JISS
Journal of Indonesian Social Science

Vol. 6, No. 4, April 2025
E-ISSN:2723 – 6692
P-ISSN:2723– 6595
http://jiss.publikasiindonesia.id/

Physical and Chemical Characteristics of Mosquito Larvae Nesting Sites In Belang District, Southeast Minahasa Regency

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KEYWORDS
Physical and chemical characteristics, mosquito larvae habitat, types of larvae;

ABSTRACT
Mosquito larvae are commonly found in tropical areas, including Indonesia, which support the development of diseases such as dengue fever, malaria, and filariasis. Belang District in Southeast Minahasa is an endemic area for malaria with an environment that supports mosquito breeding, such as stagnant water from rivers and garbage. Physical factors such as water temperature and depth, and chemicals such as pH and salinity, affect the growth of larvae. Objective: To study the physical and chemical characteristics of mosquito larval breeding habitats in Belang District. Method: This descriptive study with a cross-sectional approach was conducted in September-January 2025. This study used a purposive sampling technique by identifying the types of mosquito larvae in each habitat and measuring the physical and chemical characteristics of mosquito larval breeding sites. Physical characteristics were analyzed by measuring water temperature and depth, while chemical characteristics included pH and salinity. The study obtained mosquito larvae from the genus Aedes sp, Anopheles sp, and Culex sp. The larval habitat has a water depth of 6-82 cm, a temperature of 28.5°C-38.9°C, a pH of 7.24-8.64, and a salinity of 0-0.63‰. These data show variations in physical and chemical conditions that support the existence of mosquito larvae in the area. Conclusion: Mosquito larvae breeding sites in Belang District have different physical and chemical characteristics. These results emphasize the importance of environmental management to control the mosquito larval population in this area.

Introduction

Mosquitoes are particularly common in tropical regions, including Indonesia, where tropical climates support the development of various diseases, especially those transmitted by mosquito vectors (Windyaraini *et al*., 2020). Three genera of mosquitoes, namely *Aedes, Anopheles,* and *Culex* have special medical significance because they can cause a variety of health problems in humans. Aedes *sp.* mosquitois a vector that transmits Dengue Hemorrhagic Fever (DHF), where the mosquito carries the *dengue* virus which can be transmitted to humans through mosquito bites. Research by (Bernadus et al., 2023), reported that *Aedes aegypti mosquitoes* carry a fairly broad spectrum of viruses, including Negarnarviricota, Nucleocytoviricota, Uroviricota, Artverviricota, Kitrinoviricota, Peploviricota, Phixviricota, and Cossaviricota, which have the potential to cause public health problems. *The female Anopheles mosquito* is the main vector that transmits malaria to humans and other primates (Lempang et al., 2023). Certain *types of Culex* mosquitoes have the ability to transmit diseases to humans, such as filariasis and *Japanese Encephalitis* (JE) (Oktafian & Siwiendrayanti, 2021).

WHO (2023) reported that dengue cases reached an all-time high, with an unexpected surge in cases, recording a record of more than 6.5 million people infected and more than 7,300 people dying. Malaria ranks third as the deadliest disease in the world (Tanaka & Nakabayashi, 2024). In 2023, malaria cases continue to increase to 263 million, while the death rate has decreased again to 597,000. Meanwhile, WHO 2023 data shows that lymphatic filariasis is still a significant global health problem, with more than 657 million people in 39 countries threatened by the disease, with about 51 million people infected in 2018 (Cromwell et al., 2020)

Based on data from the Indonesian Ministry of Health in 2024, there were 119,709 dengue cases recorded in the 22nd week. Meanwhile, a 2021 WHO report recorded 800,000 cases of malaria in Indonesia, placing the country as the second-highest in Southeast Asia and fourth in the world among the largest archipelagic regions. As for lymphatic filariasis, until 2024 its prevalence in Indonesia has decreased significantly (Marina et al., 2024). In 2023, the Central Statistics Agency of North Sulawesi Province reported the number of illnesses per 100,000 population, where dengue hemorrhagic fever (DHF) reached 97.80 cases while malaria reached 0.49 cases. In Southeast Minahasa Regency, there were 35 cases of dengue and 2.47 cases of malaria, making it one of the areas with the highest number of malaria cases (BPS, 2024). This high rate of malaria can be caused by the presence of forests and swamps, both in highlands and lowlands, especially in coastal areas, which are ideal habitats for malaria-transmitting mosquitoes (Sjarkawi *et al*., 2013).

