JPPIPA 11(7) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

The Relationship between House Environmental Condition and Mosquito Larvae Density (Diptera: Culicidae) in Medan Denai Sub-District, Medan City

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Received: April 10, 2025
Revised: June 25, 2025
Accepted: July 25, 2025
Published: July 31, 2025

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DOI: 10.29303/jppipa.v11i7.11076

Abstract: Mosquitoes are the primary vectors for disease transmission in tropical regions such as Indonesia, which has high humidity levels that support their reproduction. Household environmental conditions play a crucial role in determining the presence and density of mosquito larvae as disease vectors. The Medan Denai subdistrict is a densely populated area experiencing an increase in Dengue Hemorrhagic Fever (DHF) cases. This study analyzes the relationship between household environmental conditions and mosquito larvae density. A survey was conducted on 300 homes divided into three groups. Environmental condition data were collected through direct observation, while the presence of larvae was analyzed using the House Index (HI), Container Index (CI), and Breteau Index (BI) to calculate the Density Figure (DF). Results showed that 24% of homes tested positive for larvae, primarily in dispenser containers. A total of 61% of homes had unclean environmental conditions. The highest DF of 5.3 was found in the 1–100 home group, which falls under the high-risk category for disease transmission. Chi-Square analysis revealed a significant association between environmental conditions and larval density ($p = 0.045$). These findings underscore the importance of improving environmental conditions as a strategy for mosquito vector control.

Keywords: Environmental conditions**;** Larval density; Mosquito vectors

Introduction

Various diseases can spread rapidly among humans, livestock, and wildlife through transmission vectors (Wilson et al., 2017). Mosquitoes are one of the main vectors in the spread of various diseases (Schrama et al., 2020). In tropical regions, including Indonesia, mosquitoes play an important role in vector-borne diseases. The three main mosquito genera that act as disease vectors in Indonesia are Anopheles, Aedes, and Culex (Wahono et al., 2022). The World Health Organization (WHO) states that dengue fever is a disease caused by a virus and transmitted through mosquito bites, making it one of the most significant global health challenges (World Health Organization, 2012).

The *Aedes aegypti* mosquito is known as a vector for dengue fever, chikungunya, yellow fever, and Zika (Braack et al., 2018). Viruses transmitted by Aedes mosquitoes belong to the arbovirus group, which primarily spreads through the bites of female *Aedes aegypti* mosquitoes (Simmons et al., 2012; Guzman & Harris, 2015; Ogunlade et al., 2021). *Aedes aegypti* mosquitoes are more active during the day than at other times (Chrostek et al., 2020). Meanwhile, Culex mosquitoes play a role in the spread of various

How to Cite:
Panggabean, M., Panggabean, Y. C., Siahaan, L., Sinambela, A. H., & Siregar, I. S. S. (2025). The Relationship between House Environmental Condition and Mosquito Larvae Density (Diptera: Culicidae) in Medan Denai Sub-District, Medan City. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 1066–1074. https://doi.org/10.29303/jppipa.v11i7.11076

diseases, such as West Nile, Sindbis, Wesselsbron, and filariasis (Schrama et al., 2020). Filarial parasites transmitted by Culex mosquitoes can cause elephantiasis (Sutanto et al., 2021).

Mosquitoes can survive and reproduce in various specific ecosystems influenced by environmental factors such as humidity, wind speed, temperature, and rainfall (Nurnasari & Djumali, 2010; Wirayoga, 2013; Wahono et al., 2022). Indonesia is a tropical country with high air humidity, making these environmental conditions highly conducive for mosquito reproduction (Karwur et al., 2023). High humidity plays a role in influencing the activity of Culex and Aedes mosquitoes, including increased egg production, larval index, and mosquito activity intensity (Costa et al., 2010; Khan et al., 2018; Drakou et al., 2020).

Various types of containers capable of holding water, such as bathtubs, water tanks, empty bottles or tubes, used water bottles, old tires, and flower pots, are known to be potential breeding sites for mosquitoes (Adnan & Siswani, 2019; Manulang et al., 2023). In addition, mosquito eggs are often found in open areas, such as building floors, house gutters, bamboo fence gaps, fruit peels, and other containers containing clean water (Sembel, 2009; Anggraini & Cahyati, 2017). These containers are generally found in residential areas.

