RUWA JURAI: JURNAL KESEHATAN LINGKUNGAN
ISSN (p) 1978-6204 ISSN (e) 2723-6204
https://ejurnal.poltekkes-tjk.ac.id/index.php/JKESLING

Spatial Analysis of Breeding Places of *Anopheles* sp. Mosquitoes as Potential Vectors of Malaria Infection in Pesawaran District, Lampung, Indonesia

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ARTICLE HISTORY

Received April 27, 2025
Accepted June 10, 2025
Published July 15, 2025

Keyword:

Malaria; Spatial; Environmental; Breeding place

Kata kunci:

Malaria; Spasial; Lingkungan; Tempat perindukan

A B S T R A C T

Malaria is an infectious disease caused by microorganisms of the genus Plasmodium, transmitted to humans by the female Anopheles mosquito species. The breeding place of this Anopheles mosquito is typically found in the environment, such as stagnant water in rivers, abandoned ponds, lagoons, and other similar areas. Pesawaran Regency is a malaria-endemic area in Lampung Province with an API of 1.4 in 2023. Mapping the distribution of breeding places is necessary to control malaria vectors in Pesawaran Regency. Based on this, this study will conduct a spatial analysis of the breeding sites of Anopheles sp. mosquitoes, which are potential vectors of malaria infection in Pesawaran District. This type of research is descriptive observational using cross sectional design, coordinate survey and visual inspection of larvae found in breading place and spatially processed using Arcgis V.10.8. From the observations of breeding places in the form of swamps, water reservoirs (buckets and derigen) unused fish ponds or ponds, buffering breeding place analysis carried out can be seen that malaria cases are in the area of vector flight distance of 1,000 meters and 3,000 meters. Potential breeding places were found in Teluk Pandan sub-district of Pesawaran Regency, breeding places are scattered in five villages and are located in coastal areas with a distance between 407.88 meters - 707.266 meters from the coastline, buffering analysis of breeding places can be seen that the location at risk of malaria case transmission is in the vector flight distance area of 1,000 meters and 3,000 meters covering eight villages.

Malaria adalah penyakit menular yang disebabkan oleh mikroorganisme dari genus Plasmodium yang ditularkan ke manusia melalui vektor nyamuk *Anopheles* sp. betina. *Breding place* nyamuk *Anopheles* ini banyak ditemukan di lingkungan seperti pada genangan air di lingkungan seperti sungai, tambak yang terbengkalai, laguna dan lainnya. Kabupaten Pesawaran merupakan daerah endemis malaria di Provinsi Lampung dengan API 1,4 pada tahun 2023. Pemetaan sebaran *breding place* sangat diperlukan dalam rangka pengendalian vektor malaria di Kabupaten Pesawaran. Berdasarkan hal tersebut maka pada penelitian ini akan di lakukan kajian analisis spasial *breading place* nyamuk *Anopheles* sp. sebagai Vektor potensial infeksi malaria di kabupaten pesawaran. Jenis penelitian ini adalah deskriptif observasional dengan menggunakan desain *cross sectional*, dilakukan survey koordinat dan pemeriksaan visual terhadap jentik yang ditemukan pada *breading place* dan di olah secara spasial dengan menggunakan Arcgis V.10.8. Dari hasil pengamatan *breading Place* berupa Rawa-rawa, Penamppungan air (ember dan derigen) kolam ikan atau tambak yang tidak terpakai, Analisis *buffering breeding place* yang dilakukan dapat dilihat bahwa kasus malaria berada pada area jarak terbang *vector* yaitu 1.000 meter dan 3.000 meter. Di temukan *breeding place* potensial yang berada di kecamatan Teluk Pandan Kabupaten Pesawaran, *breeding place* tersebar di lima desa dan berada di daerah pesisir pantai dengan jarak antara 407,88 meter – 707,266 meter dari garis pantai, Analisis *buffering breeding place* dapat dilihat bahwa lokasi beresiko penuaran kasus malaria berada pada area jarak terbang *vector* yaitu 1.000 meter dan 3.000 meter yang meliputi delapan desa.

