

Spatial Distribution and Bionomic Characteristics of Anopheles Mosquitoes and Their Role in Plasmodium falciparum Transmission in South Buru District, Maluku: Urban vs Rural Perspectives

Sahrir Sillehu¹, Nasruddin Syam^{2*}, Ilyas Ibrahim³, Arsystri⁴, Wardiah Hamzah⁵, Anwar Mallongi⁶

^{1,3}Maluku Husada Institute of Health Science, Indonesia

^{2,4,5}Faculty of Public Health, Universitas Muslim Indonesia, Indonesia

⁶Faculty of Public Health, Hasanuddin University, Indonesia

Email: nasruddin.syam@umi.ac.id²

*Corresponding Author

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ABSTRACT

The WHO estimates that there are 241 million cases of malaria worldwide with the number of deaths reaching 627,000 in 2020. Endemic areas in Indonesia include Regency, South Buru, in 2019 with the number of positive cases of malaria at 111 cases. The cause of malaria is the protozoan parasite of the Plasmodium species through the female Anopheles mosquito. This study aims to map the bionomic larvae and anopheles mosquitoes, then capture and identify Anopheles mosquito species, followed by epidemiological analysis based on community groups in rural and urban areas. This study is a descriptive research by conducting a survey and identification of Malaria vectors in South Buru Regency, Maluku Province. Observation and data collection were carried out at the same time. Then the Malaria vector mosquito was caught and the species was identified. Conducting interviews with both community groups to find out the risk factors for malaria events. The results of the study showed that the binomic anopheles mosquitoes in South Buru Regency in the inland community group based on geographical conditions far from the hilly coast and fields, while the urban community group based on the situation was more distributed on the beach, slope and valley. The Anopheles mosquitoes found in An.Farauti, An.Vagus, An.Flaavivirostris, An.Indefinitus, An.Subpictus, An.Tesselatus. Based on interviews and physical examinations of splenomegaly in both community groups, the suspected malaria sufferers are all children, both rural community groups (3 cases) and urban community groups (1 case).

Keywords: Anopheles, bionomics, breeding place, epidemiology of sufferers

INTRODUCTION

Malaria is a very dominant infectious disease in tropical and sub-tropical areas and can cause death. WHO estimates that there are 241 million cases of malaria worldwide with the number of deaths reaching 627,000 in 2020[1]. Most areas in Indonesia are still endemic to malaria, especially in the Papua, West Papua, Maluku, North Maluku and NTT[2]. Indonesia's national Annual Parasite Incidence (API) in 2020 is 0.9[3], while in Maluku Province it reached 0.42[3] with the number of malaria cases in South Buru Regency in 2019 being 110 cases[4].

Plasmodium falciparum is a protozoan parasite, which is one of the species of Plasmodium that causes malaria in humans[5,6]. These protozoa enter the human body through the female Anopheles [7]. Plasmodium falciparum causes the most dangerous infections and has the highest malaria complication and mortality[8].

South Buru Regency has a closed community and an open community. Closed communities are people who live in inland areas that have limited facilities and infrastructure. The life of this community is still traditional compared to the life of an open society, and their daily lives depend on the surrounding nature or live vegetatively. If a family member is sick with malaria, they use traditional medicine from natural leaf herbs in the vicinity. An open society is a society that mostly has an orientation of cultural values that are directed to life in today's civilization. Generally, open people live in urban areas, so they are called urban communities.

This study aims to map the bionomic of larvae and Anopheles mosquitoes, then capture and identify Anopheles mosquito species, followed by epidemiological analysis based on community groups in rural and urban areas.

METHOD

This study is quantitative research with an observational analytical approach. Observation and data collection were carried out at the same time. In the early stages, surveys and bionomic mapping of *Anopheles* mosquitoes were carried out based on breeding grounds, resting places and feeding habits of mosquitoes. Then it was continued with the capture of larvae and mosquitoes. To ascertain the type of Malaria vector mosquito, mosquitoes were caught in the field for 7 days by means of Landing and Resting Collection, then identified to determine the species.

In the next stage, an epidemiological survey was carried out on the inland community group, namely the Masarete Tribe and the urban community group, namely the Buru Tribe. Then interviews were conducted to obtain information on age, gender, type of occupation, and risk factors for malaria events based on travel history, history of malaria illness, history of malaria treatment and spleen enlargement as well as Splenomegaly physical examination. Sampling was carried out using the purposive sampling technique.

