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Effectiveness of Rambutan Leaf Soaking in Controlling Malaria Vectors After Earthquakes

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Abstract: After the earthquake that occurred on the island of Lombok during August 2018 malaria appeared again. The purpose of this study was to determine malaria infection and control of *Anopheles sp* with Rambutan leaves. The research method uses analytical observation for malaria infection and an experimental with completely randomized design for *Anopheles sp.* control using natural ingredients, namely rambutan leaves . The population and sample were suspected malaria and *Anopheles sp* larvae in the working area of the Penimbung Public Health Center in West Lombok District affected by the earthquake. Results of malaria examination studies with RDT/malaria sticks 13% positive for malaria, whereas microscopically 25% positive for malaria. Laboratory test results with rambutan leaf soaking concentrations of 1%, 3%, 6%, 9% and 12% were obtained the higher the concentration the more effective the killing power against larvae of *Anopheles sp*, with LC^{50}12.353% and LC^{90}19.666%. Field test results no larvae in the cupak with the soaking of rambutan leaves. Conclusion, 25% of the population affected by the earthquake were infected with malaria, the most common being plasmodium falciparum, soaking rambutan leaves is effective for controlling Malaria vectors in laboratorium and fields.

Keywords: Anopheles sp; Malaria; Rambutan Leaves

Introduction

Malaria continues to cause unacceptably high levels of disease and death. According to the latest report, there were an estimated 229 million cases and 409.000 deaths globally in 2019 (WHO, 2021). WHO continues to unequivocally support the goal of malaria eradication. The world can achieve the health-related Sustainable Development Goals and eradicate malaria (World Health Organization, 2020).

As regards malaria in Indonesia, 10.7 million people live in moderate to high endemic areas, namely Papua, West Papua, and East Nusa Tenggara. Of 514 districts/cities in Indonesia, in 2017, 266 (52%) were malaria-free, 172 (33%) were low endemic, 37 (7%) were moderate endemic, and 39 (8%) were high endemic areas. The Indonesia Government, notably the Ministry of Health (MoH), make an advance in malaria eliminating efforts envisaged to be succeeded in 2030.

In 2016, malaria had been eliminated in 247 districts/cities, from the target of 245 districts/cities. According to the result of malaria evaluation monitoring in district in West Nusa Tenggara on March 28th-31st, 2016, districts where malaria had not been eliminated agreed that the period of 2018-2019 was the target year of the certification of malaria elimination in all West Nusa Tenggara districts/cities, covering Lombok Barat.

In 2018 there were a series of earthquakes on Lombok Island. An earthquake is a sudden release of seismic wave energy. Lombok Island is an active seismic zone that has the potential to experience earthquakes tectonik because of its proximity to two earthquake prone areas in the south and north. the light damage dominated in East Lombok Districts, the moderate

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damage is on Mataram City and it dominated in West Lombok Districts. The heavy damage present in the most parts of West Lombok Districts. Historically, Lombok Island has been 12 destructive and significant earthquakes inperiod of 1979 –2018. Therefore, the island is in an earthquake-prone region. The hazard factor is one of the key factors in assessing risk. The main earthquake Mw 6.90 (05/08/2018) had the most magnitude and could significantly contribute to the appearance of seismic anomalies (Bunaga et al., 2022; Kanata et al., 2024; Ridwan et al., 2021).

And yet, as the post effect of earthquakes in Lombok in August 2018, malaria reappeared and afflicted several areas, particularly in Lombok Barat. Hence, on September 1^{2th}, 2018, the Lombok Barat local government declared the status of Extraordinary Case (KLB) of malaria in its regions. There were reportedly 137 people, encompassing infants and pregnant women, who had been transmitted with malaria (Rachmawati, 2018). MoH RI argued that refugee areas, principally Bukit Tinggi Gunung Sari, in Lombok Barat West Nusa Tenggara were malaria endemic. Some case controlling efforts made were immediate malaria medicine administration after a diagnose, epidemiological investigation, Mass Blood Survey (MBS), household contact check, insecticide-treated mosquito net provision, and antimosquito (repellent) administration.

Vector control is a vital component of malaria prevention, control and elimination strategies because it can be highly effective in providing personal protection and/or reducing disease transmission. The regular application of biological or chemical insecticides to water bodies (larviciding) was recommended as a supplementary intervention in areas where high coverage with a core intervention has been achieved (OMS, 2019).

