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TYPES OF PLASMODIUM AND THE EFFECT OF ENVIRONMENTAL FACTOR AGAINST MALARIA IN MANOKWARI, WEST PAPUA

N. Subekti*[1], M. Paiticen[2], E. I. J. J. Kawulur[3], S. H. K. Sirait[4], S. Mohammed[5]

[1,2]Biology Departement, Semarang State University, Semarang, Indonesia
[3]Biology Departement, Papua University, Manokwari, Indonesia
[4]Biology Education Departement, Papua University, Manokwari, Indonesia
[5]Department of Bioscience, Universiti Technology Malaysia

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ABSTRACT

Malaria is a disease caused by parasitic protozoa (Plasmodium) carried by a vector of mosquitoes. There are approximately 100 million regions around the world at risk of malaria. One of the endemic areas of malaria in Indonesia is Papua. Manokwari is one of the districts in West Papua that has a high number of malaria patients. The purpose of this study was to investigate mosquitoes Plasmodium parasites, and malaria in West Manokwari District. The research procedure applied initial survey of the place where malaria vector was captured, capturing malaria vector, general environmental measurement, mosquito species identification, plasmodium examination on mosquito of malaria vector, and plasmodium examination on malaria patient. The total sample obtained from 3 areas was 1550 patients and 496 mosquitos with average numbers up to 150 mosquitos per area.The physical environment, including rainfall, temperature, humidity, altitude, and environmental conditions inside and outside the home greatly affected the incidence of Malaria in Manokwari, West Papua. Malaria is a serious health problem in Indonesia. The physical condition of the environment is the main factor influencing it.The results showed that the type of malaria vector found in West Manokwari region comes from two genera namely Culicidae and Anophelidae. Each malaria vector could carry infections from Plasmodium vivax or Plasmodium falciparum. There are two kinds of Plasmodium parasites that infected humans in Manokwari; *Plasmodium falciparum* and *Plasmodium vivax*.

Keywords: plasmodium, vector, malaria, West Manokwari

INTRODUCTION

Malaria is a common disease in the tropics and subtropics, with approximately 100 million regions around the world at risk of malaria. Malaria is caused by parasitic protozoa (Plasmodium). Indonesia is one country that has a high percentage of malaria cases, especially in eastern Indonesia such as West Papua. Malaria cases occurring in Papua are caused by infections from Plasmodium parasites, mainly *Plasmodium vivax, Plasmodium falciparum, Plasmodium malariae*, and mixed infections. Research conducted by Sandy (2014) suggests that the case of malaria in Papua has spread in almost all regions. One of the areas affected by malaria cases is West Papua with tertiana malaria and tropical malaria. This case continues to increase from 2013 until the end of 2014.

Research related to malaria disease in Papua region many of which were focused on the development of medical drugs to treat patients

***Correspondence Address**
E-mail: nikensubekti@mail.unnes.ac.id

with malaria. One of which is research conducted by Laman et al. (2014) about testing artemisinin compound to overcome malaria disease in a patient. Manokwari is one of the districts located in West Papua Province. This is a new province of expansion from Jayapura. So, we need to observe the environmental impacts of land conversion from natural forest to residential ecosystems because it is a new city in the Papua province.

Manokwari has a fairly high population density. The increase in population in Manokwari is followed by the increasing number of malaria cases. The population of West Papua is 850,000 people, with rural population composition 70% and urban 30%. This high population is not comparable with the low awareness of community sanitation (Hetzel et al., 2017). Moreover, Manokwari District Health Office shows that the service access of Wastewater Distribution System in Manokwari is still low. This condition underlying to conduct research related to malaria in a rural area.

Manokwari, West Papua is the place where about 70% of malaria disease suffered by the surrounding community is a malaria disease caused by two types of Plasmodium parasites. This is indicated by research conducted by Arif (2009) which states that the most dominant type of Plasmodium with the number of percentages reaches 65% in Anopheles mosquitoes in some areas in West Manokwari District is *P. vivax*. Then the second dominant one is *P. falciparum*. Research on malaria in Papua is still limited to the spread of malaria, various methods of treatment, and resistance levels of malaria.