The environmental conditions of human settlements play a crucial role in determining the presence and population of mosquitoes as vectors for various diseases. Research by Braack et al. (2018) states that changes in environmental conditions due to human activities impact the increase in mosquito populations and the spread of diseases they transmit. An environment that is not well-maintained, coupled with high population density, tends to create an ideal habitat for mosquitoes (Williams et al., 2013; Dhewantara et al., 2019; Amelinda et al., 2022; Dwiyanthi et al., 2023).

The Medan Denai subdistrict is one of the areas with the third-highest population density in the city of Medan for the period 2020–2023, with a population of 18,994 people/km² and an area of 9.37 km² (BPS Kota Medan, 2024). This area encompasses six villages: Binjai, Denai, Medan Tenggara, Tegal Sari Mandala I, Tegal Sari Mandala II, and Tegal Sari Mandala III. According to research by Girsang et al. (2024), the high population density in Medan Denai District contributes to an increase in dengue fever (DF) cases, which is closely related to the presence of mosquito populations in residential areas.

Vector control in an area requires accurate baseline data to establish effective policies. One method to obtain relevant data is through a survey examining the relationship between residential environmental conditions and the presence of mosquito larvae. This study aims to analyze the relationship between residential environmental conditions and the presence of mosquito larvae that transmit diseases in Medan Denai District, Medan City. The results of this study are expected to provide useful information for the community in raising awareness of the importance of maintaining environmental conditions as a preventive measure against mosquito-borne diseases.

Method

This study used primary data analysis obtained through observation of the environmental conditions of homes and mosquito larvae density using a larvae index. Next, the larvae were identified to determine their species. Data analysis in this study used the Chi-Square method. Sample selection was carried out using the systematic random sampling technique. The population in this study included 33,159 homes in Medan Denai District (BPS Kota Medan, 2023), with a sample size of 300 homes. Larvae identification in the field was carried out by recording the location of the discovery, both in puddles of water in artificial containers. Larvae were collected using a pipette for small containers or a scoop for larger containers. Meanwhile, larvae found in turbid water were collected with the aid of a flashlight. The collected larvae were placed in plastic bags and labeled. In the laboratory, the larvae were killed by immersing them in water at 60°C, then placed on a microscope slide for observation. Identification is based on Rueda (2004) and identification key journals, considering morphological characteristics such as head shape, last abdominal segment, anal segment, and comb structure. Larval density can be determined using various larval indices (HI, CI, and BI) following the guidelines (World Health Organization, 2013), namely:

House Index (HI)

House Index is the percentage of the number of houses where larvae are found to the number of houses randomly inspected (World Health Organization, 2013).

$$\mathrm{HI} = \frac{\text{Number of positive houses}}{\text{Total number of house inspected}} \times 100\ \% \qquad (1)$$

Container Index (CI)

Container index is the percentage of containers found with larvae in a randomly selected number of inspected containers (World Health Organization, 2013).

$$CI = \frac{\text{Number of containers where larvae were found}}{\text{Number of containers checked}} \times 100\ \% \quad (2)$$

Breteau Index (BI)

The Breteau Index is the sum of the percentage of containers containing larvae to the number of randomly selected houses examined (World Health Organization, 2013).

$$BI = \frac{\text{Number of containers where larvae were found}}{\text{Number of houses inspected}} \times 100\ \% \quad (3)$$

Density figure (DF) is a combination of HI, CI and BI expressed on a scale of 1-9 as shown in Table 1.

Table 1. Larva Index

Density figure (DF)	House index (HI)	Container index (CI)	Breteau 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

Source: World Health Organization (2013)

Density criteria are categorized based on the DF value, with details as follows: DF = 1 indicates low density, DF between 2-5 indicates medium density, and DF between 6-9 indicates high density. Based on the results of larval surveys, a Density Figure (DF) can be determined as an indicator of larval density. DF is obtained after calculating the House Index (HI), Container Index (CI), and Breteau Index (BI), then compared with the Larva Index table. DF values of less than 1 indicate a low risk of transmission, while values between 1 and 5 indicate a moderate risk of transmission, and values above 5 indicate a high risk of transmission. In addition, the Key Index is used to identify the type of container most commonly found to contain larvae (Focks, 2003).

