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Determinant factor affected the presence of *Aedes sp*. in a customary village

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ABSTRACT

Vector surveillance and control are the only reliable means for the prevention and control of dengue fever and dengue hemorrhagic fever, such as in Customary Village environments. Indonesia is an archipelagic country that has many Customary Villages, so the variables that affect the breeding of dengue vectors are numerous and complex. This study identifies potential vector breeding places and environmental factors for the presence of *Aedes sp.* in Customary Villages. A study with a cross-sectional design was conducted in the Segenter Customary Villages, West Nusa Tenggara, Indonesia. Simple and multiple logistic regression analysis to identify risk factors associated with the presence of *Aedes* larvae. The results showed that the entomological index was in the high category and at risk as a potential breeding place for the *Aedes sp.* The determinant factor that affects the presence of dengue vectors is the traditional type of house (p-value=0.005; RP=2.138). This factor is strengthened by the 70-90% humidity (p-value= 0.009; RP=1.764), 25-30 ºC house temperatures (p-value=0.011; RP=1.650), and mixed type house (p-value=0.067; RP=1.413). These findings contribute to the development of an early warning system regarding the potential spread of *Aedes vector-borne* diseases, increase awareness, promote and prevention of dengue fever (DF), and its vectors to healthy tourism in Indonesia.

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1. INTRODUCTION

Dengue hemorrhagic fever (DHF) is an infectious disease caused by a virus that is transmitted through arthropods [1] known as the dengue virus (DENV). The virus is of the genus Flavivirus with four serotypes: DENV 1-4. DENV is transmitted through the bite of an infected *Aedes* mosquito, particularly *Aedes (Ae.) aegypti Linnaeus* and *Ae. albopictus Skuse*, which is known as a major and secondary dengue vector [2], [3]. Nearly 75% of dengue fever sufferers live in the Asia-Pacific region, and the dengue rate in Southeast Asia is 18 times higher than in the Americas, and half of the world's population lives in areas at risk for dengue [4], [5] Indonesia is a tropical country that is home to the two main mosquito vectors of DENV species, namely *Aedes aegypti* and *Ae. albopictus* so that it becomes endemic in almost all areas [6]. In 2021, there were approximately 73.5 thousand dengue cases reported in Indonesia. During 2017-2021, the highest number of dengue cases was in 2019, with more than 137 thousand confirmed cases [7].

While an effective multivalent dengue vaccine is still under research and not yet available, vector control and entomological surveillance are the only reliable means for dengue prevention and control [8]–[11]. The development and presence of dengue vectors are influenced by various factors such as ecology, socioeconomic, environment, climate change, globalization, travel, and also the evolution of the virus [12]–[14]. *Ae. aegypti* has high adaptability to urban and domestic areas, where this vector breeds around human habitations in various artificial and natural containers in urban and rural areas [15], [16]. *Ae. albopictus* exhibits strong ecological plasticity and exhibits a remarkable capacity to adapt to urban and sub-urban climates under various conditions, replacing *Ae. Aegypti* [17], [18].

Indonesia is an archipelagic country, until 2021 there were 1,331 tribes and 488 Customary Villages [19], this makes the variables that affect the breeding and reproduction of dengue vectors very large and complex [20] because each tribe and custom have different characteristics. Risk factors for potential vector breeding places and physical environment can provide important information to fill the gap in our knowledge about dengue vector dynamics, especially data related to indigenous peoples in Indonesia, which so far has not been available. Several recent studies have shown that well-constructed modern housing can be protective in many tropical countries [21] and simple features, including covered roofs, brick walls, tile or metal roofs, or ceilings can reduce entry into the house of mosquito houses [22]. However, the types of community houses in Indonesian traditional villages vary widely, such as traditional houses, mixed houses, and modern houses, so a type house screening is needed as an effort to determine its contribution to the *Aedes* vector control program. The home screening was the first intervention piloted in Italy after a link between malaria and mosquitoes was discovered [23]. Home screening has been shown to reduce the risk of malaria in India, South Africa, and the United States [24]. The latest information regarding the presence of dengue vectors and risk factors in traditional villages is important for designing effective vector control programs and dengue fever prevention strategies to create healthy tourism areas. This study aims to investigate potential vector breeding places and environmental factors for the presence of *Aedes sp.* in Customary Villages.

