	Houses Inspected	Houses with Positive Larvae	Containers Inspected	Positive Containers	CI (%)	HI (%)	BI (%)	ABJ (%)
RT 32	10	5	13	9	69.2	50.0	90.0	50.0
RT 33	14	11	30	22	73.3	78.6	157.1	21.4
RT 24	26	20	43	30	69.8	76.9	115.4	23.1
RT 23	30	28	75	67	89.3	93.3	223.3	6.7
RT 22	20	9	28	20	71.4	45.0	100.0	55.0

A larval survey conducted in five neighborhoods within the working area of the Sawah Lebar Community Health Center showed a high level of *Aedes aegypti* larvae infestation, as reflected in the House Index (HI), *Container Index* (CI), *Breteau Index* (BI), and Larva-Free Rate (LFR). Out of 100 homes inspected, 73 homes (73.0%) tested positive for larvae, with 148 out of 189 containers inspected (78.3%) containing larvae. RT 23 recorded the highest values for all indicators, namely HI 93.3%, CI 89.3%, BI 223.3%, and ABJ 6.7%, indicating that almost all houses and containers were breeding sites for larvae. RT 33 and RT 24 also showed high infestation with HI of 78.6% and 76.9%, BI of 157.1% and 115.4%, and low ABJ of 21.4% and 23.1%, respectively. Although RT 32 and RT 22 had lower HI and BI, CI remained high (69.2% and 71.4%), with ABJ at 50% and 55%, still far below the WHO safe standard of $\geq 95\%$. These findings confirm that the entire survey area is in the high-risk category for dengue transmission, making intensive vector control, routine monitoring, and increased public awareness crucial.

Table 2. Distribution of the Number and Percentage of *Aedes aegypti* and *Aedes albopictus*

Capture Location	HLC		RC	
	<i>Aedes aegypti</i>	<i>Aedes albopictus</i>	<i>Aedes aegypti</i>	<i>Aedes albopictus</i>
RT 22 RW 06	30 (66.7)	15 (33.3)	90 (81.8)	20 (18.2)
RT 24 RW 06	35 (63.6)	20 (36.4)	110 (73.3)	40 (26.7)

RT 23 RW 07	45 (75.0)	15 (25.0)	120 (75.0)	40 (25.0)
RT 32 RW 08	8 (66.7)	4 (33.3)	18 (72.0)	7 (28.0)
RT 33 RW 08	7 (70.0)	3 (30.0)	10 (66.7)	5 (33.3)
Total	125 (68.7)	57 (31.3)	348 (73.8)	112 (26.2)

The distribution of mosquitoes captured shows the dominance of *Aedes aegypti* in all neighborhoods, both using the HLC and *Resting* methods. The percentage of *Ae. aegypti* is relatively high (63.6–75.0% in HLC and 66.7–81.8% in *Resting*), while *Ae. albopictus* is only found in low proportions. This phenomenon reflects a common pattern in dengue-endemic urban areas in Indonesia, including Bengkulu.

Several local studies indicate that Bengkulu is a region with high dengue endemicity, where *Ae. aegypti* is more dominant due to environmental characteristics that provide many man-made containers such as bathtubs, drums, and plastic containers in residential areas (1,2). Conversely, *Ae. albopictus* is more frequently found in rural areas or areas with vegetation, which supports its natural habit of utilizing natural containers for egg-laying (3,4).

The dominance of *Ae. aegypti* in the *Resting Collection* method also reinforces previous reports that this mosquito has endophilic and endophagic behavior, more often biting and resting indoors. This makes the household environment a primary risk point for dengue transmission. This condition is consistent with findings in several areas in Sumatra, including Lampung and South Sumatra, which show a similar pattern where *Ae. aegypti* dominates densely populated residential environments (5,6).

Table 3.

Capture Location	MBR		RR	
	<i>Ae. aegypti</i>	<i>Ae. albopictus</i>	<i>Ae. aegypti</i>	<i>Ae. Albopictus</i>
RT 22 RW 06	1.25	0.63	0.75	0.17
RT 24 RW 06	1.46	0.83	0.92	0.33
RT 23 RW 07	1.88	0.63	1.00	0.33
RT 32 RW 08	0.33	0.17	0.15	0.06
RT 33 RW 08	0.29	0.13	0.08	0.04
Total	5.21	2.40	2.90	0.93

Mosquito surveillance results at five capture sites showed significant differences between *Ae. aegypti* and *Ae. albopictus*. *Man Biting Rate* (MBR) data showed that *Ae. aegypti* had higher values at all sites compared to *Ae. albopictus*, with the highest value at RT 23 RW 07 at 1.88. This indicates that *Ae. aegypti* is more aggressive in biting humans and has the potential to be the primary vector for mosquito-borne diseases in the study area. Meanwhile, *Ae. albopictus* had a lower MBR, with the highest value at RT 24 RW 06 at 0.83, indicating its

role as a secondary vector. *Resting Rate* (RR) analysis showed a pattern consistent with MBR, where locations with high MBR also had high RR. RT 23 RW 07 recorded the highest *Ae. aegypti* RR of 1.00, indicating that mosquitoes tend to rest in the same residential environment after biting humans, thereby increasing the risk of disease transmission.