There is no data on the relationship between mosquito species, Plasmodium species in mosquitoes and Plasmodium infecting malaria patients. This underlies the researcher's curiosity to examine more about mosquitoes, Plasmodium parasites, and malaria in West Papua, especially in west Manokwari district which is expected to produce data that can be used as a reference for further research and become information for the community.

METHODS

Tools and Materials

Equipment used in this research are sample bottle, plastic sample, microscope, object glass, glass deck, tweezers, petri dish, thermometer, hygrometer, mosquito type identification book, stationery, camera, loop 10x, loop 20x, book type Plasmodium, aspirator, strap, rubber band, flashlight, a set of light trap tools, scissors, dropper pipes, needles, and test tubes.

The materials used in this research are the sample of mosquito, giemsa, alcohol, cotton, tissue, ether, clear clay, physiological salt, methanol, emersi oil, mosquito sprayer, formalin 5%, human, and cow. The study was conducted for three months with the location of mosquito sampling conducted in AmbanPantai and Sowi, while the examination of Plasmodium parasite in malaria patients was done at RSDU Manokwari and PuskesmasSanggeng. Identification of types of Anopheles and Plasmodium on Anopheles mosquitoes was conducted in Basic Biology Laboratory of UNIPA Manokwari.

Research Procedures

Research procedures include survey activities, mosquito sampling, mosquito species identification, Plasmodium examination on mosquitoes, and examination of plasmodium in human blood. The surveys were conducted at pre-determined sites in Amban, Amban Pantai and Sowi areas in West Manokwari District. The determination of each location is based on the average flight habit of the female mosquitoes. The flight distance from the female Anopheles mosquito is 2.5 km, so it is taken a distance of five km which aims to reduce the occurrence of catching the same species.

Mosquito sampling was conducted in West Manokwari district using survey method with purposive sampling. Mosquito sampling is done in 4 ways: man landing place (where mosquito land on the human body), light trap method, using livestock feed (cow), and with a mosquito sprayer. Then the measurement of temperature and humidity of the surrounding environment are to find out the general state of the environment.

Identification of the type of mosquitoes is done in the Laboratory of Biology of the University of Papua with an identification guide. The identification of Plasmodium parasite was done by Gatton (2015) method by sampling the salivary glands made into a smear preparation with giemsa additives. Mosquito blood smear preparations were then observed using a microscope with the magnification of 100 for parasites to be seen. Data collection on Plasmodium type in humans was done by taking data in the laboratory of Manokwari Hospital and Puskesmas Sanggeng in West Manokwari District. The identification method of Plasmodium in patient's blood was adjusted to the method used by Manokwari Hospital Laboratory.

Data Analysis

The density of Mosquito Species

The data of mosquito density was then calculated using the standard method formula from WHO (2013) namely:

(a). MBR (Number of mosquitoes that bite people per hour)

$$= \frac{\text{Number of mosquitoes captured by human feed}}{\text{Number of Capture x Time of Capture (hours)}}$$

(b). MHD (The number of mosquitoes perching and captured per person per hour)

$$= \frac{\text{Number of mosquitoes perching and caught}}{\text{Number of capture x time of capture (hours)}}$$

(c). DMH (The density of mosquitoes per house)

$$= \frac{\text{Number of mosquitoes perching caught in the house}}{\text{Number of houses the mosquitoes are captured}}$$

(d). Sporozoite rate

$$= \frac{\text{Number of vector types containing sporozoid}}{\text{Number of the same vector types being dissected}}$$

The parasitic density was calculated by observing a sample object of a blood smear under a microscope then calculating the number of parasites per object. If there is no parasite, then it is denoted by the sign (-). If there are 1-10 parasites per object, it is expressed by the sign (+). If there are 11-100 per film expressed with the sign (++).

Data on the type of Plasmodium parasite in humans are analyzed descriptively and presented in the form of tables and graphs.

RESULTS AND DISCUSSION

Results of Plasmodium Examination in Human Blood

Based on the results of research conducted in the examination of plasmodium in human blood, it was revealed that there are two types of plasmodium. The examination was done by two methods namely Rapid Test Diagnosis (RTD) and manual inspection using the microscope.