This research has also received protocol approval from the Health Research Ethics Committee of the College of Health Sciences "Maluku Husada".

RESULT

1. Bionomics of *Anopheles* Mosquitoes

South Buru Regency with the capital city of Namrole has an area of 6,723 km² with a population of \pm 71,942 people. The composition of the population consists of indigenous tribes from Ambalau Island and immigrants who mostly come from the Buton and Bugis tribes. Administratively, South Buru Regency consists of 5 (five) sub-districts, namely: 1) Namrole District; 2) Lekula District; 3) Waesama District; 4) Head Madang District and 5) Ambalau Island District.

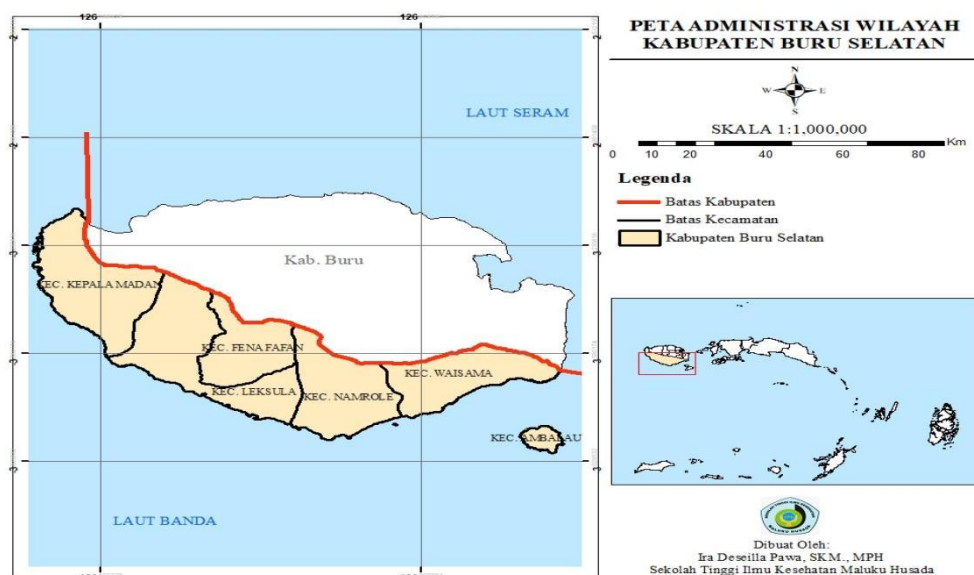


Figure 1: Administrative Map of South Buru Regency

Based on the Meteorology, Climatology and Geophysics Agency (BMKG) of South Buru Regency (2021), climatic conditions during the rainy season period last for five months, starting from December to March and July. South Buru Regency has an average annual rainfall of 1226.1 mm. The average monthly air temperature ranges from 25.9°C in July and August while in April it ranges from 28.3°C. The lowest maximum temperature occurs in July (31.1°C) and the highest in November (33.4°C). Meanwhile, the lowest minimum temperature occurred in July (22.3°C) and the highest occurred in December (24.3°C).

The situation and bionomic conditions of *Anopheles* mosquitoes in South Buru Regency in table 1 show that inland community groups based on geographical conditions far from the coast (0.0%), living in hills (100%), farming (97.4%) on hillsides (81.6%) and not in valleys (100%). Meanwhile, urban community groups based on geographical conditions, are more distributed on the coast (62.9%), on the slopes (66.1%) and valleys (100%).

The bionomic of *Anopheles* mosquitoes based on the home environment of rural community groups is more in ponds (81.6%) and rainwater puddles (92.1%), while urban community groups are more in grass/shrubs (82.3%), trees (82.3%), and rainwater puddles (82.3%). *Anopheles* mosquito breeding places (Breeding Places) in rural communities are more in swamps (92.1%) and waterlogging (94.7%). Likewise, urban community groups, where *Anopheles* mosquitoes are more breeding grounds in swamps (69.4%) and waterlogging (90.3%).