Result and Discussion

The results of the study on 300 houses showed that mosquito larvae were found in 72 houses (24%), while the remaining 228 houses (76%) did not show the presence of larvae (Table 2). These findings indicate that nearly a quarter of the total homes inspected have the potential to become mosquito breeding sites. Research conducted by Olagunju (2023) reported that approximately 26.7% of publications identified mosquito breeding sources as originating from man-made containers, tree holes, ponds, waterways, and gutters. Unmaintained environments, including the presence of standing water, also contribute to increased mosquito populations (Cruvinel et al., 2020). The presence of mosquitoes in this study may be linked to poorly maintained environmental conditions, as well as improperly managed water storage areas (WSAs), making these areas potential mosquito breeding sites.

The results presented in Table 3 show that 67 *Aedes aegypti* larvae and 5 *Culex quinquefasciatus* larvae were successfully identified. Based on the results, *Aedes aegypti* larvae were identified in dominant numbers at the study site. In line with the research conducted by Ratnasari et al. (2020), *Aedes aegypti* is known to breed in man-made containers and tends to live around human settlements. This mosquito is found in various water storage sites, such as old boats, water drums, old buckets, and old tires. *Aedes aegypti* belongs to the Culicidae family and is known as an invasive mosquito species with rapid and widespread dispersal capabilities (Paupy et al., 2010; Ratnasari et al., 2020).

Table 2. Larval Presence

Larval Presence	Number (House)	Percentage (%)
Present	72	24.0
Absent	228	76.0
Total	300	100.0

Aedes aegypti mosquitoes serve as the primary vector for the spread of dengue fever, which remains a serious threat in Indonesia. *Aedes aegypti* mosquitoes can breed and survive in tropical and subtropical climates (Hamid et al., 2017). To date, approximately 3,500 mosquito species from the Culicidae family have been identified in tropical climates (Wilkerson et al., 2015).

Table 3. Types of Larvae Encountered

Larval species	Number (larvae)	Percentage (%)
Aedes aegypti	67	93.05
Culex quinquefasciatus	5	6.95
Total	72	100.0

In Table 4, inspections were carried out on 803 water storage containers (TPA) consisting of various types of containers, such as bathtubs, jars or barrels, buckets, water storage tanks, dispensers, used cans, and water storage containers behind refrigerators. The study results indicate that the water storage containers with the highest number of larvae (key containers) were found in the drip collection compartments of dispensers, with 30 positive containers identified.

This finding indicates that dispensers, particularly the drip collection area, are the dominant habitat for mosquito larvae. This may be due to the open nature of the containers and insufficient attention to the removal of standing water by household members. Dispensers are typically located indoors and often overlooked during cleaning activities, making them an ideal environment for mosquito larvae development.

These results align with the research by Nurdin et al. (2023), which states that containers that can hold water and are rarely cleaned have a high potential as breeding sites for *Aedes aegypti* mosquitoes. These mosquitoes are commonly found indoors and utilize man-made containers as egg-laying sites. These containers contribute to the formation of mosquito habitats that play a role in the transmission of various diseases, such as dengue fever, chikungunya, and Zika (Kolimenakis et al., 2021).

The study results showed that no mosquito larvae were found in used cans or in water storage containers behind refrigerators. It is likely that the used cans had recently been discarded by the community, so by the time the study was conducted, the mosquito eggs had not yet developed into larvae. No mosquito larvae were found in the water storage containers behind the refrigerator either. This is likely due to the temperature in that area being unsuitable for mosquito development, as the temperature behind the refrigerator tends to be too high, making the environment unsuitable for mosquito development and reproduction. The optimal temperature for the growth and development of Aedes eggs ranges from 24.5 to 27.5 °C (Hikmawa & Huda, 2021). When the environmental temperature exceeds 35 °C, the mosquito growth process can be inhibited, thereby reducing the likelihood of larval development (Yang et al., 2009).

Table 4. Inspected Water Containers and the Presence of Mosquito Larvae

Type of water container	Number of containers inspected	Number of containers with larvae
Bathroom water storage	114	13
Clay jars/drums	89	7
Buckets	474	21
Water reservoir tank	19	1
Water dispenser	89	30
Used cans	13	0
Refrigerator water tray	5	0
Total	803	72

Based on Table 5, out of 300 houses studied, 117 houses were located in clean environments, while 183 houses were located in unclean environments. The results of this study indicate that the majority of environmental conditions still face hygiene problems.

These issues were determined based on several criteria, including: the presence of uncovered water storage containers outside the house, insufficient efforts to bury or recycle waste, the habit of cleaning the bathtub less than once a week, the accumulation of waste around the house, and the presence of bushes or wild plants in the surrounding environment. Additionally, the absence of window screens or ventilation, the presence of mosquito larvae in bathtubs, the presence of waste in water channels or drains, and the absence of mosquito nets or insect repellent inside homes also indicate low environmental cleanliness.