Belang District, is one of the sub-districts in Southeast Minahasa with the largest number of villages reaching 20 villages. Belang District flows the Wewesan River, which can overflow and flood the environment along its path when heavy rain occurs (Lempoy et al., 2023). Another worrying condition is the lack of awareness among residents to maintain cleanliness by not throwing garbage in the river (H. Thomas, 2024). Piles of garbage in the river are one of the habitats of mosquitoes that act as vectors of disease. In addition, garbage that accumulates in the river can also hinder the flow of the river, causing inundation that becomes a breeding ground for mosquitoes (Harviyanto & Windraswara, 2017). In addition, the puddle can contain various kinds of bacteria and viruses that can ultimately harm human health (P. Thomas, 2024).

Autino (2012) in Belang Village shows that the density of mosquito larvae in coastal areas is categorized as moderate, and this area is classified as malaria endemic areas. The latest data supports these findings, with the Molompar Health Center recording 1 case of malaria in March

2023 which increased to 7 cases in October 2024, although there were no cases of dengue fever (DHF) during that period. Meanwhile, in the work area of the Belang Health Center, 2 cases of malaria were recorded in 2020, and dengue cases showed a gradual increase from 1 case in 2020, to 2 cases in 2021, and 4 cases in 2022. This study provides insight that changes in environmental conditions may have an impact on disease vector dynamics, indicating the need for further studies to understand the factors that influence the spread of mosquitoes in this region (Arthur et al., 2017; Ma et al., 2022; Thai & Anders, 2011).

In this study, a more in-depth explanation of the direct impact of mosquito larvae presence on public health is necessary. The accumulation of mosquito larvae in standing water, such as in riverbanks or stagnant ponds, poses significant risks by increasing the likelihood of vector-borne diseases like dengue, malaria, and filariasis. These diseases are primarily transmitted by the mosquitoes' ability to carry harmful pathogens. Malaria, in particular, has been linked to mosquito larvae habitats in areas prone to flooding or poor waste management, which serves as breeding grounds for mosquitoes. This highlights the importance of mosquito vector management, such as controlling larvae habitats and reducing standing water. A comprehensive understanding of the environmental conditions influencing the mosquito life cycle will be essential in informing local governments and health policymakers about effective vector control programs. Such programs may include better waste disposal systems, routine water treatment, and educational campaigns for communities in endemic areas to ensure early detection and intervention of mosquito-related diseases.

The objective of this study is to evaluate the role of mosquito larvae in the transmission of vector-borne diseases and to explore the effectiveness of various vector control methods in reducing disease spread. The benefits of this research include providing actionable recommendations for improving mosquito vector management strategies in areas with high disease incidence. Additionally, this study can inform the development of more effective public health programs that target environmental factors influencing mosquito proliferation, ultimately improving public health outcomes and reducing the burden of mosquito-borne diseases.

Research Method

This type of research uses a descriptive research design with a cross-sectional method conducted in September-December 2024. The research population includes mosquito larvae nesting sites in Belang District, Southeast Minahasa Regency. Sampling of this study uses the Purposive Sampling technique, based on predetermined research criteria. The inclusion criteria in this study are in the form of mosquito larvae nesting sites in Belang District, Southeast Minahasa Regency, covering various locations such as puddles around residential areas, swamps, swamps, wells, sewers, buckets, coastal areas, riverbanks, wastewater, and ponds where mosquito larvae are located, while the exclusion criteria are in the form of mosquito larvae nesting sites that are difficult to reach.

The data used is primary data taken through direct observation and physical examination at the sample location. The research variables measured in this study include water temperature, depth, salinity, and pH, as well as mosquito larval nesting sites. Water temperature, salinity, and pH are measured using the Digilife Water Quality Meter, while the depth of water is measured by dipping a ruler perpendicular to the water until it touches the bottom, then recording it as shown on the ruler scale. The presence of mosquito larvae in nesting sites is observed by observing larvae in transparent containers and identification based on the 2019 Indonesian Ministry of Health Identification Key Pocket Book.