Locations RT 32 RW 08 and RT 33 RW 08 showed low MBR and RR values for both species, indicating a smaller mosquito population and lower risk of disease transmission. This spatial distribution is likely influenced by environmental factors, including population density, sanitation, the presence of water storage, and vegetation around homes. These findings are in line with previous studies showing that *Ae. aegypti* is more anthropophilic and more commonly found in residential environments than *Ae. albopictus* (Kusriastuti et al., 2021; Sari et al., 2022).

Based on these results, mosquito control strategies should focus on locations with high MBR and RR, such as RT 23 RW 07 and RT 24 RW 06, through a combination of human-based control, such as the use of mosquito nets and *repellents*, and environment-based control, such as fumigation and elimination of breeding sites. Locations with low MBR and RR still need to be monitored regularly to prevent a sudden increase in the mosquito population. This approach is in line with the *Integrated Vector Management* (IVM) principle recommended by the Indonesian Ministry of Health (2023) to reduce the risk of vector-borne disease transmission effectively and sustainably.

Based on the research results, the working area of the Sawah Lebar Community Health Center showed high levels of larval infestation and adult mosquito density, with *Aedes aegypti* as the main vector species for dengue fever. This condition indicates that vector control needs to be carried out through an integrated approach involving various environmental, social, and behavioral aspects of the community. The survey results show a significant relationship between household environmental conditions and the presence of *Aedes aegypti* larvae. Environmental factors such as open water containers, poor waste management, and the lack of routine mosquito breeding site elimination (PSN) practices are important determinants in increasing the risk of larvae presence in households.

Table 4. Statistical Analysis of the Relationship between Environmental Factors and the Presence of *Aedes aegypti* Larvae

Environmental Factors	Households with Larvae (%)	Households Negative Larvae (%)	p-value for
Open water containers	85	15	0.004
Poor waste management	76.3	23.7	0.021
Not performing routine PSN	88.6	11.4	0.001

The *chi-square* test results show a significant relationship between the three environmental factors and the presence of mosquito larvae. Households with open water containers and those that do not perform routine cleaning and maintenance have a higher chance of finding mosquito larvae compared to households with closed containers that perform routine cleaning and maintenance. These findings are in line with the results of studies by Nasution et al. (2020) and Rahmawati et al. (2022), which reported that open water containers that are not properly managed are the main habitat for *Aedes aegypti* to breed.

The *Integrated Vector Management* (IVM) approach is an important strategy in addressing this problem. According to the WHO (2020), the IVM concept includes environment-based vector control, the use of biological agents, the application of selective insecticides, and community empowerment. Cross-sectoral involvement, such as from the Health Office, local government, schools, and community organizations, is very important in strengthening community-based control interventions. Strategies that can be implemented in the study area include: Strengthening 3M Plus PSN Education: Involving the community in routine cleaning, covering, and recycling of water containers. Implementation of Periodic Larvae Monitoring: Involving jumantik cadres to conduct routine inspections and report on the condition of larvae in each house. Use of Biological Agents: Such as mosquito-eating fish or *Bacillus thuringiensis israelensis* bacteria to reduce the larval population. Integration of Spatial Data and Entomological Index: To determine priority areas for intervention and improve the effectiveness of resource use. The implementation of this approach is expected to reduce the entomological index to below the risk threshold for dengue fever transmission (). A consistent and sustainable community-based approach is the key to success in reducing transmission risk and maintaining public health in dengue-endemic areas such as Bengkulu.

CONCLUSION

The working area of the Sawah Lebar Community Health Center in Bengkulu City showed a high level of larval infestation and a high density of *Aedes aegypti* mosquitoes, indicating a substantial risk of dengue transmission. The predominance of *Aedes aegypti* and the significant associations between uncovered water containers, poor waste management, and the absence of source reduction activities with larval presence highlight the urgent need to improve community behavior and environmental sanitation. Implementing Integrated Vector Management (IVM) through community education, routine larval surveillance, and environment-based control measures is essential to sustainably reduce vector populations and prevent dengue transmission.

ACKNOWLEDGMENTS

The author extends gratitude to the Head of the Sawah Lebar Health Center in Bengkulu City, the Environmental Health Department of the Bengkulu Health Polytechnic,

and all field staff and community members in the study area for their support, cooperation, and participation throughout the entomological survey process.

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