Table 1: Bionomic Mosquitoes based on Geographical Conditions, Home Environment, and Breeding Place in Rural and Urban Communities in Namrole District, South Buru Regency in 2023

Mosquito Bionomics		Community Groups	
		Rural (%)	Urban (%)
Geographical			
Beach	Yes	0 (0,0%)	39 (62,9%)
	No	38 (100%)	23 (37,1%)
Total		38 (100%)	62 (100%)
Hill	Yes	38 (100%)	11 (17,7%)
	No	0 (0,0%)	51 (82,3%)
Total		38 (100%)	62 (100%)
Field	Yes	37 (97,4%)	9 (14,5%)
	No	1 (2,6%)	53 (85,5%)
Total		38 (100%)	62 (100%)
Slope	Yes	31 (81,6%)	41 (66,1%)
	No	7 (18,4%)	21 (33,9%)
Total		38 (100%)	62 (100%)
Valley	Yes	0 (0,0%)	62 (100%)
	No	38 (100%)	0 (0,0%)
Total		38 (100%)	62 (100%)
Home environment			
Steva	Yes	0 (0,0%)	51 (82,3%)
	No	38 (100%)	11 (17,7%)
Total		38 (100%)	62 (100%)
Savanna	Yes	0 (0,0%)	51 (82,3%)
	No	38 (100%)	11 (17,7%)
Total		38 (100%)	62 (100%)
Lagoon	Yes	0 (0,0%)	0 (0,0%)
	No	38 (100%)	62 (100%)
Total		38 (100%)	62 (100%)
Pond	Yes	2 (5,3%)	0 (0,0%)
	No	36 (94,7%)	62 (100%)
Total		38 (100%)	62 (100%)
Pool	Yes	31 (81,6%)	36 (58,1%)
	No	7 (18,4%)	26 (41,9%)
Total		38 (100%)	62 (100%)
River	Yes	1 (2,6%)	5 (8,1%)
	No	37 (97,4%)	57 (91,9%)
Total		38 (100%)	62 (100%)
Rain puddles	Yes	35 (92,1%)	51 (82,3%)
	No	3 (7,9%)	11 (17,7%)
Total		38 (100%)	62 (100%)
Breeding Place			
Swamps	Yes	35 (92,1%)	43 (69,4%)
	No	3 (7,9%)	19 (30,6%)
Total		38 (100%)	62 (100%)
Puddle	Yes	0 (0,0%)	0 (0,0%)
	No	38 (100%)	62 (100%)
Total		38 (100%)	62 (100%)
Water plants	Yes	36 (94,7%)	56 (90,3%)
	No	2 (5,3%)	6 (9,7%)
Total		38 (100%)	62 (100%)
Ricefield	Yes	0 (0,0%)	2 (3,2%)
	No	38 (100%)	60 (96,8%)
Total		38 (100%)	62 (100%)
Pold	Yes	1 (2,6%)	3 (4,8%)
	No	37 (97,4%)	59 (95,2%)
Total		38 (100%)	62 (100%)

2. Capture of larvae and mosquitoes of Anopheles, identification of mosquito species

Larval and mosquito capture to determine the type of Malaria vector mosquito is carried out by catching mosquitoes in the field by means of Landing and Resting Collection and then identified to determine mosquito species.

Table 2: Distribution of Anopheles Larvae, Breeding Place and Environment in South Buru Regency

Region/Village	Anopheles larval species	Breeding Place	Environment
Lektema	An.Farauti, An.Vagus	Forest, Swamp, Brackish Water	Physics/Chemistry; temperature 26°C, pH 7, salinity 0 ‰ Biology; Aquatic plants : Moss, grass, water hyacinth, genjer Shade : None/open
Elfule	An.Vagus An.Flaavirostris	River, Forest	Physics/Chemistry; temperature 27°C. pH 7, salinity 0 ‰ Biology;
Kamaglale	An.Flaavirostris	Swamps, puddles	Physics; Soil, non-flowing, temperature 28°C, pH 7, salinity 0‰ Biology;
Emori	An.Indefinitus An.Flaavirostris	Puddle	Physics/Chemistry; temperature 28°C. pH 7, salinity 0 ‰ Biology; Aquatic plants : Moss, grass shade : None/open Nearby plants : Grass, weeds
Waenono	An.Subpictus An.Tesselatus	Forest, Swamp, Brackish Water	Physics/Chemistry; temperature 27°C. pH 7, salinity 0 ‰ Biology; Aquatic plants : Moss, grass, water hyacinth, genjer Shade : None (open) Nearby plants : Shrubs

Table 2 shows that the larvae of Anopheles found in southern Buru Regency are An.Farauti, An.Vagus, An. Flaavirostris, An. Indefinitus, An. Subpictus, An.Tesselatus with breeding places in the form of swamps, puddles, rivers, forests and brackish water. The physical/chemical environment is generally at a temperature of 27°-27° C. pH 7, salinity 0 ‰.