The use of synthetic insecticides including organophosphates, carbamates, and pyrethroids has to be regulated given that the development of insecticide resistance is widespread. There is concern regarding the damage to the environment and effects on non-target organisms. The limitations of traditional insecticide-based strategies, particularly the development of insecticide resistance, have resulted in significant efforts to develop alternative eco-friendly methods (Benelli et al., 2016; Liu, 2015; Naqqash et al., 2016; Ranson & Lissenden, 2016)

A diversity of plants have been reported with insecticidal compounds and the use of products of plants origin to control mosquito larvae has been shown to be an exciting alternative to traditional methods of larval controlling, as they are not associated with the problems (Khader et al., 2018) . Some medicinal plants contain aromatic essential oils and compounds that can act as mosquito repellents and larvicides. These essential oils and compounds are usually produced by plants for protection against microorganisms and other harmful organisms (Astuti et al., 2023; Neelawala et al., 2019). The discovery of insecticidal activity of phytotoxins present in Asteraceae species has stimulated the search for new plant-derived insecticides (Tarwish et al., 2017).

Research result on larvicidal potentials of three indigenous plants (*Calotropis gigantean* fruits, *Aframomum melegueta* fruits *and Blighia sapida* seeds) against Malaria vector *Anopheles gambiae L. Aframomum melegueta* was the most potent plant (Aina et al., 2021). A review of the literature in the last five years showed 52 compounds had been tested for mosquito larvicidal activity against malaria mosquitoes. Most of the studies were focused on plants (70%), followed by bacteria (17%) and then fungi (13%) (Milugo et al., 2021).

Rambutan leaves (*Nephelium lappaceum L.*) contain tannin compounds, saponins. Saponins are destroying red blood cells through the reaction of hemolysin, are toxic to cold-blooded animals, including cold-blooded insects, one of the insects that often interfere with human life is mosquitoes (Fajriansyah, 2019).

Due to the Extraordinary Case status of Malaria in 2018 in post-earthquake shelters in Lombok Barat, specifically in Penimbung Community Health Center, it is critical for conducting studies of malaria infection and *Anopheles sp.* control using natural medicinal ingredients. Lombok Barat is rich in such ingredients, e.g., rambutan plants, which can be used as a larvicide.

Method

Research methods with analytical observational research design for malaria infection and experiments to test the effectiveness of the killing power of rambutan leaves in the laboratory and field in controlling *Anopheles sp*. The population and sample were suspected malaria and *Anopheles sp* larvae in the working area of the Penimbung Public Health Center in West Lombok District affected by the earthquake. Descriptive analysis of malaria infection research results. The effectiveness test of rambutan leaf soak in the laboratory with *Probit* analysis. Field test of larvicide effectiveness using soaked rambutan leaves with descriptive analysis.

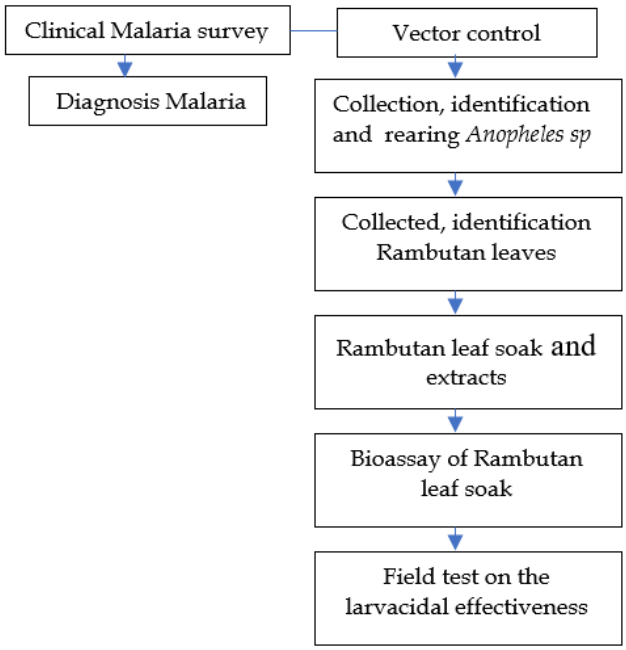

Figure 1. Research flow

Clinical Malaria Survey and Diagnosis

A clinical malaria survey was conducted in earthquake-affected malaria endemic areas close to Penimbung Community Health Center Lombok Barat. It was executed using data from Penimbung Community Health Center and interviews to determine research subjects, who were patients with suspected malaria, by criteria.

Malaria diagnosis was performed on patients with suspected malaria in earthquake-affected malaria-endemic areas close to Penimbung Community Health Center Lombok Barat using a malaria stick (rapid diagnostic test). Further confirmed by microscopic examination at the Penimbung Community Health Center Laboratory.