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1. Introduction

Malaria is an infectious disease caused by microorganisms of the *Plasmodium genus*, transmitted to humans through the bite of *Anopheles mosquitoes*. The HIV/AIDS and tuberculosis, malaria remains is the most serious global health challenges, where becomes the control in the Sustainable Development Goals (SDGs) as a global target to be achieved by 2030. In line with this, the Indonesian Ministry of Health has established a malaria elimination program aimed at making the entire country malaria-free by 2030. This target aligns with the Decree of the Minister of Health of the Republic of Indonesia No. 293/Menkes/SK/IV/2009 dated April 28, 2009, regarding "*Eliminasi Malaria di Indonesia*" and the Decree of the Director General of Disease Prevention and Control No. HK.02.03/D.1/1.2/99/2015 concerning the Technical Guidelines for Assessing Malaria Elimination Malaria merupakan penyakit menular yang disebabkan oleh mikroorganisme dari genus Plasmodium (Kementrian Kesehatan, 2023).

Four districts/cities in Lampung Province have reported zero malaria cases in 2023, with a zero API. These areas are Tulang Bawang Barat, Central Lampung, East Lampung, and West Lampung. Meanwhile, 10 districts are classified as low endemic areas (API <1), including West Lampung (0.01), Tanggamus (0.01), Tulang Bawang (0.01), North Lampung (0.01), Pringsewu (0.01), Way Kanan (0.01), Mesuji (0.01), Metro (0.02), South Lampung (0.03), and Bandar Lampung (0.07). Only one district, Pesawaran, is categorized as moderately endemic (API 1–5), with an API of 1.40. Pesawaran Regency also recorded the highest number of cases in the province, contributing a total of 706 malaria cases (Lampung Provincial Health Office, 2024).

The malaria cases in Pesawaran Regency are spread across several health service areas. The Pedada Health Center reported 74 cases, Padang Cermin 97 cases, Maja 67 cases, while Kota Dalam and Gedong Tataan each recorded 1 case. Pesawaran Hospital reported 5 cases, with the highest number found in the Hanura Health Center area, at 461 cases. Pesawaran Regency remains an endemic area for malaria, primarily due to its natural environment, which provides ideal conditions for mosquito breeding and the continued transmission of the disease (Dinas Kesehatan Pesawaran, 2024).

The physical environmental factors, including a house's proximity to Anopheles mosquito habitats and the type of building construction, influence malaria transmission. Adjusting these factors can reduce the risk of mosquito bites through preventive measures, such as using mosquito repellents, installing wire mesh, or using bed nets. (Ginandjar, 2018). Although various efforts, such as bed net use, vector control, diagnosis, and treatment, to maintain a clean environment around the home, remain a key strategy in preventing malaria transmission. (Deviani Utami, Tusy Triwahyuni, 2019).

Spatial analysis is a region-based method used in disease management to examine disease data about population distribution, environmental risk factors, ecosystems, and socioeconomic conditions, thereby involving the geographic analysis of disease data. In the context of malaria, this approach helps identify the distribution and concentration of cases within specific areas over time. (Achmadi, 2009). Environmental factors such as the presence of lakes, puddles, forests, rice fields, fish ponds, and mining areas can increase the risk of malaria, as these locations serve as ideal breeding grounds for malaria-carrying mosquitoes (Suyono et al., 2021).

According to the background, the study aims to analyze the spatial distribution of breeding places of *the Anopheles sp*. mosquito, a potential vector of malaria infection, in the Pesawaran district.

2. Methods

This study used a descriptive observational with a cross-sectional design. The study was conducted in Teluk Pandan Sub-district, Pesawaran Regency, from October to November 2024. It involved direct observation of potential Anopheles mosquito breeding sites, with visual identification and documentation of larvae. The data collected were

processed and analyzed using ArcGIS software version 10.8, and the results were presented in map form, showing the spatial distribution of breeding sites along with buffer analysis.

3. Results

Based on research conducted in Teluk Pandan District, Pesawaran Regency, seven potential mosquito breeding sites were identified across five target villages. These include swamps in Sukajaya Lempasing, freshwater containers such as buckets and jerry cans in malaria-affected households near active ponds in Hanura, sewers and swamps in Sidodadi, unused ponds in Gebang, and abandoned fish ponds in Batu Menyan. These findings suggest that the Teluk Pandan District encompasses multiple environments that are conducive to mosquito development. The regional distribution of these habitats is shown in Figure 1.