The assessment was conducted by assigning a score of 2 for each criterion met (answer 'yes') and a score of 1 for those not met (answer 'no'). The environment is categorized as unclean if the total score is more than 14, while if the score is less than or equal to 14, the environment is categorized as clean. Based on the research results, unclean environmental conditions accounted for the highest percentage at 61%, while clean environments only accounted for 39% of the total studied. In line with the research by Hamid & Hamdin (2023), it was reported that the habit of the community to neglect the presence of standing water inside the house, rarely draining stagnant water, and not closing water containers tightly, can be the main factors in providing breeding grounds for *Aedes aegypti* mosquito larvae.

Table 5. Household Environmental Conditions

Environmental condition	Number of houses	Percentage (%)
Clean	117	39
Not clean	183	61
Total	300	100

A total of 300 houses were inspected to observe the Density Figure (DF) and were divided into three groups. The first group included houses 1–100, the second group included houses 101–200, and the third group consisted of houses 201–300.

Group of Houses 1–100

In the group of houses 1–100, the House Index (HI) value obtained was 38%, the Container Index (CI) was 14.56%, and the Breteau Index (BI) was 38%, with the following calculations:

$$\mathrm{HI} = \frac{38}{100} \times 100\% = 38\ \%$$

$$\mathrm{CI} = \frac{38}{261} \times 100\ \% = 14.56\ \%$$

$$\mathrm{BI} = \frac{38}{100} \times 100\ \% = 38\ \%$$

Based on the Density Figure (DF) classification, the HI value is at risk level 6, CI at level 5, and BI at level 5. Thus, the DF value for this group is calculated as:

$$DF = \frac{6+5+5}{3} = 5.3\ \%$$

Housing Group 101–200

In housing group 101–200, the HI value was 16%, the CI was 5.6%, and the BI was 16%, with the following calculation details:

$$HI = \frac{16}{100} = 16\ \%$$

$$CI = \frac{16}{288} = 5.6\ \%$$

$$HI = \frac{16}{100} = 16\ \%$$

All three indicators are at risk level 3. Therefore, the DF value for this group is:

$$DF = \frac{3+3+3}{3} = 3\ \%$$

Housing Group 201–300

In housing group 201–300, the HI value was recorded at 18%, CI at 7.1%, and BI at 18%, with the following calculations:

$$HI = \frac{18}{100} \times 100\% = 18\ \%$$

$$CI = \frac{18}{254} \times 100\ \% = 7.1\ \%$$

$$BI = \frac{18}{100} \times 100\ \% = 18\ \%$$

Based on the DF classification, the HI value is at risk level 4, CI at level 3, and BI at level 3. Therefore, the DF value is calculated as:

$$DF = \frac{4+3+3}{3} = 3\ \%$$

The Density Figure (DF) value of 5.3 found in the 1–100 house group indicates that the area is in the high transmission risk category. Meanwhile, the 101–200 and 201–300 house groups each have a DF value of 3, which is classified as moderate transmission risk. Overall, out of 300 houses inspected, 200 houses (66.7%) fall into the moderate larval density category, while 100 houses (33.3%) show high larval density (Table 6). These findings confirm that most of the studied areas remain in a condition requiring attention, particularly in efforts to prevent dengue transmission through mosquito larvae population control.

Table 6. Mosquito Larval Density

Larval density	Number of houses	Percentage (%)
Moderate	200	66.7
High	100	33.3
Total	300	100

This study shows the distribution of larval density in the study area, which is dominated by the moderate category, but there are still a number of houses with high density levels that have the potential to increase the risk of vector-borne disease transmission. Kolimenakis et al. (2021) reported that the results of 18 previous studies indicated a significant relationship between vector abundance and disease transmission rates. The higher the vector population in an area, the greater the likelihood of disease spread by that vector.