Collection, identification and rearing Anopheles sp

Anopheles sp. breeding places in earthquake-affected malaria-endemic areas close to Penimbung Community Health Center Lombok Barat were surveyed to find malaria transmission sources. Collection of eggs and larvae *Anopheles sp* from *cupak (palm sugar molds)* people's house. Both the eggs and the larvae were rearing and identification in Research and Development Installation General Hospital West Nusa Tenggara Province.

Collected Rambutan leaves and identified

Rambutan leaves were collected from working area of Penimbung Community Health Center Lombok Barat and identified at advance Biology laboratory, Faculty of Math and Science, Mataram University.

Rambutan leaf soak and extracts

Rambutan leaf soak or Rambutan leaf infusion were made by soaking fresh leaves in jars of tap water. Each jar were filled with 1 liter of tap water. Fresh rambutan leaves were weighed according to concentration Rambutan leaf soak that has been determined before cutting into small pieces and put into each jar (1%, 3%, 6%, 9% and 12%).

Rambutan leaf extract as a positive control with an effective concentration of 0.8% were made in the Analytic laboratory of Universitas Mataram using a maceration method (Asiah et al., 2009). Rambutan leaves were dried at room temperature (28˚- 29˚ C) for 2 days (48 hours) then made simplicia to get 100 grams of simplicia.Rambutan leaf simplicia was soaked in 1 L 96% ethanol solution for 3 days then filtered through filter paper. The residue was macerated once again then the filtrate was concentrated again with a rotary evaporator at a temperature of 40˚C (Abubakar & Haque, 2020).

Bioassay of Rambutan leaf soak

Twenty five active third instar larvae of the *Anopheles sp* were transferred into test bowl containing 100 ml fresh water and 1 ml from each graded concentrations Rambutan leaf soak was added. Negatif control was tap water without any addition. After 24 hour exposure, larval mortality was recorded. Five replications to acquire LC50 and LC90 (Waldetensai, 2019). Probit Analysis was carried out using the SPSS program.

Field Test on the Larvicidal Effectiveness

The field test on larvicidal effectiveness of rambutan leaf extracts was conducted in the breeding places of *Anopheles sp.*, namely cupak (palm sugar molds) soaking sites. The field test was carried out by soaking 12 rambutan leaves which were estimated to weigh 12 grams in a small bucket that was given two liters of water with two cups. Then the bucket was observed for 7 days according to the mosquito life cycle

Result and Discussion

The malaria infection diagnosis was performed after the clinical malaria survey to collect data in areas surrounding Penimbung Community Health Center, which were two earthquake-affected malaria-endemic villages, i.e., Bukit Tinggi and Penimbung. The diagnosis targets were 100 patients with fever (≥ 40^{o}C). The diagnosis result is shown in Tables 1.

The malaria diagnosis was undertaken using the RDT method with a malaria stick and the microscopic method with thick smears and drops. A difference of 12% in the diagnosis result was figured out especially in *Pl falciparum* identification.

The *Anopheles sp.* control test using a natural ingredient, namely rambutan leaf soak, was carried out using laboratory and field tests. The result of *Anopheles sp.* control laboratory test using rambutan leaf soak was exhibited in Table 2.

Table 1. The Post-earthquake Malaria Diagnosis Result

Test Method	Test Result				qty	%
	Positive		Negative			
	qty	%	qty	%		
RDT	13 (Pf=8, Pv=2, Mix=3)	13	87	87	100	100
Microcopic	25 (Pf=20, Pv=2, Mix=3)	25	75	75	100	100

The laboratory result test of *Anopheles sp.* control using rambutan leaf soak indicated that the higher the concentration, the higher the larva mortality mean. The probit analysis result manifested that concentrations of rambutan leaf extracts had an effect on the *Anopheles sp.* larva mortality mean at a significance value of 0.000 < α 0.05. It also pointed out a Lethal Concentration 50 of 12.353% and LC 90 of 19.666%.

The field test, carried out by soaking rambutan leaves into cupak, presented neither *Anopheles sp.* eggs nor larvas. Malaria is an acute fever disease, whose symptoms appear in 10-15 days after a non-immune individual is bitten by an infected mosquito. Early symptoms of malaria, i.e., fever, dizziness, and chills, are mild and hence unidentifiable. If not treated within 24 hours, *P. falciparum* malaria might develop into a fatal severe disease (Anam et al., 2019).