Table 1. Results of Plasmodium Examination in Human Blood

Category of Patient	Types of Plasmodium	Infection Categories and Number of Patients Infected	Type of Malaria (number of patients)	Prevalence (%)
Children	PF = 171	+ = 106	Tropica (175)	29.7
		++ = 61		
		+++ = 4		
	GF = 4	+ = 4		
		++ = 0		
		+++ = 0		
	PV = 180	+ = 102	Tertiana (184)	31.2
		++ = 73		
		+++ = 5		
	GV = 4	+ = 4		
		++ = 0		
		+++ = 0		
	N = 234			39.7
Adults	PF = 362	+ = 268	Tropica (369)	38.5
		++ = 87		
		+++ = 7		
	GF = 7	+ = 6		
		++ = 1		
		+++ = 0		
	PV = 275	+ = 187	Tertiana (284)	29.6
		++ =78		
		+++ = 10		
	GV = 9	+ = 7		
		++ = 2		
		+++ = 0		
	N = 304			31.7

Information

PF : *Plasmodium falciparum*
N : Normal
GF : Gamet falciparum
Children : Under 12 years
PV : *Plasmodium vivax*
Adult : Above 13 years
GV : Gametvivax
\+ :1-10 parasite/ film
++ : 11-100 parasite/ film
+++ : More than 100 parasite/ film

Table 1 shows data on the results of plasmodium in human blood. Based on Table 1, it can be seen that from 1550 patients who performed blood tests, as many as 1018 patients were positively affected by malaria. The category of patients infected by malaria is divided into two, namely children and adults. There are two types of plasmodium that infect the patient namely *P. falciparum* and *P. vivax*. When infecting patients, both types of plasmodium are in the adult and gamete phases with infection categories ranging from small (+), moderate (++), to multiple (+++). This indicates that malaria suffered by patients consists of malaria tertiana and tropica.

Karyana et al. (2008) mentioned that the average patient affected by malaria is a patient of children, pregnant women, and immigrants. This is less appropriate with the results of conducted research stating that the largest number of patients come from the adult group. However, because of no more detailed categorization of patients such as the patient's general condition, address, and history of the disease, there is a possibility that of the number of patients examined included pregnant women and immigrants. Figure 1 shows the number of patients infected with plasmodium.

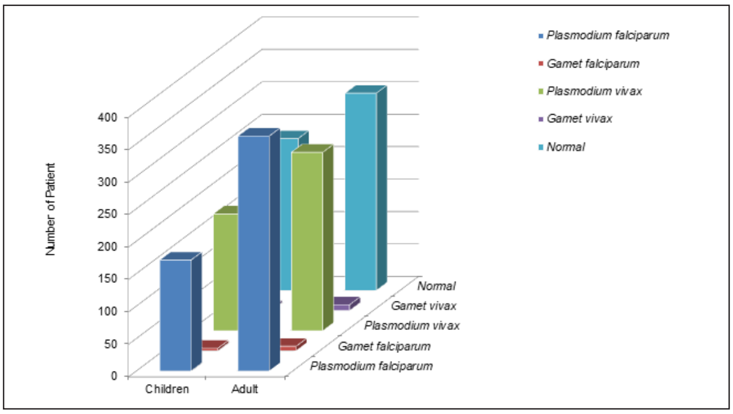

Figure 1. Number of Patients Infected by Two Types of Plasmodium and by Theirgamet Phase

Based on the picture above, it can be seen that patients who perform the blood test are mostly adult patients (900 patients), while child patients are up to 600 patients. The category of adult patients is a group of patients aged 13 years and above consisting of adolescents in SLTA, pregnant women, parents, and immigrants. The categories of pediatric patients consist of infants, toddlers, elementary and junior high school children.

Plasmodium examination of patients only categorizes patients by age so it cannot be known in more detail about the general condition of patients such as conditions of pregnancy, immigrant, infants, and toddlers. The number of patients who have infections is 1018 patients, from the total number of 1550. Type of plasmodium that dominates infection in children and adult patients is *P. falciparum*. *Plasmodium falciparum* infected 541 patients. Previous research performed by Kwenti et al. (2017) found that *P. falciparum* was the only species causing clinical malaria in the target population. Plasmodium phase that causes many infections is trophozoite phase compared to gamete phase. Figure 2 below is a screened image showing the infection ofplasmodium in adult (trophozoite) and gamete phase.