Table 3: Distribution of Anopheles Larvae, Breeding Place and Environment in South Buru Regency

Region/Village	Anopheles Mosquito Species	Number of Mosquitoes Caught
Lektema	An.Farauti, An.Vagus	76 47
Elfule	An.Vagus An.Flaavirostris	89 20
Kamaglale	An.Flaavirostris	46
Emori	An.Indefinitus An.Flaavirostris	52 37
Waenono	An.Subpictus An.Tesselatus	30 50

Table 3 shows that the Anopheles mosquito found in southern Buru Regency is An. Farauti, An. Vagus, An.Flaavirostris, An. Indefinitus, An. Subpictus, An.Tesselatus.

3. Epidemiology of Malaria Patients with P. falciparum Based on Rural and Urban Communities Characteristics Responden

Table 4 explains the characteristics of respondents in the rural community group, based on the most age in the 0-10 years category (57.9%), based on balanced gender (50%) while based on the type of occupation is other occupations such as hunting (41.1%). Meanwhile, in the urban community group, based on age, the most in the category of 41-40 years (29%), based on gender, the most are men (61.3%), based on the type of work, namely others (62.9%).

Table 4: Characteristics of Respondents Based on Age, Gender, Type of Work in Rural and Urban Communities in Namrole District, South Buru Regency in 2023

Characteristics	Community	
	Rural (%)	Urban (%)
Age		
0-10 years old	22 (57,9)	7 (11,3)
11-20 years old	5 (13,2)	5 (8,1)
21-30 years old	7 (18,4)	12 (19,4)
31-40 years old	3 (7,9)	14 (22,6)
41-50 years old	1 (2,6)	18 (29,0)
≥ 51 years	0 (0,0)	6 (9,7)
Total	38 (100)	62 (100)
Gender		
Man	19 (50)	38 (61,3)
Woman	19 (50)	24 (38,7)
Total	38 (100)	62 (100)
Job Type		
Merchant	0 (0,0)	2 (3,2)
Farmer	9 (2,3)	12 (19,4)
Civil servants	0 (0,0)	6 (9,7)
Housewives	2 (5,3)	3 (4,8)
Not yet employed (toddlers and children)	11 (28,9)	0 (0,0)
Other	16 (42,1)	39 (62,9)
Total	38 (100)	62 (100)

Risk Factors for Malaria Incidence and Characteristics of Subjects with Malaria**Table 5:** Risk Factors for Malaria Incidence based on Travel History, History of Malaria Illness in Rural and Urban Communities in Namrole District, South Buru Regency in 2023

Risk Factors for Malaria Incidence	Community	
	Rural (%)	Urban (%)
Travel History		
No travel history	37 (97,4)	51 (82,3)
Have a travel history	1 (2,6)	11 (17,7)
Total	38 (100)	62 (100)
History of Malaria Illness		
No history of malaria illness	21 (55,3)	61 (98,4)
Have a history of malaria illness	17 (44,7)	1 (1,6)
Total	38 (100)	62 (100)
History of Taking Anti-Malarial Drugs		
Tradisional	3 (17,6)	0 (0,0)
ACT	0 (0,0)	1 (100)
Untreated	14 (82,4)	0 (0,0)
Total	17 (100)	1 (100)
Splenomegals		
Splenomegals	3 (7,9)	1 (1,6)
No Splenomegaly	35 (92,1)	61 (98,4)
Total	38 (100)	62 (100)

Risk factors for malaria incidence based on travel history in rural communities show a travel history (2.6%) while in urban communities there is a higher travel history (17.7%). Based on the history of malaria in the rural community group is higher (44.7%) compared to the urban community (1.6%). Based on the physical examination of splenomegaly, there was no splenomegaly in rural communities (17.6%), while in urban communities there was no splenomegaly (98.4%).

Table 6: Characteristics of Subjects Based on Symptoms, History of Malaria Disease, History of Taking Anti-Malarial Drugs, Enlargement of the Spleen and History of Travel in Rural and Urban Communities

Sample Number	Age (year)	Symptom existing	History of Malaria Illness	Splenomegals	OAM Drinking History	History of traveling to other areas
27 (urban)	2	Hot, cold	(-)	(+)	(-)	(-)
28 (rural)	2	Hot, cold	(-)	(+)	(-)	(-)
30 (rural)	3	Hot	(-)	(+)	(-)	(-)
31 (rural)	7	Fever	(-)	(+)	(-)	(-)

Information

(-) : Sample declared Negative, (+): Sample tested Positive

All malaria sufferers are children (4 cases) and more cases are found in rural communities (3 cases) than urban communities (1 case). The symptoms are generally hot and cold with a negative history of malaria, negative splenomegaly and a negative travel history.