Results and Discussions

This study (Table 1) shows that each type of mosquito larvae has different physical habitat preferences, particularly in terms of water temperature and depth. Based on Table 1, Aedes sp larvae are found in habitats with temperatures ranging from 28.5–33.0°C and depths of 14–82 cm. This temperature range indicates that Aedes sp larvae prefer relatively stable temperatures in the tropics, both in shallow and deeper habitats, such as artificial containers or natural waterlogs.

Anopheles sp larvae are found in habitats with slightly higher temperatures, i.e. 29.3–35.3°C, and with much shallower water depths, between 7–13 cm. This preference indicates that Anopheles sp tends to breed in shallow puddles with warmer conditions, such as rice paddies or shallow swamps.

In contrast, Culex sp larvae show a wider tolerance to physical variations in habitat. Culex sp can live in environments with temperatures of 28.6–38.9°C and depths of 6–62 cm. This range reflects the adaptability of Culex sp to various types of habitats, both natural such as swamps and artificial ones such as ditches and water containers.

Overall, the water temperature at the mosquito larvae breeding site in Belang District ranges from 28.5–38.9°C, with a water depth between 6–82 cm. These variations suggest that physical environmental conditions, particularly water temperature and depth, greatly influence the distribution and habitat preferences of mosquito larvae. This information is critical for environment-based vector control, especially in determining habitat management priorities to minimize the risk of disease spread.

Table 1. Physical characteristics of mosquito larvae nesting sites

Larvae	**Physical Characteristics**	
	Temperature (°C)	**Height (cm)**
Aedes	28.5-33.0	14-82
Anopheles	29.3-35.3	7-13
Culex	28.6-38.9	6-62

Table 2. Chemical characteristics of mosquito larvae nesting sites

Larvae	**Chemical Characteristics**	
	pH	**Salinity (**ppm)
Aedes	7.69-8,64	0.0-0.03
Anopheles	8.21-8.48	0.0-0.63
Culex	7.24-8.55	0.0-0.63

Based on the results of this study (Table 2), it is shown that the chemical characteristics of mosquito larvae nesting sites in Belang District include variations in pH values and water salinity.

Aedes sp **larvae** are found in habitats with a pH ranging from 7.69–8.64, showing a preference for slightly alkaline water. The salinity of water in the habitat of Aedes sp is very low, ranging from 0.0–0.03 ppm, which suggests that this species prefers freshwater habitats with minimal salt content, such as standing water in artificial containers or uncontaminated natural environments.

Anopheles sp **larvae** live in habitats with a narrower pH, i.e. 8.21–8.48, also in the slightly alkaline range. Salinity in this habitat varies more widely, from 0.0 to 0.63 ppm. This indicates the tolerance of Anopheles sp to environments with higher salt content, such as swamps or rice fields with little exposure to brackish water.

Meanwhile, Culex sp **larvae** have a wider tolerance to pH, namely 7.24–8.55, and a salinity of 0.0–0.63 ppm. This reflects the adaptability of Culex sp to breed in a wide variety of habitats, including more alkaline and higher salt waters, such as ditches or wastewater puddles.

Overall, the pH value of mosquito larvae nesting sites in Belang District ranges from 7.24–8.64, which indicates that all types of mosquito larvae prefer habitats with neutral to slightly alkaline water. Water salinity varies from 0.0 to 0.63 ppm, with Aedes sp larvae showing the lowest tolerance to salinity. This information provides the basis for more effective mosquito control through water quality management in breeding habitats.

Table 3. Distribution of genus larvae by breeding site

Larvae	**Breeding Site**
Aedes	Bucket, Barrel, Toren
Anopheles	Swamp, Rice Field
Culex	Field puddles, Roadside, Broken boat, Pond, Rice field, Gutter, Swamp, Sewage

This study (Table 3) shows that the types of mosquito larvae in Belang District have differences in nesting site preferences. Aedes sp **larvae** tend to breed in artificial nesting sites such as buckets, barrels, and toren. These places are usually around human settlements, suggesting that Aedes sp has a preference for artificial containers filled with clean water. This type is known as a vector of dengue hemorrhagic fever (DHF), so the management of artificial containers is very important for its control.

Anopheles sp **larvae** are found in natural habitats such as swamps and rice fields. These places provide clean, shallow water, and support the life cycle of Anopheles larvae. Given that Anopheles is a vector of malaria, management of swamps and rice fields that have the potential to become breeding grounds can help prevent the spread of this disease.