2. METHOD

2.1. Study location

This research was conducted in the Segenter Customary Village, North Lombok, West Nusa Tenggara, Indonesia. Reports of DHF cases in North Lombok in 2020 are 247 cases. The local culture is still preserved by the community, one of which is the Segenter Traditional Village. This hamlet is inhabited by the Sasak people in the form of belief in ancestral traditions that influence the behavior and patterns of community settlements. Every rule has a meaning that contains the value of obedience and norms. The traditional house is made of bamboo, ground/mud floor, thatch roof, and woven walls is a potential place for mosquitoes to enter the house. The use of the container in community activities has the potential to be a breeding place for vectors.

2.2. Study design and sample size

This study used a cross-sectional design with samples from the community living in the Segenter Customary Village. The sample size was determined based on the random survey formula (α=5%) [25] and the number population of as many as 81 houses, thus, it takes 67 houses as a sample by using a simple random sampling technique with a lottery system.

2.3. Entomology survey

Larvae were collected from all large natural and artificial containers (>30 liters of water) found around the sample house by the procedure of ‘five sweeps’ using a fine-mesh hand screen. In small containers (<30 liters of water volume) use a larval dipper or pipette [26]. The collected water sample is poured through a sieve into a white bowl for better visualization, counting, and specimen collection [27]. The larvae obtained were identified using the guidelines from Rueda [28] and calculated using the container index (CI), house index (HI), and breteau index (BI) indicators.

2.4. Potential vector breeding places

The indicator used to identify potential breeding places for *Aedes sp.* larvae is the maya index (MI). MI uses two indices, namely the hygiene risk index (HRI) and the breeding risk index (BRI). HRI is obtained by calculating the availability of disposable containers (DC), namely containers that are no longer used or wasted. BRI is obtained by calculating the availability of controllable containers (CC), namely containers that are still used.

2.5. Physical environment

The variables measured are i) type of house, consisting of traditional houses, mixed houses, and modern houses [29], [30]. ii) house temperature (from e.g. 25–30 °C) [31]. iii) the level of lighting was measured using a lux meter [32]. iv) humidity was measured using a hygrometer (from e.g. 70-90%) [33]. v) the existence of cattle pens was measured using a distance meter. All measuring instruments used to measure physical environmental conditions have been calibrated.

2.6. Statistical analysis

The data were analyzed in three stages, namely univariate analysis to get an overview of the entomological survey results, type of house**,** potential breeding places for *Aedes sp.* vector, and physical environment. Bivariate and multivariate analysis using simple and multiple logistic regression test with α: 0.05. The results of a simple logistic regression analysis were used to determine the relationship between potential vector breeding places and the physical environment associated with the vector presence of *Aedes sp*. with a p-value <0.25 [27].

2.3. Ethical approval

The Ethical Committee of the Faculty of Health Science, Respati University of Yogyakarta, approved this study under the ethical clearance number: 115.3/FIKES/PL/IV/2020.

3. RESULTS AND DISCUSSION

3.1. Characteristics of customary community

Characteristics of customary community in Village Segenter are aged 30-44 years (38.8%), female (79.1%), do not attend school (44.8%), farm laborers (83.6%), Sasak ethnicity (100%) are the indigenous tribe that inhabits the island of Lombok.

3.2. Type of houses

There are three types of community houses in Segenter, namely customary houses, mixed houses, and modern houses can be seen in the Figure 1. The arrangement of the residential area of the house is built facing each other between the door of the house and other houses and the distance between houses is not too far ± 3-5 meters. A fence does not separate each house but a berugaq is a family gathering place because the owners of the house still have family relationships [30], [34]. The traditional customary house has a box-shaped house made of simple bamboo material, has an earth/mud floor, a thatched roof, and a berugaq with an open side. In the interior of the house, there are several rooms without partitions. Customary houses do not have windows or ventilation, but the walls of woven bamboo with a gap of 1.5-2 meters can be a place for light and air to enter and exit (Figure 1(a)). The mixed house type is a combination of a traditional house with a modern house. The construction and shape of the building are quite simple like a traditional house, but some parts have been changed, such as the roof made of zinc/tile and the floor of the house made of cement (Figure 1(b)). The modern house has followed the changing times. All house-building materials use bricks, walls are made of cement, roofs are made of zinc/tile, windows and ventilation, and floors are made of ceramic/cement (Figure 1(c)).