DISCUSSION

1. Spatial analysis of the bionomic mosquito Anopheles

The situation and binomic conditions of anopheles mosquitoes in South Buru Regency show that inland community groups based on geographical conditions far from the coast (0.0%), living in hills (100%), farming (97.4%) on hillsides (81.6%) and not in valleys (100%). Meanwhile, urban community groups based on geographical conditions, are more distributed on the coast (62.9%), on the slopes (66.1%) and valleys (100%).



Figure 2. Map of Mosquito Breeding Place Buffer with Environmental Conditions and Geography of Southern Buru

The bionomic distribution of Anopheles mosquitoes is in the vicinity of fields, rivers and gardens, which are around community settlements. Lektama Village is a residential area of urban community groups, breeding places that are found such as forests, swamps, and brackish water. Meanwhile, in Elfule Village, the breeding place is in the form of a river and a forest. The health center as a means of health services for people suffering from malaria is located in Elfule Village, Namroloe District.

Anopheles mosquito breeding places show similarities between urban and rural community groups. This is because South Buru Regency is an archipelago, so environmental conditions tend to be the same. The main difference, however, is that the interior does not have a beach, since its people are in mountainous and forested areas.

Research in three Senegalese cities shows that Anapholes has always been in existence every year with a high incidence of malaria[9], in contrast to the urban communities of Buru Regency experiencing a decrease in malaria incidence. Urban areas in Bening, a study to assess breeding sites in urban and non-urban areas, showed that the habitat diversity of Anopheles mosquito larvae in urban areas is influenced by climate, human activities and physicochemical factors[10]. Likewise with the use of pesticides in the urban area of Akim Oda, Ghana[11]. Meanwhile, in urban areas of South Buru Regency, it shows that people have also used pesticides for

agricultural, plantation and fishery activities. Although it is not yet known whether this activity affects the density of *Anopheles* larvae.

2. Capture of larvae and mosquitoes of *Anopheles*, identification of mosquito species

The capture of *Anopheles* larvae and mosquitoes shows that the *Anopheles* larvae found in South Buru Regency are *An.Farauti*, *An.Vagus*, *An. Flaavirostris*, *An.Indefinitus*, *An. Subpictus*, *An.Tesselatus* with breeding places in the form of swamps, puddles, rivers, forests and brackish water. The physical/chemical environment is generally at a temperature of 27°-27° C. pH 7, salinity 0 %.

The type of *Anopheles* larvae is not much different from *Anopheles* larvae found in other regions in Indonesia such as *An.Vagus*[12], *An. Sundaicus*[13], *An. Subpictus*[14]. Meanwhile, another *Anopheles* larva that is also found in Indonesia is *An. Maculatus* in the North Buton Islands[15] and *An.Kochi* Halmahera Islands[14]. Meanwhile, in Southeast Asia, the larvae of *Anopheles* found such as *An. Sundaicus*[16], *An. Gambiae*[17] and *An. Subpictus* in Thailand[18].

The *Anopheles* mosquitoes found in southern Buru Regency are *An.Farauti*, *An.Vagus*, *An.Flaavirostris*, *An.Indefinitus*, *An.Subpictus*, *An.Tesselatus*. Meanwhile, another *Anopheles* mosquito that is also found in Indonesia is *An. Farauti*[14], *An.Vagus*[12], *An. Flaavirostris*[15], *An. Indefinitus*[14], *An. Subpictus*[14], *An. Kochi*[14]. Meanwhile, in Southeast Asia, *Anopheles* mosquitoes such as *An. Sundaicus*[16], *An. Gambiae*[17] and *An. Subpictus* in Thailand[18].

The many similarities between the larvae or *Anopheles* mosquitoes found in South Buru Regency and mosquitoes in other regions in Indonesia can be caused by the similarity of ecological conditions in other regions of Indonesia consisting of islands, mountains and mainland. Not to mention, the development of transportation and increased mobility encourage the movement of mosquitoes from one area to another[19].