Meanwhile, Culex sp **larvae** have the most diverse habitat preferences, including standing water in fields, roadsides, broken boats, ponds, rice paddies, sewers, swamps, and sewage. This shows that Culex sp has a high adaptability to various types of habitats, both natural and artificial, as well as tolerance to varied water quality. This species is often associated with filariasis and Japanese encephalitis, so habitat control of Culex sp requires a broader approach, encompassing both natural and artificial environments.

Overall, these data show that mosquito larvae nesting preferences are influenced by habitat type and water quality. This information is very important in determining environmentally-based mosquito control strategies, such as waste management, waterlogging drainage, and cleaning of artificial containers to reduce mosquito populations in the Belang District area.

Temperature

The study identified three genus of mosquitoes, Aedes, Anopheles and Culex. Based on the results of this study (table 1), it can be seen that in each of the physical characteristics of water and water chemistry, the mosquito larvae found are different. Water temperatures have different resistance ranges in different habitats. Reinhold et al. (2018) stated that Aedes mosquito larvae can survive at temperatures of 16°C to 34°C, with optimal growth at 32°C.59 The results show that this type of mosquito larvae were found with temperature observations of 28.5-33°C These results are in accordance with the literature that Aedes mosquito larvae can grow in habitats with such temperature ranges. Anopheles Mosquito larvae are also found with a temperature of 29.3-35.3°C These results show that *Anopheles larvae* have good adaptability, as they are able to survive in the temperature range of 29.3-35.3°C. These findings support Agyekum (2021), which states that *Anopheles larvae* are able to survive at temperatures of 10-40°C, but these larvae grow optimally at 27°C ((Agyekum et al., 2021). Culex mosquito larvae are found with a water temperature of 28.6-38.9°C. This suggests that *Culex larvae* can survive a fairly wide temperature range, from 28.6-38.9°C, reflecting the adaptability of this species to environmental temperature variations. Ciota (2014) examined the influence of temperature on the life cycle characteristics *of Culex* mosquitoes (Pinheiro & Corber, 2016). The results showed that *Culex larvae* can survive in the temperature range of 10-40°C, with the optimal temperature for growth being in the range of 25-27°C (Ciota et al., 2014). The temperature tolerance of each genus of mosquitoes varies, depending on the species, as each species has a different response to changes in habitat temperature (Agyekum *et al*., 2021; Ciota *et al*., 2014).

Depth

According to Ustiawaty (2022), Aedes mosquito larvae are generally found at depths of 8-20 cm. This type of mosquito larvae prefer clear, shallow habitats, such as puddles on the banks of rivers, water reservoirs, or in other places that do not flow. The results of observations (Table 1) of Aedes mosquito larvae at a depth of 14-82cm. However, the results of these observations do not fully match the findings, as some *Aedes* larvae are still found at greater depths. Nonetheless, these habitats are likely still favored by *Aedes* larvae because they are in non-flowing locations, which provide stable and protected conditions (Grech *et al*., 2019). Anopheles mosquito larvae in (Table 1) were found with a water depth of 7-13 cm Ustiawaty (2022) identified the types of mosquito larvae that are often found at a depth of 10-40 cm in non-flowing places such as rice fields and other vegetated places. The results of the study show results that are in accordance with the literature. However, this finding found *Anopheles* larvae at a depth of 4 cm, This indicates a difference in the optimal depth preferences of *Anopheles* larvae depending on their habitat conditions (Ustiawaty, 2022). In (Table 1) the water depth of Culex mosquito larvae was found to be 6-62cm Noori (2015) stated that Culex mosquito larvae can be found at water depths of more than 30 cm, especially in cloudy and clear water habitats (Nori *et al*., 2015). However, observations made by Ustiawaty (2022) show that these larvae *Culex* are also able to survive in habitats with a depth of less than 30 cm. The results show that the water depth varies (Syukur, 2021).

PH

Research by Ratnari *et al*. (2020), reported that Aedes mosquito larvae in coastal areas of South Sulawesi can grow and develop up to pH 9 (Ratnasari *et al*., 2025). This was also found in this study (Table 1). This indicates that the water in the area tends to be neutral towards the base. Research by Lempang (2023), also reported that the habitat where *Anopheles* larvae roost in Southeast Sulawesi has a pH ranging from 8 to 10 (Lempang *et al*., 2023). This is in line with the results found in this study, namely pH 8.21-8.48 indicating neutral towards alkaline. The results

(Table 1) found from the larval genus *Culex* are with a pH of 7.24 -8.55. Grech et al. (2019) Culex larvae are also reported to be found in waters with a pH ranging from 3-11.