Table 2. Test Result of *Anopheles sp.* Control Using Rambutan Leaf soak

Concentration/Treatmen %	Replication					Larva mortality mean	
	1	2	3	4	5	quantity	%
1	1	1	2	0	0	0.8	3.2
3	3	1	4	2	2	1.4	5.6
6	4	2	2	3	2	1.6	6.4
9	3	3	3	2	4	3	12
12	16	15	14	15	15	15	60
Control (+)	25	25	25	25	25	25	100
Control (-)	0	0	0	0	0	0	0

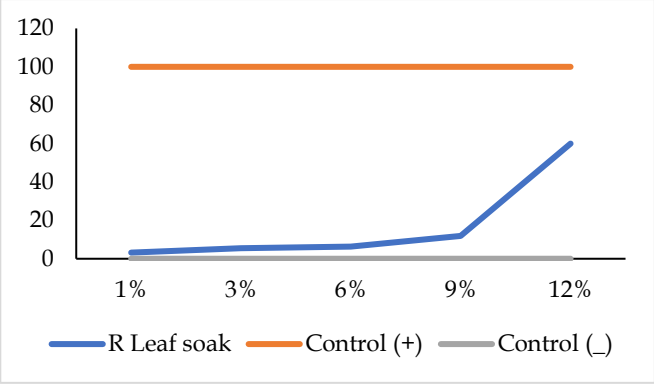

Figure 2. Graphic of Test Result of *Anopheles sp.* Control Using Rambutan Leaf soak

Anopheles mosquitoes are prevalent vectors in several regions in Indonesia. Factors related to the life cycle influence the transmission potential of the malaria vector Anopheles sp. Mosquito vectors transmit pathogens during the incubation period and needs blood feeding. So the vector capacity of mosquitoes depends on increasing the number of mosquito bites (Iacovidou et al., 2022; Izzatinnisa & Utami, 2020).

Natural disasters, such as earthquakes, tsunamis, and typhoons, may breed increased incidents of communicable diseases. For example, earthquakes frequently bring about conditions of a dramatic increase in insects, nuisance, and diseases, covering malaria. The 1983 earthquake in Ecuador increased the incidence of malaria by seven times. 61 malaria cases occurred in November 2010-February 2011 after an earthquake with the force of 7.0 magnitude of the Richter scale shook Leogane Haiti. In addition, of 255 patients with similar fever, 76 (29.8%) were diagnosed with *Plasmodium falciparum* (Feng et al., 2016).

An earthquake disaster is an event that causes various damage and loss of life. Lombok Barat, one of the districts in West Nusa Tenggara, suffered from severe impacts, namely collapsed buildings, due to non-stop earthquakes which shook Lombok in 2018 (Amin et al., 2022). The incident re-brought malaria infections into existence, even Lombok Barat was declared for an Extraordinary Case status when there were reportedly 137 malaria-infected residents, encompassing infants and pregnant women (Rachmawati, 2018).

As shown in data from Penimbung Community Health Center in Penimbung, one of the impacted villages in Lombok Barat, in 2018, there were 8,933 clinical malaria cases. 754 cases were declared positive, and most cases came about in Bukit Tinggi.

The malaria diagnosis in 100 research subjects in Penimbung Community Health Center using the RDT method showcased 13 positive patients (13%): eight

patients with *Pl. falciparum*, two patients with *Pl. vivax*, and three patients with mixed *Pl. falciparum* and *Pl. vivax*. Moreover, the microscopic test, which is considered the gold standard for the diagnosis of malaria, demonstrated 25 positive patients (25%): 20 patients with *Pl. falciparum*, two patients with *Pl. vivax*, and three patients with mixed *Pl. falciparum* and *Pl. vivax*.

According to the malaria sequence, API (Annual Parasite Incidence), the figure of 25% or 2.5% belongs to the middle incidence area. In 2014-2016, Lombok Barat had an API of < 1/100 populations, which boosted the urgency of the manifestation of 2018 malaria elimination in the district. Malaria elimination is aimed at desisting local malaria transmission within a certain geographical area. Accordingly, there may be still malaria cases in a certain area but they are imported cases. The infected mosquitos might still be around, and hence health workers, the government, and the community should remain vigilant to avert another transmission.

The survey of *Anopheles sp*. breeding places in Bukit Tinggi Lombok Barat demonstrated broods located around community residences, especially in untreated *cupak* (a cut bamboo to mold palm sugar) soaking sites. Rivers or springs where *Anopheles sp*. might breed were deep located in forests and ravines.