Table 7. Relationship between Environmental Conditions and Larval Density in Medan Denai Sub-District

Environmental condition	Larval density		Total	P
	Moderate	High		
Clean	83 (27.67 %)	34 (11.33 %)	117 (39.00 %)	0.045
Not clean	117 (39.00 %)	66 (22.00 %)	183 (61.0 %)	
Total	200 (66.67 %)	100 (33.33 %)	300 (100 %)	

Based on Table 7, out of a total of 300 houses inspected, 117 houses (39%) had clean environmental conditions, while 183 houses (61%) were classified as unclean. In houses with clean environments, 83 houses (27.67%) were found to have moderate larval density, and 34 houses (11.33%) showed high larval density. Meanwhile, in unclean environments, 117 houses (39.00%) had moderate larval density, and 66 houses (22.00%) experienced high larval density.

The results of the analysis using the Chi-Square test showed a p-value of 0.045 ($p < 0.05$), indicating a significant relationship between the cleanliness of the home environment and the level of larval density. This finding reinforces the hypothesis that environments with poor cleanliness have a higher tendency to support mosquito larval development.

Research by Asryadin et al. (2023) supports this finding, stating that low public awareness of environmental cleanliness can be one of the factors triggering an increase in the *Aedes aegypti* population. The presence of mosquitoes in urban areas is closely related to environmental conditions, particularly in terms of cleanliness. An increase in the volume of non-organic waste, such as discarded containers that can hold water, can create an ideal habitat for mosquito breeding (Mendonça et al., 2009).

The presence of mosquitoes in urban areas is closely related to environmental conditions, particularly hygiene. An increase in the volume of non-organic waste, such as used containers that can hold water, can create an ideal habitat for mosquito breeding (Mendonça et al., 2009). Research by Vikram et al. (2015) and Romeo et al. (2018) states that the poor solid waste management system in the Delhi region, combined with limited access to clean water, encourages the community to store water in containers. This practice indirectly creates environmental conditions that support mosquito development.

The results of this study indicate that household environmental factors, such as cleanliness and the presence of water storage containers that can potentially hold stagnant water, play an important role in determining the density of larvae in the area. Thus, vector control efforts need to focus on improving environmental conditions to reduce the mosquito larvae population and prevent the risk of vector-borne disease transmission.

Conclusion

This study showed a significant relationship between the cleanliness of the home environment and the density of mosquito larvae. Of the 300 houses examined, 24% were found to be positive for larvae, with the distribution of larval density dominated by the medium category (66.7%) and the rest classified as high (33.3%). The highest Density Figure value (5.3) was found in the 1-100 house group, which falls into the high risk category for disease transmission. In addition, houses with unsanitary environments had a greater proportion of moderate and high larval densities than houses with clean environments. Chi-Square test results ($p = 0.045$) reinforced the significant association between environmental hygiene and larval development. This finding confirms that vector control efforts need to focus on environment-based interventions, particularly through improved house hygiene and water reservoir management, to prevent the transmission of mosquito-borne diseases.

Acknowledgments

We would like to thank the Subdistrict Head of Medan Denai for allowing us to conduct the study, the health cadres at the Medan Denai Health Center for their help, and the community of Medan Denai for their cooperation in conducting this study.

Author Contributions

Observation, conducting research, collecting data, analyzing and writing the original manuscript, M.P.; concept, idea, process administration and validation, Y.C.P., L.S., A.H.S., and I.S.S.S. All authors have read and approved the final version of the manuscript for publication.

Funding

We would like to thanks Universitas Sumatera Utara for their support of our research grant by the Grant TALENTA Universitas Sumatera Utara No. 5338/UN5.I.R/PPM/2017.

Conflicts of Interest

The authors declare that there is no competing interest that could inappropriately influence this paper.

References

Adnan, A. B., & Siswani, S. (2019). Peran Kader Jumantik Terhadap Perilaku Masyarakat dalam Upaya Pencegahan Penyakit Demam Berdarah Dengue (DBD) di Wilayah Kerja Kelurahan Tebet Timur Tahun 2019. *Jurnal untuk Masyarakat Sehat (JUKMAS)*, *3*(2), 204-218. https://doi.org/10.52643/jukmas.v3i2.609

Amelinda, Y. S., Wulandari, R. A., & Asyary, A. (2022). The Effects of Climate Factors, Population Density, and Vector Density on the Incidence of Dengue Hemorrhagic Fever in South Jakarta Administrative City 2016-2020: An Ecological Study. *Acta Bio Medica: Atenei Parmensis*, *93*(6). https://doi.org/10.23750/abm.v93i6.13503

Anggraini, T. S., & Cahyati, W. H. (2017). Perkembangan Aedes aegypti pada Berbagai Kondisi pH Air dan Salinitas Air. *HIGEIA (Journal of Public Health Research and Development)*, *1*(3), 1-10. Retrieved from https://journal.unnes.ac.id/sju/higeia/article/view/15165

Asryadin, A., Aqwam, A., Khairunnisa, R., Endang, H. K., Rosita, R., Annas, F., & Hasan, H. (2023). Dengue Hemorrhagic Fever in Bima City: A Study. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4869-4879. https://doi.org/10.29303/jppipa.v9i6.4787

BPS Kota Medan. (2023). *Jumlah Rumah Tangga Menurut Kecamatan (Rumah Tangga), 2016-2019*. Medan: BPS Kota Medan.