Salinity

The results of observations (Table 2) show that the salinity of the breeding habitat ranges from 0 ‰ to 1 ‰. This shows that the habitat of the observed mosquitoes is in fresh waters. These results are in line with the research of Tallan and Mau (2016), who reported similar results (Daya *et al*., 2016). However, Purnamasari et al. (2017) reported that Aedes mosquito larvae can survive in higher salinity ranges, even reaching 20‰ Purnamasari & Kadir, 2016). Anopheles mosquito larvae from the research of Anasis (2014) have a fairly high salinity tolerance of up to 30‰ (Purnamasari & Kades). Meanwhile, observations made by Ustiawaty et al. (2022), Culex mosquito larvae have low salinity tolerance, higher salinity levels can inhibit and reduce the population density of these larvae (Ustiawaty *et al*., 2022).

This study (Table 3) shows that Aedes mosquito larvae are found in inundation-shaped habitats in containers, such as buckets and barrels. This type of larva prefers clear, not too deep habitats, such as puddles on the banks of rivers, water reservoirs, or other places that do not flow (Ustiawaty *et al*., 2022). Furthermore, *Anopheles* mosquito larvae were found in nesting places where there was vegetation. These larvae are more often found in waters that do not flow, both in rice fields and in other vegetated places (Ustiawaty *et al*., 2022). Finally, the larvae of *the Culex mosquito* are found in somewhat murky habitats, such as field water and wastewater. These larvae can be found in a variety of habitats, including dirty puddles, ditches, and rice paddies (Ustiawaty *et al*., 2022).

Conclusion

The findings from this study indicate that the physical and chemical characteristics of mosquito larvae habitats in Belang District, Southeast Minahasa Regency, such as water temperature (27.4–38.9°C), depth (6–82 cm), pH (7.2–48.64), and salinity (0–63‰), support the development of disease-transmitting mosquitoes. These environmental conditions are favorable for the breeding of vectors like Aedes, Anopheles, and Culex, which are responsible for spreading diseases such as dengue, malaria, and filariasis. Given the increasing incidence of mosquito-borne diseases in this region, immediate action is necessary to control mosquito proliferation.

Practical recommendations include the implementation of systematic water management practices, such as regular drainage of standing water in residential and public areas, covering water storage containers, and improving river cleanliness by preventing waste accumulation. Local governments and community stakeholders must collaborate to establish routine larvicide application programs and promote environmental education campaigns to raise public awareness about the importance of eliminating breeding sites. For future research, it is suggested to explore the seasonal variations in larval population dynamics and correlate them with disease incidence to inform more precise vector control strategies. Additionally, studies focusing on community behavior and the effectiveness of local vector control programs could provide deeper insights into sustainable mosquito management. Investigating the genetic resistance of local mosquito populations to larvicides could also be a valuable contribution to vector control efforts in endemic areas.

REFERENCES

Agyekum, T. P., Botwe, P. K., Arko-Mensah, J., Issah, I., Acquah, A. A., Hogarh, J. N., Dwomoh, D., Robins, T. G., & Fobil, J. N. (2021). A systematic review of the effects of temperature on Anopheles mosquito development and survival: implications for malaria control in a future warmer climate. *International Journal of Environmental Research and Public Health*, *18*(14), 7255.

Anasis, A. M., Setyaningrum, E., & Suratman, S. (2014). Studi Ekologi Tempat Perindukan Vektor Malaria di Daerah Rawa Desa Lempasing Kecamatan Padang Cermin Kabupaten Pesawaran Propinsi Lampung. *Jurnal Ilmiah Biologi Eksperimen Dan Keanekaragaman Hayati (J-BEKH)*, *2*(1), 10–15.

Arthur, R. F., Gurley, E. S., Salje, H., Bloomfield, L. S. P., & Jones, J. H. (2017). Contact structure, mobility, environmental impact and behaviour: the importance of social forces to infectious disease dynamics and disease ecology. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1719), 20160454.

Autino, B., Noris, A., Russo, R., & Castelli, F. (2012). Epidemiology of malaria in endemic areas. *Mediterranean Journal of Hematology and Infectious Diseases*, *4*(1), e2012060.