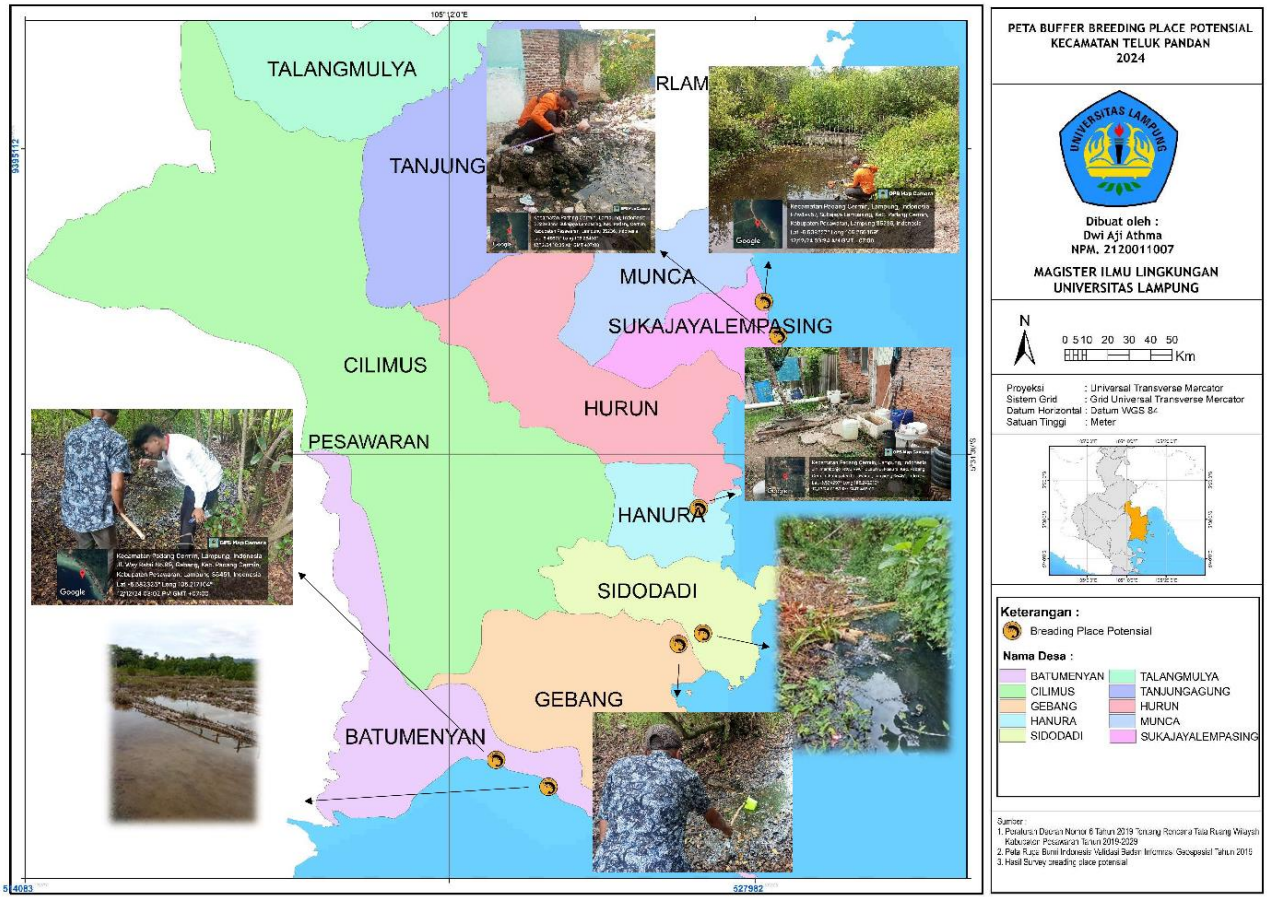

Figure 1. Map of the distribution *of potential breeding places* in Teluk Pandan sub-district for October – November 2024

Buffering analysis of mosquito breeding sites revealed that malaria cases were concentrated within the vector's flight range, especially within 1,000 and 3,000 meters. A total of 79 cases (81.44%) were located within the 1,000-meter zone, while 18 cases (18.55%) were found within the 3,000-meter zone. The breeding sites in Teluk Pandan District are situated in coastal areas, with distances ranging from 407.88 to 707.27 meters from the shoreline. The spatial analysis results, generated using GIS mapping software, are presented in Figure 2.