Malaria vectors that breed in the hills or forests are An.balabacensis, An.bancrofti, An.punculatus, and An.umbrosus. Whereas for coastal areas or river basins, the types of malaria vectors found are An. flavirostris, An.koliensis, An.ludlowi, An.minimus, An.punctulatus, An.parangensis, An.sundaicus, and An.subpictusAnopheles vagus was the most abundant species found in both inland and mountain. The species of Anopheles captured per hour in the inland and mountain were A. vagus and A. Nigerrimus, respectively. The diversity index of Anopheles spp in the inland (H=1.32) was higher than in the mountain (0.53) (Rahayu et al., 2023; Udin et al., 2016)

Results study Flatie B.T and Munshea A., the odds of malaria infection in individuals who had poor knowledge and poor practice were 26.93 and 13.09 times higher, respectively, as compared to individuals who were knowledgeable and had good practice towards malaria. Health education which is aimed at raising community's awareness about the disease is necessary (Flatie & Munshea, 2021).

Study literature show there are several factors that most dominantly influence the incidence of malaria in Indonesia, as follows : the use of mosquito nets, the existence of breeding places, the habit of going out of the house night, and use of mosquito repellent (Yayank & Raharjo, 2021). The distribution of malaria cases was random, while the distribution of Anopheles larvae was dispersed. Buffering zone >1000 m from the breeding site indicated that it does not have the potential in malaria transmission due to malaria patients were at a long distance from the breeding site of Anopheles spp. and flight distance of Anopheles spp. not exceeding 1000 m (Tampubolon et al., 2023).

Result research environmental and behavioral factors affecting malaria cases in high endemic area of Central Java: a geographic information system analysis, there was no correlation between weather factors and malaria incidence. There was a correlation between the presence of larval breeding habitat, the condition of the wall of the house and the habit of going out at night with the incidence of malaria (Nababan et al., 2018).

Chief malaria control efforts are to identify the patients as early as possible and to treat them immediately. Also, we have to control the vector, which is *Anopheles sp*., by installing an insecticide-treated mosquito net and applying antimosquito lotion as a larvicide (Rahmawati et al., 2023). The research results showed that there was a larvicidal effect of brewing clove leaves (Syzygium aromaticum L.) on the mortality of Anopheles sp mosquito larvae, where the effective concentration was 6% and had an LC50 value in killing Anopheles sp larvae of 0.89% (Sapulette et al., 2019). Research result that male breadfruit powder concentrations of 0.5, 1, 1.5, 2, 4, and 6% had a biolarvicidal effect causing mortality of *Anopheles sp*. mosquito larvae with an effective concentration of 6% (97.2% mortality), of which 50% mortality (LC50) of Anopheles sp. occurred at a concentration of male breadfruit pollen at a concentration of 3.95% (Moniharapon et al., 2023).

There is a need to minimize environmental impact and effect on non-target organisms has spurred interest in the development of eco-friendly larvicides of natural origin. The use of insecticides of plant origins may serve as a suitable alternative to chemical insecticides in the future with their characteristic relative safety, degradability, and abundance in many areas of the world (Aina et al., 2021; Febri et al., 2024; Milugo et al., 2021; Mustaming, 2022; Utami & Cahyati, 2017)

Rambutan leaves (*Nephelium lappaceum L.*) contain tannin compounds, saponins. Saponins are destroying red blood cells through the reaction of hemolysin, are toxic to cold-blooded animals, including cold-blooded insects, like mosquitoes that live around humans (Tatontos et al., 2022). The results of research on the effect of rambutan leaf extract (Nephelium lappaceum L.) on the death of *Aedes aegypti* mosquito larvae are very effective at concentrations of 5%, 10% and 15% (Fajriansyah, 2019). The results of research on the use of rambutan leaf extract on the death of *Culex quinquefasciatus* larvae were very effective, at

concentrations of 0.025%, 0.05%, 0.1%, 0.2%, 0.4%, and 0.8% respectively with results of 77%, 86%, 87%, 95% ,98%,and 100% (Dwi et al., 2014)

The results of this study, larvacide rambutan leaf soak was effective in the laboratory and in the field. Rambutan leaf, besides tannin, also contain flavonoids and saponins functioning as larvicides.

In Lombok Barat, notably around Penimbung Community Health Center, we can find a large number of rambutan trees, whose leaves may be used to control malaria vectors. People can maintain the environment to prevent the transmission of malaria by always cleaning the bucket where to soak the cupak and add rambutan leaves.

Conclusion

Fifty five percent of the population affected by the earthquake were infected with malaria, the most common being plasmodium falciparum, soaking rambutan leaves is effective for controlling Malaria vectors in laboratorium and fields.