BPS Kota Medan. (2024). *Kota Medan dalam Angka*. Medan: BPS Kota Medan.

Braack, L., Almeida, A. P. G. D., Cornel, A. J., Swanepoel, R., & Jager, C. D. (2018). Mosquito-Borne Arboviruses of African Origin: Review of Key Viruses and Vectors. *Parasites & vectors*, *11*, 1-26. https://doi.org/ 10.1186/s13071-017-2559-9

Cruvinel, V. R. N., Zolnikov, T. R., Obara, M. T., Oliveira, V. T. L. D., Vianna, E. N., Santos, F. S. G.

D., & Scott, J. A. (2020). Vector-Borne Diseases in Waste Pickers in Brasilia, Brazil. *Waste Management*, *105*, 223-232. https://doi.org/10.1016/j.wasman.2020.02.001

Costa, E. A. P. D. A., Santos, E. M. D. M., Correia, J. C., & Albuquerque, C. M. R. D. (2010). Impact of Small Variations in Temperature and Humidity on the Reproductive Activity and Survival of Aedes aegypti (Diptera, Culicidae). *Revista Brasileira de Entomologia*, *54*, 488-493. https://doi.org/10.1590/S0085-56262010000300021

Chrostek, E., Hurst, G. D., & McGraw, E. A. (2020). Infectious Diseases: Antiviral Wolbachia Limits Dengue in Malaysia. *Current Biology*, *30*(1), R30-R32. https://doi.org/10.1016/j.cub.2019.11.046

Dhewantara, P. W., Marina, R., Puspita, T., Ariati, Y., Purwanto, E., Hananto, M., Hu, W., & Magalhaes, R. J. S. (2019). Spatial and Temporal Variation of Dengue Incidence in the Island of Bali, Indonesia: An Ecological Study. *Travel Medicine and Infectious Disease*, 32, 101437. https://doi.org/10.1016/j.tmaid.2019.06.008

Drakou, K., Nikolaou, T., Vasquez, M., Petric, D., Michaelakis, A., Kapranas, A., & Koliou, M. (2020). The Effect of Weather Variables on Mosquito Activity: A Snapshot of the Main Point of Entry of Cyprus. *International Journal of Environmental Research and Public Health*, *17*(4), 1403. https://doi.org/10.3390/ijerph17041403

Dwiyanthi, K. L., Setiani, O., & Adi, M. S. (2023). Spatial Analysis of Dengue Hemorrhagic Fever Incidents Distribution and Dengue Virus Detection in Tanjung Priok Sub-District, DKI Jakarta. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 815-821. https://doi.org/10.29303/jppipa.v9iSpecialIssue.5394

Focks, D. A. (2003). *A Review of Entomological Sampling Methods and Indicators for Dengue Vectors*. Geneva: WHO.

Guzman, M. G., & Harris, E. (2015). Dengue. *The Lancet*, *385*(9966), 453-465. https://doi.org/10.1016/S0140-6736(14)60572-9

Girsang, V. I., Harefa, H. S., Siregar, L. M., & Sirait, A. (2024). Kepadatan Penduduk dengan Kejadian Demam Berdarah Dengue di Kota Medan. *Jurnal Keperawatan Cikini*, *5*(2), 224–239. https://doi.org/10.55644/jkc.v6i02.177

Hamid, P. H., Prastowo, J., Ghiffari, A., Taubert, A., & Hermosilla, C. (2017). Aedes aegypti Resistance Development to Commonly Used Insecticides in Jakarta, Indonesia. *PLoS One*, *12*(12), e0189680. https://doi.org/10.1371/journal.pone.0189680

Hamid, A., & Hamdin, H. (2023). Relationship between Mosquito Nest Eradication Behavior and the Habit of Using Mosquito Repellent Against Dengue Hemorrhagic Fever in Pekat Village, Sumbawa District, Sumbawa Regency. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 87-92. https://doi.org/10.29303/jppipa.v9i1.2035

Hikmawa, I., & Huda, S. (2021). *Peran Nyamuk sebagai Vektor Demam Berdarah Dengue (DBD) Melalui Transovarial*. Semarang: Satria Publisher.