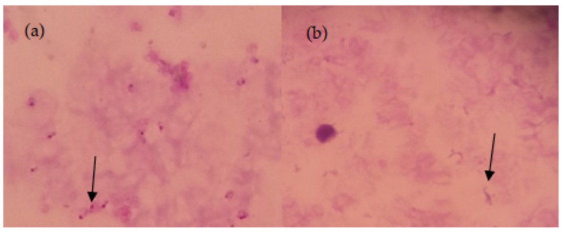

Figure 2. The Infected Blood Samples of *Plasmodium falciparum*. (a) Introphozoite Phase and (b) in Gamet Phase.

Based on Figure 2, it can be seen that the plasmodium infection of trophozoite falciparum is characterized by the appearance of red spots on red blood cells or erythrocytes. Figure

2a above shows *Plasmodium falciparum* infection in the trophozoite phase with infection category +++ which indicates severe infection in human erythrocytes. The characteristic of *Plasmodium falciparum* infection in trophozoite phase is characterized by red spots on the edges of red blood cells. According to Weeratunga et al. (2016), it is suggested that the characteristics of *Plasmodium falciparum* infection in the trophozoite phase are characterized by red spots on erythrocytes. The red spots on the edges of the erythrocytes are trophozoite from plasmodium which will then develop into schizont.

Schizont is a phase of development of plasmodium which is the result of the development of trophozoite. Schizont phase is a phase before gamete formation of *P. falciparum*. Figure 2b shows *P. falciparum* infection in human erythrocytes in gamete phase. Gamete phase is characterized by the appearance of red spots with a lot of intensity in erythrocytes. The erythrocyte will usually dilate and then over time will break apart with the development of gametes in erythrocyte.

Infections of *P. falciparum* result in tropical malaria disease. Buffet et al. (2010) mentioned that tropical malaria is one of four types of malaria known to infect humans. According to Zhang et al. (2016) malaria that can infect humans are tropical malaria, malaria tertiana, malaria malariae or quartana, and malaria ovale. The four types of malaria can be transmitted by a vector of mosquitoes. The vector of malaria is a mosquito of the genus anophelidae, but there are also some of the genusCulicidae that are reported to spread the plasmodium that causes malaria.

Another plasmodium found from the patient's blood test results is *P. vivax*. Plasmodium causes the patient to suffer from malaria tertiana. Groger et al. (2017) stated that the characteristics of patients affected by malaria tertiana include, rising body temperature, sweaty body, weak body condition and sometimes accompanied by dizziness or a headache. Figure 3 below shows the observed images of *P. vivax* infection in the trophozoite and gamete phases.

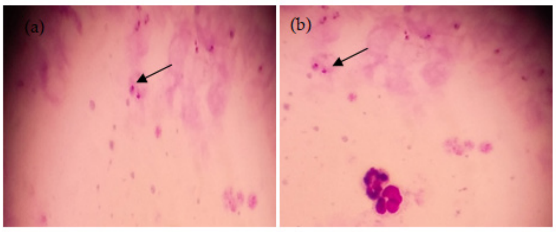

Figure 3. Sample of Human Erythrocyte Infected by *Plasmodium vivax*. (a) Introphozoite Phase and (b) in Gamet Phase.

Figure 3 shows an infection of *P. vivax* in human erythrocytes. Based on the results of the examination, patients infected by *P. vivax* are 468 of the total of 1012 patients infected by plasmodium. Infection by *P. vivax* causes the patient suffering from tertiana malaria disease. The characteristics of infection by *P. vivax* in human erythrocyte are at first glance almost identical. The difference in features of *P. vivax* infection with *P. falciparum* lies in the form of the infected erithrocyte.

Currently, it is known that malaria which is commonly encountered especially in the Southeast Asia region of malaria tropica and tertiana. Based on Table 1, it is known that the prevalence of malaria tropica disease is greater than malaria tertiana. This is in accordance with the statement of Karyana et al. (2008) which stated that in the Papua region, the highest prevalence of malaria cases is malaria tropica. The results showed that the total prevalence of tropical malaria was 68.2% while malaria tertiana reached 60.8%.