Bernadus, J. B. B., Pelealu, J., Kandou, G. D., Pinaria, A. G., Mamahit, J. M. E., & Tallei, T. E. (2023). Metagenomic Insight into the Microbiome and Virome Associated with Aedes aegypti Mosquitoes in Manado (North Sulawesi, Indonesia). *Infectious Disease Reports*, *15*(5), 549–563.

Ciota, A. T., Matacchiero, A. C., Kilpatrick, A. M., & Kramer, L. D. (2014). The effect of temperature on life history traits of Culex mosquitoes. *Journal of Medical Entomology*, *51*(1), 55–62.

Cromwell, E. A., Schmidt, C. A., Kwong, K. T., Pigott, D. M., Mupfasoni, D., Biswas, G., Shirude, S., Hill, E., Donkers, K. M., & Abdoli, A. (2020). The global distribution of lymphatic filariasis, 2000–18: a geospatial analysis. *The Lancet Global Health*, *8*(9), e1186–e1194.

Harviyanto, I. Z., & Windraswara, R. (2017). Lingkungan Tempat Perindukan Nyamuk Culex quinquefasciatus di Sekitar Rumah Penderita Filariasis. *HIGEIA (Journal of Public Health Research and Development)*, *1*(2), 131–140.

Lempang, M. E. P., Permana, D. H., Asih, P. B. S., Wangsamuda, S., Dewayanti, F. K., Rozi, I. E., Syahrani, L., Setiadi, W., Malaka, R., & Muslimin, L. (2023). Diversity of Anopheles Species and zoonotic malaria vector of the Buton Utara wildlife sanctuary, Southeast Sulawesi, Indonesia. *Malaria Journal*, *22*(1), 221.

Lempoy, I. R., Jansen, T., & Supit, C. (2023). Analisis Pengaruh Backwater Di Muara Sungai Wawesen Kecamatan Belang Kabupaten Minahasa Tenggara. *Jurnal Teknik Sipil Terapan*, *5*(2), 80–92.

Ma, J., Guo, Y., Gao, J., Tang, H., Xu, K., Liu, Q., & Xu, L. (2022). Climate change drives the transmission and spread of vector-borne diseases: an ecological perspective. *Biology*, *11*(11), 1628.

Marina, R., Manalu, H. S. P., Letelay, A. M., Rokhmad, M. F., & Isnani, T. (2024). Inovasi program pengendalian malaria menuju eliminasi malaria di Kabupaten Fakfak, Papua Barat: Malaria Control Program Innovation Towards Malaria Elimination in Fakfak District, West Papua. *ASPIRATOR-Journal of Vector-Borne Diseases Studies*, *15*(1), 9–22.

Noori, N., Lockaby, B. G., & Kalin, L. (2015). Larval development of Culex quinquefasciatus in water with low to moderate. *Journal of Vector Ecology*, *40*(2), 208–220.

Oktafian, M., & Siwiendrayanti, A. (2021). Karakteristik Tempat Perindukan Nyamuk Culex sp. di Sekitar Tempat Tinggal Penderita Filariasis Limfatik di Kabupaten Brebes Tahun 2020. *Indonesian Journal of Public Health and Nutrition*, *1*(1), 133–141.

Pinheiro, F. P., & Corber, S. J. (2016). Global situation of dengue and dengue haemorrhagic fever, and its emergence in the Americas. *World Health Statistics Quarterly*, *50*, 161–169.

Syukur, A. (2021). *Buku Pintar Penanggulangan Banjir*. DIVA PRESS.

Tanaka, H., & Nakabayashi, M. (2024). 18. Ministry of Health, Labour and Welfare. In *Handbook of Japanese Public Administration and Bureaucracy* (pp. 320–335). Amsterdam University Press.

Thai, K. T. D., & Anders, K. L. (2011). The role of climate variability and change in the transmission dynamics and geographic distribution of dengue. *Experimental Biology and Medicine*, *236*(8), 944–954.

Thomas, H. (2024). *Occupational and activity analysis*. Taylor & Francis.

Thomas, P. (2024). *Bacteria and Viruses*.

Ustiawaty, J. (2022). Identifikasi jenis larva nyamuk sebagai vektor penyakit dan karakteristik habitatnya di Desa Penimbung Kecamatan Gunung Sari Lombok Barat. *Media of Medical Laboratory Science*, *6*(1), 23–30.