Kolimenakis, A., Heinz, S., Wilson, M. L., Winkler, V., Yakob, L., Michaelakis, A., & Horstick, O. (2021). The Role of Urbanisation in the Spread of Aedes Mosquitoes and the Diseases They Transmit—A Systematic Review. *PLoS Neglected Tropical Diseases*, *15*(9), e0009631. https://doi.org/10.1371/journal.pntd.0009631

Karwur, T. G., Bernadus, J. B., & Pijoh, V. D. (2023). Survei Tingkat Kepadatan Jentik Nyamuk Aedes spp. pada Tempat Penampungan Air (TPA) di Kelurahan Paal Dua Kota Manado. *Medical Scope Journal*, *5*(1), 129-135. https://doi.org/10.35790/msj.v5i1.45252

Khan, M. A., Elhossary, S., Khan, I. A., Zahrani, M. H. A., Zahrani, F. S. A., & Bashri, F. M. A. (2018). The Impact of Climatic Variables with GIS Application on the Abundance of Medically Important Mosquitoes (Diptera: Culicidae) in Jeddah, Saudi Arabia. *Int. J. Mosq. Res*, *5*(5), 12-18. Retrieved from https://www.dipterajournal.com/archives/2018/5/5/A/5-3-23

Manulang, C. S., Samino, A. K., & Sari, F. E. (2023). Influence of Community Knowledge and Attitude with Dengue Fever Prevention Behavior (DHF) in the Padang Cermin Health Center Working Area. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4666-4672. https://doi.org/10.29303/jppipa.v9i6.3827

Mendonça, F. D. A., Souza, A. V., & Dutra, D. D. A. (2009). Saúde Pública, Urbanização e Dengue no Brasil. *Sociedade & Natureza*, *21*, 257-269. https://doi.org/10.1590/s1982-45132009000300003

Nurnasari, E., & Djumali, D. (2010). Pengaruh Kondisi Ketinggian Tempat Terhadap Produksi dan Mutu Tembakau Temanggung. *Buletin Tanaman Tembakau, Serat dan Minyak Industri*, *2*(2), 45-59. https://doi.org/10.21082/bultas.v2n2.2010.45-59

Nurdin, N., Martini, M., Raharjo, M., & Husni, S. H. (2023). The Relationship between Mosquito Nest Eradication Practice and The Existence of Larvae Aedes aegypti with Dengue Incidence in Penjaringan District, North Jakarta. *Jurnal*

Penelitian Pendidikan IPA, *9*(10), 8830-8836. https://doi.org/10.29303/jppipa.v9i10.4953

Paupy, C., Ollomo, B., Kamgang, B., Moutailler, S., Rousset, D., Demanou, M., & Simard, F. (2010). Comparative Role of Aedes albopictus and Aedes aegypti in the Emergence of Dengue and Chikungunya in Central Africa. *Vector-Borne and Zoonotic Diseases*, *10*(3), 259-266. https://doi.org/10.1089/vbz.2009.0005

Olagunju, E. A. (2023). Is the Presence of Mosquitoes an Indicator of Poor Environmental Sanitation?. *Journal of Water and Health*, *21*(3), 385-401. https://doi.org/10.2166/wh.2023.280

Ogunlade, S. T., Meehan, M. T., Adekunle, A. I., Rojas, D. P., Adegboye, O. A., & McBryde, E. S. (2021). A Review: Aedes-Borne Arboviral Infections, Controls and Wolbachia-Based Strategies. *Vaccines*, *9*(1), 32. https://doi.org/10.3390/vaccines9010032

Ratnasari, A., Jabal, A. R., Rahma, N., Rahmi, S. N., Karmila, M., & Wahid, I. (2020). The Ecology of Aedes aegypti and Aedes albopictus Larvae Habitat in Coastal Areas of South Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *21*(10). https://doi.org/10.13057/biodiv/d211025

Rueda, L. M. (2004). Pictorial Keys for the Identification of Mosquitoes (Diptera: Culicidae) Associated with Dengue Virus Transmission. *Zootaxa*, *589*(1), 1-60. https://doi.org/0.11646/zootaxa.589.1.1

Romeo-Aznar, V., Paul, R., Telle, O., & Pascual, M. (2018). Mosquito-Borne Transmission in Urban Landscapes: The Missing Link between Vector Abundance and Human Density. *Proceedings of the Royal Society B*, *285*(1884), 20180826. https://doi.org/10.1098/rspb.2018.0826

Sembel, D. T. (2009). *Entomologi Kesehatan*. Yogyakarta: Penerbit Andi.