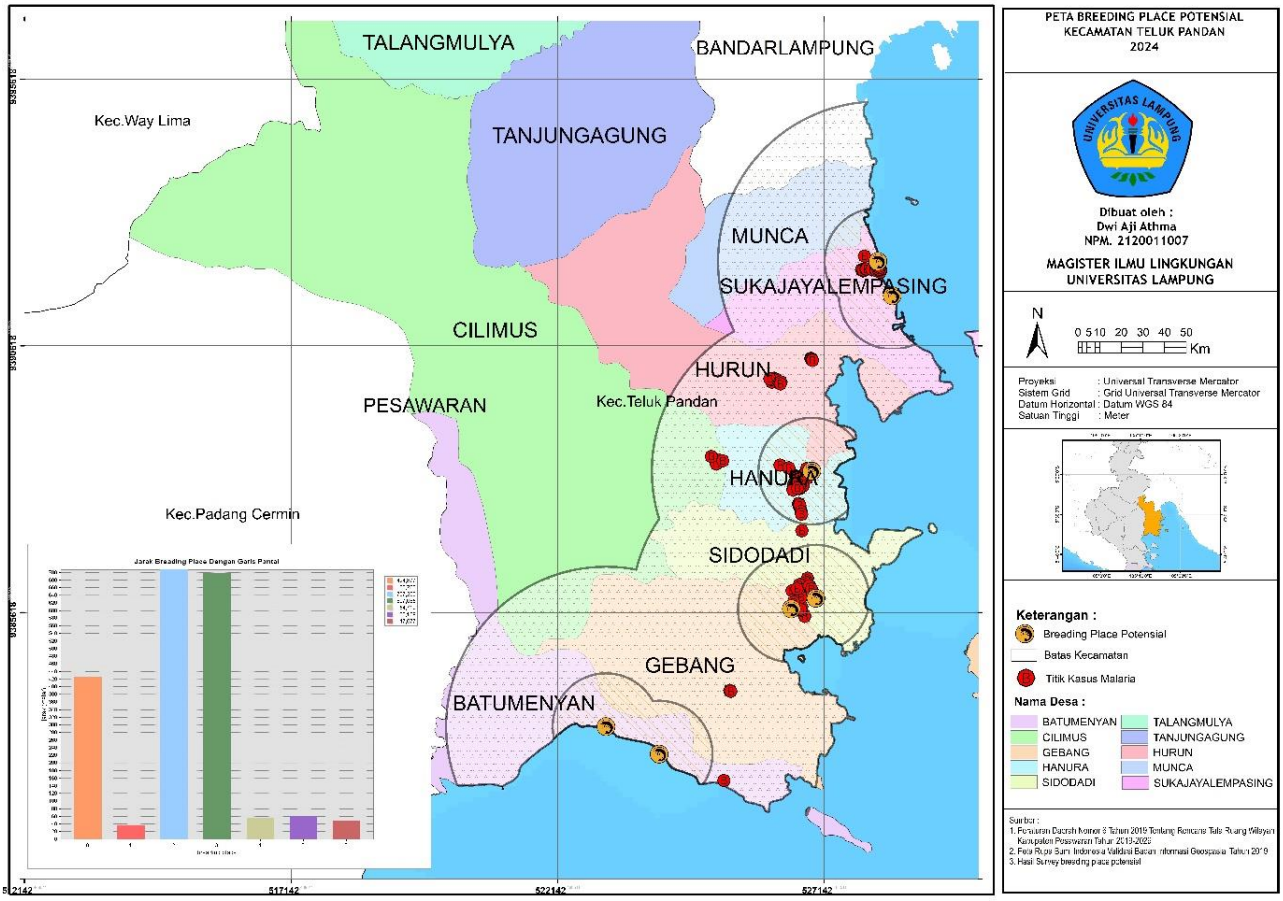

Figure 2. Map of buffering breeding place in Teluk Pandan District

4. Discussion

In this study, larvae were collected using the incubation technique. Observations identified several breeding sites, including freshwater containers such as buckets and jerry cans, ditches, swamps, and unused ponds. These locations were found across five villages categorized as coastal areas, which provide ideal conditions for breeding Anopheles mosquitoes. A study by Maya Tindige, Joy V. I. Sambuaga (2017) found that *Anopheles larvae* were commonly found in three types of breeding sites: puddles or sewers, rivers, and swamps.