Data on prevalence calculations from both malaria types show that infection of malaria tropica is higher than malaria tertiana. Based on the results of a survey conducted on patients at Manokwari District Hospital, the results showed that tropical malaria is suffered by almost all age groups. In a day, new patients infected with tropical malaria look healthy and only have a fever with a high enough temperature. While patients with malaria tertiana look weak, sweaty, and get the high fever.

In areas like Papua, adults infected with malaria have no clinical symptoms of infected malaria. However, the results of the blood test show positive infection of malaria. This condition accords with the previous finding of Sorontou & Pakpahan (2015) that all of the malaria cases in Jayapura district Papua do not show any clinical symptom or called as asymptomatic. This is due to the immunity that occurs due to recurrent infections. The spleen usually enlarges in the first severe infection or after several infections. West Manokwari is one of the areas classified as malaria endemic. Survey on local residents shows that malaria is commonly suffered by people from children to adulthood especially productive age. Malaria incidents mostly happened on toddlers and productive age (Ogutu et al., 2009).

The Result of Capturing Malaria Vector

The location of the capturing activity is done in three different places with three-time repetition. The method used for capturing the object is the method of man landing place where human bait is used to catch the mosquito. Then, the calculation of the number of perching per hour is up to four repetitions. The capturing results revealed the data shown in Table 2.

Table 2. Identification of Malaria Vector Captured in 3 Areas

Location	MBR (%)	MHD (%)	DMH (%)	Types of Mosquito (heads)	Total Number of Mosquitoes (heads)
Amban	18	4, 5	8	Anophelidae (10)	163
				Culicidae (153)	
Amban Pantai	15, 8	6	6,3	Anophelidae (21) Culicidae (122)	143
Sowi	21, 1	9, 5	12, 3	Anophelidae (33)	190
				Culicidae (157)	

MHD: *Man Hour Density*
DMH: Density of Mosquito per House

Based on the above table, the sampling locations are three different areas. Each location is selected based on environmental conditions and altitude. The first location taken is the Amban area. Amban is an urban area in West Manokwari District. The amban area consists of Amban town and Amban beach. Based on the survey results, Amban beach is an area that has very few populations. The environment around Amban Beach has a lot of vacant lands. Additionally, there are many puddles and ditches around the houses.

Amban Beach is part of the Amban urban area. Amban region itself is included in the city area with a considerable population compared to the Amban Coast area. In the Amban area, the city still has vacant lots and gardens. Taviv et al. (2016) stated that the mosquito breeding habitat is diverse. The mosquito of the genus Anopheles likes a place with high gloom, low temperature, and low light intensity. These conditions are crucial for microbial and algal community development especially for aquatic mosquitoes satges (Kweka et al., 2015). Moreover, the light intensity can also affect their flight and oviposition behaviour. They are normally nocturnal, oviposit at twilight and during moon-lit flight (Kampango et al., 2011)

Table 2 shows the results of captured mosquitoes which are malaria vector. Based on Table 2, it can be seen that there are two types of mosquitoes of malaria vector that belong to Culicidae and Anophelidae. Both types of mosquitoes are found throughout the fishing grounds. In the Amban area, the mosquitoes found were 163 heads with ten heads of genus Anphelidae and 153 heads of the genus culicidae. The number of mosquitoes of the genus Culicidae is more than the genus Anophelidae. This can be caused by some environmental factors such as the temperature and humidity of the surrounding air, the intensity of light, the presence of water puddles or the location of mosquito breeding is appropriate with the habitat of the mosquitoes of genus Culicidae.

Anophelidae mosquitoes found in Amban area are only ten tails. The small number of captured Anophelidae is because Amban area is a region that can be categorized as a city area. The mosquitoes of the genus Anophelidae are mosquitoes that like the breeding environment with low light intensity like in the swamps. Amban territory that has been categorized as a city is not suitable as a mosquito environment of the genus Anophelidae.