Simmons, C. P., Farrar, J. J., Nguyen, V., & Wills, B. (2012). Dengue. *The New England Journal of Medicine*, *366*(15), 1423–1432. https://doi.org/10.1056/NEJMra1110265

Sutanto, I., Ismid, I. S., Sjarifuddin, P. K., & Sungkar, S. (2021). *Buku Ajar Parasitologi Kedokteran*. Jakarta: Fakultas Kedoteran Universitas Indonesia.

Schrama, M., Hunting, E. R., Beechler, B. R., Guarido, M. M., Govender, D., Nijland, W., & Gorsich, E. E. (2020). Human Practices Promote Presence and Abundance of Disease-Transmitting Mosquito Species. *Scientific Reports*, *10*(1), 13543. https://doi.org/10.1038/s41598-020-69858-3

Vikram, K., Nagpal, B. N., Pande, V., Srivastava, A., Gupta, S. K., Anushrita, V. P., & Telle, O. (2015). Comparison of Ae. aegypti Breeding in Localities of Different Socio-Economic Groups of Delhi, India. *International Journal of Mosquito Research*, *2*(3), 83-88. Retrieved from https://www.dipterajournal.com/archives/2015/2/3/B/2-2-45

Wahono, T., Widjayanto, D., & Poerwanto, S. H. (2022). Karakteristik Habitat Larva Nyamuk dan Kepadatan Nyamuk Dewasa (Diptera: Culicidae) di Kabupaten Jembrana, Provinsi Bali (Analisis Data Sekunder Rikhus Vektora 2017): Habitat Characteristics of Mosquito Larvae and Density of Adult Mosquitoes (Diptera: Culicidae) in Jembrana Regency, Bali Province (Rikhus Vektora 2017 Secondary Data Analysis). *ASPIRATOR-Journal of Vector-Borne Diseases Studies*, *14*(1). https://doi.org/10.22435/asp.v14i1.5038

Wilkerson, R. C., Linton, Y. M., Fonseca, D. M., Schultz, T. R., Price, D. C., & Strickman, D. A. (2015). Making Mosquito Taxonomy Useful: A Stable Classification of Tribe Aedini that Balances Utility with Current Knowledge of Evolutionary Relationships. *PloS one*, *10*(7), e0133602. https://doi.org/10.1371/journal.pone.0133602

Williams, C. R., Johnson, P. H., Ball, T. S., & Ritchie, S. A. (2013). Productivity and Population Density Estimates of the Dengue Vector Mosquito Aedes aegypti (Stegomyia aegypti) in Australia. *Medical and Veterinary Entomology*, *27*(3), 313–322. https://doi.org/10.1111/j.1365-2915.2012.01051.x

World Health Organization. (2013). *A Review of Entomological Sampling Methods and Indicators for Dengue Vectors*. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/68575/TDR_IDE_DEN_03.1.pdf

World Health Organization. (2012). *Global Strategy for Dengue Prevention and Control 2012-2020*. World Health Organization. Retrieved from https://iris.who.int/handle/10665/75303

Wilson, A. J., Morgan, E. R., Booth, M., Norman, R., Perkins, S. E., Hauffe, H. C., & Fenton, A. (2017). What Is A Vector?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1719), 20160085. https://doi.org/10.1098/rstb.2016.0085

Wirayoga, M. A. (2013). Hubungan Kejadian Demam Berdarah Dengue dengan Iklim di Kota Semarang Tahun 2006-2011. *Unnes Journal of Public Health*, *2*(4). https://doi.org/10.15294/ujph.v2i4.3055

Yang, H., Macoris, M. D. L. D. G., Galvani, K. C., Andrighetti, M. T. M., & Wanderley, D. M. V. (2009). Assessing the Effects of Temperature on the Population of Aedes aegypti, the Vector of Dengue. *Epidemiology & Infection*, *137*(8), 1188-1202. https://doi.org/10.1017/S0950268809002040