3.3. Entomology Survey

The larval survey was carried out during the rainy season (May–November) in 368 containers from 67 houses it was found that the larvae of *Aedes sp.* were in 145 containers from 39 houses. The most common species found were 167 larvae of *Ae. aegypti* (73.1%) followed 39 larvae of *Ae. albopictus* (26.5%). The observations in containers show that the density level based on the HI indicator is 58.2%, CI 39.4%, and BI 145.0%.

3.4. Potential vector breeding places

The characteristics of containers in Customary Villages are calculated based on MI indicators. MI is categorized, namely: CC and DC as shwon in Table 1. Table 1 shows that the most widely used CC-type containers and larvae found were *"bongs"* (Figure 2(a)) by 67.6%. Bong is a water storage place made of clay outside the house and placed next to the customary house. The existence of bongs is not for personal interests but for common interests, such as the ritual of ablution before praying. There is a belief from the customary community that water reservoirs are allowed to be in the traditional house environment but should not be as large as a pond, if there are house owners who violate it will bring "*roga"* (disease). The type of bath (Figure 2(c)) used by the community is made of cement and is large enough ±60 liters to meet the needs of 5-6 family members such as bathing, cooking, washing, and defecating. The most used type of DC containers and found larvae were used water jugs (Figure 2(b)). The former water jug is a former place to store drinking water made of clay. Most people prefer to drink jug water because it feels more refreshing and there is a belief that jug water has the property of curing minor ailments such as stomachaches.

(a)

(b)

(c)

Figure 1. Comparing the potential risk factors for the presence of *Aedes sp.* vector based on the type of house in the Segenter traditional village, namely: (a) customary houses, (b) mixed houses, (c) modern houses

Table 1. Potential breeding places for *Aedes sp.* in Customary Villages

Types of container	Number	Container with larvae	Percentage larva-positive	Percentage larva-positive of the total container
Controllable containers	307	126	41.0	86.9
Bucket	12	2	16.7	1.4
Bath	98	26	26.5	1.9
Bong	197	98	49.7	67.6
Disposable containers	61	19	31.1	13.1
Used tires	1	0	0.0	0.0
Plastic container	11	2	18.2	1.4
Water jug Wood/Bamboo/Iron pieces	44	16	36.4	11.0
(Glass shards)	5	1	20.0	0.7
Total	368	145		100

Table 2 shows that the potential breeding places for *Aedes sp.* larvae found in the Segenter Customary Village based on the BRI value are included in the high-risk category because the community provides a lot of CC for daily water needs for all family members. Based on the HRI value, it is included in the high category because there is still some garbage in the home environment that has the potential to be breeding places for *Aedes sp.* vectors. Table 3 based on MI values shows that most of the houses (43.3%) in Customary Village are at high risk as potential breeding places for *Aedes sp*.

(a) (b) (c)

Figure 2. Types of CC and DC in traditional villages where *Aedes sp.* larvae, namely: (a) Bong/Crock, (b) Water Jug, (c) Bath

Table 2. 3x3 Matrix of BRI, HRI, and maya index (MI) value proportion in customary house

HRI/BRI categories		BRI Low		BRI Medium		BRI High	
		Number of houses	Percentage	Number of houses	Percentage	Number of houses	Percentage
HRI	Low	2	3.4	4	6.0	21	31.3
	Medium	4	6.0	5	7.5	5	7.5
	High	3	4.5	9	13.0	14	20.9

Table 3. The value proportion of BRI, HRI, and MI in customary house

Categories	HRI		BRI		Maya index	
	Number of houses	Percentage	Number of houses	Percentage	Number of houses	Percentage
Low	26	38.8	9	13.0	10	14.9
Medium	14	20.9	18	27.0	28	41.8
High	27	40.3	40	59.7	29	43.3
Total	67	100.0	67	100.0	67	100.0

The larval density in the Segenter Customary Village is based on the WHO Density Figure with the CI and BI indicators included on a scale of 8, HI included on a scale of 7 [35]. These results indicate that the presence and density *of Aedes sp.* vectors in the Customary Village environment are in the high category. Traditionally, entomological indices such as HI, BI, and CI were the main monitoring tools of many vector control programs in dengue-endemic countries around the world [34]. This index not only measures the success of vector control strategies but also helps to understand vector ecology. There has been no DHF control program carried out by the community health center based on the characteristics of the community and the area of the customary community. This condition should not be ignored, because of the high attractiveness of Customary Villages as destinations for tourists, thus allowing for the potential for dengue transmission. Tourists who come from various DHF endemic and non-DHF endemic areas, if supported by the presence and density of the *Aedes sp.* vector in the area visited, they have the potential not only to be transmitted but also to spread dengue virus infection both from tourists and residents [36].