The results of the mosquito vector in Amban Beach and Sowi areas also show that the population of the genus Culicidae mosquito is more common than the genus Anophelidae. The main characteristic of the distinction betweenCulicidae and Anophelidae lies in the length of proboscis and palpus. The mosquitoes of the genus Culicidae have palpus that is shorter than the proboscis, whereas the mosquitoes of the genus Anophelidae have palpus that have almost the same length or longer than their proboscis. Additionally, the wing of mosquitoes of the genus Anophelidae has a distinctly luminous darkness whereas the Culicidae has no dark shades of light. The wings of Culicidae are patterned black on the bones of their wings.

Research conducted by Taviv et al. (2016) showed that the population of mosquitoes of genus Culicidae is more common than the genus aphelidae. This is in line with the observed data obtained in the West Manokwari area. The results of the MBR or Man Bitting Rate calculations show that in the three locations, the average number of mosquitoes that bite humans each day is above 15%. MBR figures indicate that the number of people bitten by mosquitoes every day is quite a lot. This becomes one of the opportunities for the infection of malaria.

The results of the data analysis also counted the number of mosquitoes that bite humans every hour or so-called MHD (Man Hour Density). Table 2 shows the number of analysis results of MHD in the three locations which have averaged above 4% of the total average number of 150 mosquitoes. The percentage 4% indicates that every 1 hour, the average number of mosquitoes that bite the population is above six heads. This figure is considered quite high and has the potential to become one of the causes of the population infected by malaria.

Transmission of vector diseases such as malaria is influenced by many factors. One of the factors that have been known to have an association with malaria is the topographic area which is closely related to transmission pattern. The height of place can also be a determining factor. Every 100-meter increase then the difference in air temperature with the original place is 0,5°C. If the difference in the place is high enough, then the temperature difference will also affect many other factors including influence by the growth and the spread of mosquitoes. The optimum temperature, between 20-30 °C, is required for mosquitoes to breed in both the aquatic and adult phases (Githeko et al., 2010).

According to the Ministry of Health of the Republic of Indonesia, the location of transmission of vector infectious diseases is determined by the type of topography and the existence of vectors that can adapt to the environment and lifestyle of the community. Idris et al. (2016) stated that malaria disease in the tropics area happens on rapid population growth, migration, and poor sanitation. The dominant factor causing malaria in Manokwari is poor sanitation, seen on their poor environmental hygiene and waste processing. Based on the location of vector infectious diseases, it should be noted that several aspects are zoogeography division, altitude, geographical location, geological arrangement, and area. Moreover, the behavior of each different type of vector also needs to be considered.

Habitat Characteristic of Malaria Vector

Examination of habitat character of malaria vector was performed in 3 different locations. The location of the observed character is the location where the malaria vector has been previously identified and examined. Type of habitat taken consists of 3 types namely in the house, yard, and around ponds and puddles. The following table 3 is the result of examination of the habitat character of the captured malaria vector.

Table 3. Habitat Characteristic of Malaria Vector in 3 Areas Observed

Location	Type of Habitat	Type of Mosquito	Characteristics of Habitat		
			Shades	The temperature of Environment (°C)	Humidity (%)
Amban	Inside House	Culicidae Anophelidae	Sheltered	32	73
	House Yard	Culicidae	Sheltered	31	73
	Puddle	Culicidae Anophelidae	Well lighted	32	73
Amban Pantai	Inside House	Anophelidae	Sheltered	32	74
	House Yard	Culicidae	Well lighted	31	74
	Puddle	Culicidae	Well lighted	31	74
Sowi	Inside House	Culicidae Anophelidae	Sheltered	32	74
	House Yard	Culicidae Anophelidae	Sheltered	32	75
	Puddle	Culicidae Anophelidae	Sheltered	31d	75

Based on Table 3, it can be seen that the category of selected sampling environment is in the house, yard, and pond or puddle around the house. Each environment has its reasons that make the environment potentially as a place of existence of mosquitoes. The home environment is considered to be one of the potential places for mosquitoes due to several factors, namely the humidity in the house tends to be higher than the humidity in the yard environment. This condition supports the mosquito habitat. In some corners of the house, there are places such as humid showers. The bathroom is one of the most important targets for the presence of a mosquito as a reservoir that can potentially be a mosquito-laying environment.