In line with Taher et al. (2021), potential breeding sites for Anopheles mosquitoes include abandoned shrimp ponds, lagoons, puddles, springs, fish ponds, wells, and swamps. (Dhewantara, Pandji Wibawa, Astuti, Endang Puji, 2012) conducted a bioecological study of Anopheles sundaicus in Ciamis Regency, which identified the presence of Anopheles larvae in six locations across Suresik Village. These habitats were characterized by abandoned ponds and rainfed rice fields located at altitudes of 34–46 meters above sea level. A study in Bengkulu also revealed a significant relationship between breeding site variables and malaria incidence, with a p-value = 0.000 (Hasyim et al., 2014). In other studies, factors related to the placement of Anopheles larvae included the size of the vegetation where they bred, the presence of predators, sunlight, water flow, temperature, water surface tension, hydrogen concentration, and the presence of salt minerals (Kazwaini & Martini, 2015). The prevalence of malaria varies geographically, depending on the season, vegetation type, and distance from the village to the river, as well as rainfall, which is also associated with the spread of malaria (Shilpa Hakre, 2003).

The buffering analysis showed that nearly all villages in Teluk Pandan District, Pesawaran Regency, fall within the range of mosquito breeding sites. These villages include Sukajaya Lempasing, Hanura, Sidodadi, Gebang, Batu

Menyan, Cilimus, Hurun, and Munca. Being within the flight range of Anopheles mosquitoes increases the risk of malaria transmission. The closer a residential area is to breeding sites, the greater the chance of infection, as Anopheles is the primary vector responsible for spreading malaria.

Buffer areas are regions with a high risk of malaria transmission, which is mainly dependent on the presence of malaria vectors (Suwandi et al., 2014). Female Sundaicus mosquitoes can fly quite far with a maximum of >3 km (Aida et al., 2023). Based on this flight range, buffer zones can be established around transmission sources to prevent contamination. In some cases, these zones extend beyond the boundaries of Pesawaran Regency, contributing to the broader spread of malaria throughout the region. It is well known that the southern coastal areas of Bandar Lampung and Pesawaran Regency are endemic zones for malaria in Lampung Province (Suwandi et al., 2014).

Malaria cases often occur within the flight range of the vector. Female mosquitoes are capable of flying 0.5 to 5 kilometers, whereas male mosquitoes typically remain near their breeding sites (Pratiwi, 2024). Based on research in Bulude Village, Kabaruan District, Talaud Islands Regency, conducted by Maya Tindige and Joy V. I. Sambuaga (2017). The distance between Anopheles larvae habitats and malaria case households was analyzed using three buffer zones: 100 meters, 200 meters, and 300 meters. Out of 36 malaria cases recorded in 2017 in Bulude Village, Kabaruan District, Talaud Islands Regency, only one case fell outside the identified transmission zone. The red buffer zone (0–100 meters) contained the highest number of cases, with 32 households located closest to breeding sites. The yellow zone (101–200 meters) included 2 cases, while the green zone (201–300 meters) accounted for 1 case.

In line with (Suyono et al., 2021), carried out by Waigete District, Sikka Regency, which stated that the buffering zone <500 meters from the type and type of nesting site that was positive for larvae showed 26 cases of malaria found in the buffer zone. This can indicate that potential breeding sites and positive larvae have the potential to result in malaria transmission. From the existing buffer zone, malaria cases are still found outside the buffer zone, <500 meters. However, the case is still at a distance of less than 1,000 meters. The distance of 1,000 meters is still a normal flight distance because the Anopheles mosquito can fly up to 2 – 3 km when influenced by wind direction and population mobility.

These findings highlight the urgent need for cross-regional coordination in controlling malaria, especially in the coastal areas of Pesawaran Regency, Lampung Province. Mapping and spatial analysis of malaria cases can provide a solid foundation for developing targeted prevention strategies, as malaria transmission is influenced by various factors, including mosquito breeding sites, the presence of infected individuals, population mobility, and environmental conditions, which require more than just a health-sector approach. It calls for collaborative efforts across sectors and regions. For that reason, strong attention and commitment are needed from both local and national policymakers to address malaria more effectively, not just in Pesawaran, but across Indonesia.

5. Conclusions

According to the study's results, the potential breeding places in Telukpandan sub-district, Pesawaran Regency, are located in five villages in the coastal areas. Anopheles mosquito larvae are found in swamps, water reservoirs, fish ponds, unused ponds, and sewers. Analysis of buffering breeding places reveals that the location at risk of malaria transmission is within the vector flight distance area, specifically 1,000 meters and 3,000 meters, as all malaria cases are concentrated in this area, which encompasses eight villages out of a total of 10 villages in Teluk Pandan District. It was concluded that the eight villages were included in the malaria transmission zone.

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