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Author Contributions
EYT: Investigation and data collection, data analysis and interpretation, research conceptualization and drafted the manuscript. IWG: Methodology and supervision. MWD: Writing, reviewing and editing manuscript. U: Formal analysis, data curation and validation. All authors read and approved the final manuscript.

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Conflicts of Interest
The authors declare that they have no competing interests.

References

Abubakar, A. R., & Haque, M. (2020). Preparation of Medicinal Plants: Basic Extraction and Fractionation Procedures for Experimental Purposes. *Journal of Pharmacy & Bioallied Sciences*, *12*(1), 1–10. https://doi.org/10.4103/jpbs.JPBS_175_19

Aina, S. A., Onajobi, I. B., Sanusi, A. S., & Kolejo, O. S. (2021). Larvicidal Potentials of Three Indigenous Plants Against Malaria Vector, Anopheles Gambiae L. *Jordan Journal of Biological Sciences*, *14*(4), 847–852. https://doi.org/10.54319/jjbs/140426

Amin, M., Hiden, H., & Minardi, S. (2022). Identification of Earthquake Hazard Vulnerability in Bengkaung Village, West Lombok Using Geomagnetic Methods. *Jurnal Penelitian Pendidikan IPA*, *8*(2 SE-Research Articles), 548–557. https://doi.org/10.29303/jppipa.v8i2.1338

Anam, L. S., Badi, M. M., Assada, M. A., & Al Serouri, A. A. (2019). Evaluation of two malaria surveillance systems in Yemen using updated CDC guidelines: lessons learned and future perspectives. *Inquiry: The Journal of Health Care Organization, Provision, and Financing*, *56*, 0046958019880736. https://doi.org/10.1177/0046958019880736

Asiah, S., Gama T, A., & Ambarwati. (2009). Efektivitas ekstrak etanol daun rambutan (Nephelium lappaceum L.) terhadap kematian larva nyamuk Aedes aegypti instar III. *Jurnal Kesehatan*, *2*(2), 103–114. Retrieved from https://publikasiilmiah.ums.ac.id/xmlui/bitstream/handle/11617/2070/1.pdf?sequence=1

Astuti, R. R. U. N. W., Illahi, A. N., Umri, W. N. S., & Falah, A. A. (2023). Potency of Secondary Metabolites from Salacca zalacca, Sonchus arvensis, and Carica papaya against Aedes aegypti L. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 4931–4937. https://doi.org/10.29303/jppipa.v9i7.4129

Benelli, G., Jeffries, C. L., & Walker, T. (2016). Biological control of mosquito vectors: Past, present, and future. *Insects*, *7*(4), 1–18. https://doi.org/10.3390/insects7040052

Bunaga, I. G. K. S., Rosid, M. S., & Anggono, T. (2022). The Existence of Faults that Cause Earthquakes on Lombok Island: A Critical Literature Review. *Jurnal Penelitian Pendidikan IPA*, *8*(6 SE-Research Articles), 2827–2832. https://doi.org/10.29303/jppipa.v8i6.2346

Dwi L, Anik N, Nuryani. S. (2014). Penggunaan Berbagai Konsentrasi Ekstrak Ethanol Daun Rambutan (Nephelium lappaceum L .) Terhadap Mortilitas Larva Culex quinquefasciatus Dwi Lestari , Anik Nuryati , Siti Nuryani. *Jurnal Analis Kesehatan Poltekkes Kemenkes Yogyakarta*, *Vol 3*(No 1), 6–13.

Fajriansyah. (2019). Effect of rambutan leaf extract (Nephelium lappaceum L.) on the death of aedes aegypti mosquito larvae. *SAGO : Gizi Dan Kesehatan*, *1(1)*, 73–78. https://doi.org/http://dx.doi.org/10.30867/gikes.v1i1.291

Febri, F. R., Elimasni, E., & Jumilawaty, E. (2024). Effectiveness of Green Betel Leaf Powder (Piper betle L.) as a vegetable biopesticide against the Mortality of Rice Weevil (Sitophilus oryzae L.).