The results indicated that the air temperature had a relationship with the incidence of malaria in Manokwari region. The air temperature measurements carried out during the study and also reported by BMG West Papua showed that the average maximum and minimum temperature limits were still within the temperature range that was in accordance with the survival of malaria mosquitoes. The suitability of the air temperature in this research location made malaria mosquitoes survived and reproduced optimally.

Air temperature is a transmission of malaria. Malaria would develop along with the development of mosquitoes. If the temperature of the region allows the anopheles mosquitos to live, then malaria will also develop in the region. Temperature is a major factor in the development of mosquitoes. The sporogonic cycle takes 9-10 days. The temperatures of >30^{o} C will have an impact on the short incubation period of parasites so that the proliferation of malaria becomes faster.

Humidity is one of the main factors of physical environmental conditions associated with malaria. Direct humidity measurements at the study site showed an average humidity of 73-75%. This high humidity was influenced by evaporation and the presence of plant growths such as sago, nipah and others. This degree of air humidity could still be adapted by plasmodium. The humidity of >60% will cause the significant increase in infection rates.

Rainfall is an environmental factor that greatly affects the life of anopheles mosquitoes. The results revealed that rainfall in the research location was high. This high rainfall was influenced by abundant coastal water vapor. High rainfall causes a lot of water. This pool of water causes the mosquito to optimally lay eggs.

At the study site, the researchers found that the pH of the water was one of the factors causing malaria. 6-7 pH of water is the normal level for the survival of the Anopheles mosquito larvae. The normal pH levels strongly support the larval and larvae development of Anopheles mosquitoes. Anopheles larvae are very fond of normal pH conditions.

The height of the research site was a factor that influenced the incidence of malaria in the Manokwari region. The results showed that the study location was in the lowlands. At low research locations, mosquitoes had a wide range of flying. The height of the place is related to temperature, resulting in the lowlands' high temperature than the plateau.

The physical condition of the houses in the Manokwari community was generally very simple since it was made of used boards, bamboo, thus, holes in the wall of the house were easily found. These holes were not coated with gauze, so that the anopheles mosquitoes could freely enter the house and attacked the occupants. The houses' cleanliness both inside and outside was not well-mantained. Much dirt, many untreated tools, and stuffy house conditions made the anopheles mosquitoes liked such condition. Outside the house, there were often piles of used goods and scattered garbage. Overall, the condition of dirty houses was the cause of malaria in Manokwari, West Papua.

The yard of the house becomes one of the locations chosen to be included as the location of the mosquito environment. The underlying selection of home yard as a location of catching mosquito is due to the existence of plants around the home yard. In addition to the temperature and humidity of biotic factors, plants become one important factor where mosquitoes are breeding. When laying eggs, several species of mosquitoes look for locations with plants around it as the place for the candidate of the mosquito larvae.

The location of the third arrest is selected in the puddle. Water puddles become one of the important locations as a breeding ground for mosquitoes, especially spawning. Mosquitoes need a water surface to place the eggs. Female mosquitoes will put their eggs on the surface of the water that will hatch and develop into larvae. In addition, water becomes one of the important components for mosquito breeding because the aqueous environment tends to be moist and the temperature is low.

Based on the data, there were two types of mosquitoes captured, namely genus Culicidae and Anophelidae. The mosquitoes of the genus Culicidae are found in all locations both inside the house, the yard, and the puddles. While the mosquitoes of the genus Anophelidae are found only in homes and pools of homes. Differences in the environment where two types of mosquitoes are found shows that both have some different breeding characteristics.