3. Epidemiology of Malaria Patients with *P. falciparum* Based on Rural and Urban Communities

This research found that children under the age of 10 suffer from malaria, both in urban and rural communities. Rural communities live in malaria-endemic areas and do not have access to health services. In contrast to urban communities who have access to health services. Children who are young are more susceptible to malaria, because of the imperfect immune system[20], especially if the child has anemia[21] and poor nutritional status[22]. In addition, environmental and socioeconomic factors influence the incidence of malaria, such as a history of traveling to malaria-endemic areas. Longitudinal longitudinal studies show that children in endemic areas experience many episodes of malaria, with susceptibility varying significantly based on individual circumstances[22].

This research also found that gender is a factor in the vulnerability of malaria events. Both urban and rural communities suffering from malaria are female. A study in Nigeria revealed that children under five years of age in female-led households face an increased risk of malaria[23]. In 6 Angolan villages, there was a gender vulnerability to malaria[24]. However, other studies showed that there was no difference in malaria incidence by sex[25].

Rural and urban communities in South Buru Regency generally work outside the home as farmers, so they have the potential to be bitten by *Anopheles* mosquitoes. Moreover, their settlement is close to breeding places in the form of forests, rivers, puddles (swamps) and lagoms.

Figure 3 shows the existence of larvae-positive breeding sites with malaria cases using a buffer pattern of the <500 m zone. The results show the distance between the breeding site and the four suspected malaria cases identified within the flight range of *Anopheles* mosquitoes, namely three cases in rural communities and one case in urban communities.

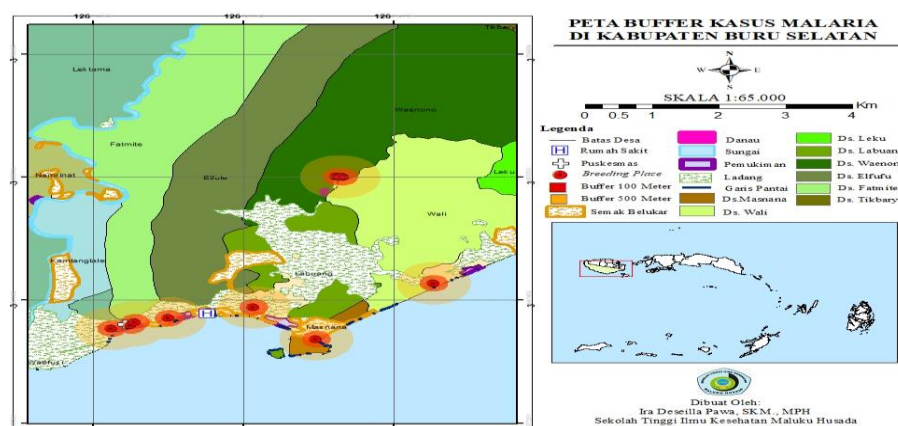


Figure 3. Buffer Map of Malaria Cases in South Buru Regency

This research shows that based on interviews and physical examinations of splenomegaly, all patients suspected of malaria are children, both rural community groups (3 cases) and urban community groups (1 case). The children are suspected of having malaria infections around their homes. This can be seen from the absence of a travel history to other endemic areas. At the same time, his home settlement is an endemic malaria area with a breeding place distance of less than 500 m[26]. The behavior of children who like to play outside the house and during breaks at home, also do not use mosquito nets. In Bangladesh, children's behavior of playing outdoors at night and in the morning affected the incidence of malaria[27]. Similarly, the behaviour of children in Southeastern Tanzania, who perform routine household tasks such as fetching water, washing dishes, cooking, and recreational activities such as playing and learning keeps children outdoors during peak mosquito activity hours (between 18:00 and 23:00)[28].

In addition, children's sleep patterns and the structural design of the house, play an important role in mosquito access. Open homes and the presence of animals increase mosquito infestation, while inadequate use of insecticide-treated nets (ITNs) increases the risk,

To prove and establish the diagnosis of suspected malaria cases, blood samples are taken, then microscopic examinations and/or rapid diagnostic tests (RDT) examinations. Positive results, to immediately be given malaria treatment according to the situation and condition of the children. [29-31]

CONCLUSION

The results showed that the binomic anopheles mosquitoes in South Buru Regency in inland community groups based on geographical conditions far from hilly coasts, farming, while urban community groups based on distributed conditions were more distributed on beaches, slopes and valleys. The Anopheles mosquito found in An.Farauti, An.Vagus, An.Flaavivirostris, An.Indefinitus, An.Subpictus, An.Tesselatus. Cases of suspected malaria were found in children both in rural community groups (3 cases) and urban community groups (1 case) with Anopheles mosquitoes sourced from breeding places around their settlements.

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