Jurnal Penelitian Pendidikan IPA, *10*(3), 1340–1348. https://doi.org/10.29303/jppipa.v10i3.6949

Feng, J., Xia, Z., Zhang, L., Cheng, S., & Wang, R. (2016). Risk Assessment of Malaria Prevalence in Ludian, Yongshan, and Jinggu Counties, Yunnan Province, After 2014 Earthquake Disaster. *The American Journal of Tropical Medicine and Hygiene*, *94*(3), 674–678. https://doi.org/10.4269/ajtmh.15-0624

Flatie, B. T., & Munshea, A. (2021). Knowledge, Attitude, and Practice towards Malaria among People Attending Mekaneeyesus Primary Hospital, South Gondar, Northwestern Ethiopia: A Cross-Sectional Study. *Journal of Parasitology Research*, *2021*, 5580715. https://doi.org/10.1155/2021/5580715

Iacovidou, M. A., Barreaux, P., Spencer, S. E. F., Thomas, M. B., Gorsich, E. E., & Rock, K. S. (2022). Omitting age-dependent mosquito mortality in malaria models underestimates the effectiveness of insecticide-treated nets. *PLOS Computational Biology*, *18*(9), e1009540. https://doi.org/10.1371/journal.pcbi.1009540

Izzatinnisa, & Utami, U. dan A. M. (2020). Relative Frequency (Composition) of Anopheles sp. Mosquitoes as Malaria Vectors in Kulon Progo District Special Region of Yogyakarta. *Jurnal Riset Biologi Dan Aplikasinya*, *2*(50), 18–25. https://doi.org/10.26740/jrba.

Kanata, B., Rosmaliati, Zubaidah, T., Yadnya, M. S., Zainuddin, A., Ratnasari, D., Fitratunnisa, N., & Akbar, M. F. (2024). Unraveling the Seismic Signal Anomaly at Mount Rinjani Station: In-Depth Exploration with the Detrended Fluctuation (DFA) Analysis Method in Connection with the 2018 Big Earthquake on Lombok Island, West Nusa Tenggara. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 116–123. https://doi.org/10.29303/jppipa.v10i1.6263

Khader, S. Z. A., Syed Zameer Ahmed, S., Sathyan, J., Mahboob, M. R., P. Venkatesh, K., & Ramesh, K. (2018). A comparative study on larvicidal potential of selected medicinal plants over green synthesized silver nano particles. *Egyptian Journal of Basic and Applied Sciences*, *5*(1), 54–62. https://doi.org/10.1016/j.ejbas.2018.01.002

Liu, N. (2015). Insecticide resistance in mosquitoes: impact, mechanisms, and research directions. *Annual Review of Entomology*, *60*, 537–559. https://doi.org/10.1146/annurev-ento-010814-020828

Milugo, T. K., Tchouassi, D. P., Kavishe, R. A., Dinglasan, R. R., & Torto, B. (2021). Naturally Occurring Compounds With Larvicidal Activity Against Malaria Mosquitoes. *Frontiers in Tropical Diseases*, *2*(August), 1–10. https://doi.org/10.3389/fitd.2021.718804

Moniharapon, D. D., Unitly, A. J. A., & Silahooy, V. B. (2023). Biolarvicide Activity of Male Breadfruit Flower Causes Mortality of Anopheles sp. Mosquito Larvae Malaria Vector. *Jurnal Penelitian Pendidikan IPA*, *9*(9 SE-Research Articles), 7699–7704. https://doi.org/10.29303/jppipa.v9i9.4246

Mustaming, M. (2022). Efek Obat Antituberkulosis Fase Intensif dan Konsumsi Purin Terhadap Kadar Asam Urat Pasien Tuberkulosis. *The Journal of Muhammadiyah Medical Laboratory Technologist*, *5*(1), 15. https://doi.org/10.30651/jmlt.v5i1.7939

Nababan, R., Sitti, & Umniyati, R. (2018). Faktor lingkungan dan malaria yang memengaruhi kasus malaria di daerah endemis tertinggi di Jawa Tengah. *Berita Kedokteran Masyarakat; (BKM Journal of Community Medicine and Public Health)*, *34*(1), 11–18. Retrieved from https://core.ac.uk/download/pdf/295356057.pdf

Naqqash, M. N., Gökçe, A., Bakhsh, A., & Salim, M. (2016). Insecticide resistance and its molecular basis in urban insect pests. *Parasitology Research*, *115*(4), 1363–1373. https://doi.org/10.1007/s00436-015-4898-9

Neelawala, D., Rajapakse, S., & Kumbukgolla, W. W. (2019). Potential of medicinal plants to treat dengue. *International Journal of One Health*, *15*, 86–91. https://doi.org/10.14202/IJOH.2019.86-91

OMS. (2019). Guidelines for Malaria Vector Control. In *Guidelines for Malaria Vector Control*. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/310862/9789241550499-eng.pdf?ua=1%0A

Rachmawati, F. (2018). *137 Warga Lombok Terjangkit Malaria, Tes Darah dan Bagi Kelambu Terus Dilakukan*. Retrieved from https://regional.kompas.com/read/2018/09/16/13580391/137-warga-lombok-terjangkit-malaria-tes-darah-dan-bagi-kelambu-terus.