Temperature and humidity in the capturing location of mosquito are quite effective as a living environment and breeding place for mosquitoes. Temperature and humidity greatly affect the life of mosquitoes. According to the Ministry of Health of the Republic of Indonesia, the rain will affect the rise of air relative humidity and increase the number of vector breeding places (breeding places). Air relative humidity is the amount of moisture content in the air. If there is a large water shortage in the air, then this air has a large evaporation power. Respiratory system in mosquitoes is using air pipe (trachea) with holes in the mosquito body wall called spiracle. The spiracle is open without any regulatory mechanism(Mamai et al., 2016). At low humidity, it will cause the evaporation of water from inside the body of the mosquito that can lead to the drying of body fluids of mosquitoes.Umaru & Akogun (2015) suggested that ideal air and water temperature for larvae and adult Anopheles mosquito is respectively 26.5-28^{0}C and 33-36^{0}C with relative humidity of approximately 60-75%.The peak biting time for *Anopheles spp* was between 19:00 and 20:00 h but continued throughout the night outdoors. The peak biting indoors was between 22:00 and 23:00 h (Liu et al., 2011).

According to Correia et al. (2015) and Fernández et al. (2017), Anopheles's breeding habitats are classified into two categories, i.e., flowing water habitats and aquatic habitats. Flow water habitats can be slow-flowing water channels, irrigation canals, and streams that flow swiftly or slowly. Anopheles larval habitats found close to residential areas indicate the magnitude of the transmission risk of malaria if the habitat has a vector that breeds. The distance between the vector and residential breeding habitats is one of the risk factors for malaria incidence. Anopheles larvae breeding habitat is found to be commonly found in aquatic plants. Plants are very influential on the life of mosquitoes, among others, as a place to lay eggs, shelter, where to find food and shelter for larvae and resting place for mosquitoes (Rejmánková et al., 2013).

Results of Plasmodium Inspection on Malaria Vectors

The examination was carried out with samples of mosquitoes captured at three locations in West Manokwari District, i.e., Amban, Amban Pantai, and Sowi. Based on the results of the examination (Table 4), it can be seen that there are two types of plasmodium in the vector examined, *P. vivax* and *P. falciparum*. The results show that the two types of plasmodium could be found in both the malaria vector of Anophelidae and Culicidae.

Table 4. Results of Plasmodium Examination on Malaria Vectors

Location	Type of Mosquito	Examined Mosquito (Heads)	Type of Plasmodium		Sporozoid Rate (%)
			PF	PV	
Amban	Anophelidae	7	+	-	70
		3	-	-	
	Culicidae	153	-	-	0
Amban Pantai	Anophelidae	11	+	-	52,3
		10	-	-	
	Culicidae	3	+	-	2,6
		119	-	-	
Sowi	Anophelidae	9	+	-	36,3
		3	-	+	
		11	-	-	
	Culicidae	157	-	-	0

The intensity of *P. falciparum* discovery in the malaria vector is higher than that of *P. vivax*. This is consistent with malaria patients who are mostly infected with *P. falciparum* compared to *P. vivax*. Elyazar et al. (2011) explained that *P. falciparum* and *P. vivax* were the most commonly occure together in Indonesia, but *P. falciparum* dominated in more locations than *P. vivax* (60% vs 30%). The number of malaria vector which positively contains plasmodium is still small compared to those who negatively contain plasmodium. The least plasmodium found in malaria vectors indicates that there has been a decrease in the malaria-spreading vector that affects the reduced number of malaria-infected patients.

Based on data from West Papua Provincial Health Office 2015, the data show that malaria patients in West Manokwari District reach 50% of the total population. When it is compared to the examination data on the number of malaria patients in western Manokwari hospital, it can be predicted that the number of malaria patients decreased. A decrease in the number of malaria patients shows that efforts to overcome the spread of malaria disease and show a good impact than ever before. Nevertheless, this study provides relevant information on what can be done in the prevention and control of malaria effectively in these areas. In addition, this information then leads people to maintain the environmental health to prevent malaria.

CONCLUSION

Based on the results of this study it can be concluded that the type of mosquitoes which are the vectors of malaria found in West Manokwari region consists of two genera namely genus Culicidae and Anophelidae. Each malaria vector can carry infections from both *P. vivax* and *P. falciparum*. From the results of the examination, plasmodium which is commonly found is *P. falciparum*. Plasmodium parasites that infect humans are *P. falciparum* and *P. vivax* with a single type of infection in which the patient is only infected by one type of plasmodium and double that is the patient infected with more than one type of plasmodium.The environmental factors that affected the proliferation of Anopheles mosquitoes included temperature, humidity, rainfall, pH, and the physical condition of the house.

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