Rahayu, N., Suryatinah, Y., & Ferdina, A. R. (2023). Strengthening Malaria Migration Surveillance at Village Level in Tanah Bumbu Regency, South Borneo, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9733–9740. https://doi.org/10.29303/jppipa.v9i11.4609

Rahmawati, S., Winarsih, Santoso, T., Ahmar, D. S., Magfirah, & Suherman. (2023). Potential of Beluntas Leaf Extract (Pluchea indica L) as a basic ingredient for Making Liquid Anti-Mosquito Repellent. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 3992–3997. https://doi.org/10.29303/jppipa.v10i7.8331

Ranson, H., & Lissenden, N. (2016). Insecticide Resistance in African Anopheles Mosquitoes: A

Worsening Situation that Needs Urgent Action to Maintain Malaria Control. *Trends in Parasitology*, *32*(3), 187–196. https://doi.org/10.1016/j.pt.2015.11.010

Ridwan, M., Yatini, Y., & Pramono, S. (2021). Mapping of Potential Damages Area in Lombok Island Base on Microtremor Data. *Jurnal Pendidikan Fisika Indonesia*, *17*(1), 49–59. https://doi.org/10.15294/jpfi.v17i1.27028

Sapulette, F., Unitly, A., & Moniharapon, D. (2019). Activity of Clove Leaves (Syzygium aromaticum L.) Larvacides on Mortality OF Anopheles sp. *RUMPHIUS. Pattimura Biological Journal*, *1*(2). https://doi.org/10.30598/rumphiusv1i2p042-046

Tampubolon, S. K. M., Raharjo, M., & Sulistiyani, S. (2023). Environmental Vulnerability against the Presence of Anopheles spp. with Malaria Cases in North Jakarta. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue SE-Research Articles), 878–884. https://doi.org/10.29303/jppipa.v9iSpecialIssue.5359

Tarwish, B., Ngeranwa, J. J. N., & Matasyoh, J. C. (2017). Phytochemical composition of crude extracts derived from Vernonia spp. and its larvicidal activity against Anopheles gambiae. *Bonorowo Wetlands*, *7*(2), 108–116. https://doi.org/10.13057/bonorowo/w070207

Tatontos, E. Y., Getas, I. W., & Urip, U. (2022). The Effectiveness of the Combination of Lethal Ovitrap Attractant of Local Organic Materials and Natural Larvicides in Dengue Hemorrhagic Fever Endemic Areas. *Jurnal Penelitian Pendidikan IPA*, *8*(6 SE-Research Articles), 2961–2968. https://doi.org/10.29303/jppipa.v8i6.2448

Udin, Y., Maksud, M., Risti, R., Srikandi, Y., Kurniawan, A., & Mustafa, H. (2016). Keragaman Anopheles Spp Pada Ekosistem Pedalaman Dan Pegunungan Di Kabupaten Sigi, Sulawesi Tengah. *Vektora: Jurnal Vektor Dan Reservoir Penyakit*, *8*(2), 61–70. https://doi.org/10.22435/vektora.v8i2.4940.61-70

Utami, I. W., & Cahyati, W. H. (2017). Potensi Ekstrak Daun Kamboja sebagai Insektisida Terhadap Nyamuk Aedes aegypti. *Higeia: Journal of Public Health Research and Development*, *1*(1), 22–28. Retrieved from https://journal.unnes.ac.id/sju/higeia/article/view/14001

Waldetensai, A. (2019). *Guideline for efficacy testing of mosquito larvicides Ethiopian Public Health Institute (EPHI) Public Health Entomology Research Team (PHERT)* (Issue October). Retrieved from https://www.researchgate.net/publication/336871420_Guideline_for_efficacy_testing_of_mosquito_larvicides

WHO. (2021). *WHO Guidelines for malaria treatment 2021*. Retrieved from https://www.who.int/publications/i/item/guidelines-for-malaria

World Health Organization. (2020). World Malaria Report: 20 years of global progress and challenges. In *World Health Organization*. Retrieved from https://www.who.int/publications/i/item/9789240015791

Yayank L. M., & Raharjo, M. (2021). Faktor Risiko yang Mempengaruhi Kejadian Malaria Di Indonesia : Review Literatur 2016-2020 Risk Factors Affecting the Incidence of Malaria in Indonesia: A Literature Review 2016-2020. *Jurnal Kesehatan Lingkungan*, *11*(1), 16–28. https://doi.org/10.47718/jkl.v10i2.1168