Ae. aegypti is the main dengue vector in Indonesia and is well adapted to human habitation and the surrounding environment [37], [38]. The results of the measurement of the regional risk level based on the MI indicator show that the customary environment is at a high-risk level as a potential breeding place for the vector *Aedes sp.* This is because the customary community provides lots of CC and DC-type containers that have the potential to become mosquito-breeding places, such as bongs, water jugs, and baths made of cement and clay. Containers made from cement and soil have a rough surface, so they have the impression of being difficult to clean, easy to grow moss, and have low light reflections. This condition makes it easier for microorganisms to grow on the walls of the container serving as larval food [14]. On the trough walls of the container, female mosquitoes can hold on tightly, so that they can adjust their body position when laying eggs [39]. Containers made of cement and soil tend to be darker in color, making them more preferred by *Ae. aegypti* as a breeding place [15]. This type of container is related to the culture of customary community, traditions, and beliefs from generation to generation in choosing the type of container to hold water as shown in Figure 2. The belief of these indigenous peoples is a strong binding rope, where violations of these traditions can cause feelings of guilt in the adherents [40].

Aedes sp. is a type of vector with very good adaptability to various environmental conditions related to the various types of containers, especially man-made open habitats/containers [15], [41], while water quality and characteristics determine the species diversity and composition of mosquitoes [42]. Several types of containers in this study are similar to the observations made by Wijayanti in Purwokerto which found that indoor baths are the main breeding places for *Ae. aegypti* in districts with high and low incidence [43]. However, this study contradicts the research of Edillo *et al.* in the Philippines who found that plastic drums, metal drums, and plastic containers were the main breeding places for *Ae. aegypti* [44]. To eliminate the main breeding places for *Aedes sp*. it is recommended that containers be emptied, tightly closed, and cleaned regularly, while used goods that can accommodate can be disposed or recycled [45].

3.5. Risk factors for the presence of dengue vectors

This study observed environmental factors associated with the presence of dengue vectors. Observations were made on house type, house temperature, light intensity, humidity, and corral as shown in Table 4. The table shows that the traditional house and mixed type house are at risk 2,148 times and found higher larvae *Aedes sp*. compared to modern houses. Observation results showed that >73% of houses with high *Aedes sp.* vector larval findings came from houses that had a temperature of 25-30 ºC and humidity of 70-90%. Risk values show that a house temperature of 25-30 ºC has a risk of 1,750 times and air humidity of 70-90% has a risk of 1,824 times and the test results also show that there is a significant difference (p-value <0.05). Distance from the house close to the corral has a risk of 1,256 times, but there is no significant difference in the high *Aedes sp.* compared to houses with a faraway corral (p-value>0.05).

Table 4. The relationship between the environment with the presence of dengue vectors in Customary Village

Variable	Control measures for vector *Aedes sp.*				Point estimates			Ratio prevalence (CI 95%)	p-value
	High risk (CI>20%)		Low/Not risk (CI≤20%)		Risk (%)				
	n	%	n	%	Ex-posed	Un-Exposed	Overall		
House type									
Modern* (Unexposed)	13	19.4	20	29.9					
Mixed (Exposed)	15	22.4	6	9.0	45.5	39.4	40.9	1.813 (1.097-2.996)	0.0256
Traditional (Exposed)	11	16.4	2	3.0	84.6	39.4	52.1	2.148 (1.326-3.480)	0.0069
House temperature									
Risk (Exposed)									
No risk (Unexposed)	24	35.8	8	11.9	75.0	42.9	58.2	1.750 (1.136-2.695)	0.0090
	15	22.4	20	29.9					
Light intensity									
Dim (Exposed)	23	34.3	12	17.9	65.7	50.0	58.2	1.314 (0.863-2.002)	0.2061
Bright (Unexposed)									
	16	23.9	16	23.9					
Humidity									
Risk (Exposed)	27	40.3	10	14.9	73.0	40.0	88.2	1.824 (1.129-2.949)	0.0079
No-risk (Unexposed)									
	12	17.9	18	26.9					
Corral									
Distance (Exposed)	22	32.8	12	17,9	64.7	51.5	58.2	1.256 (0.830-1.900)	0.2883
Distance (Unexposed)									
	17	25.4	16	23.9					
Total	39		28						

Notes: %: Percentage, CI 95%: Confidence interval 95%

3.6. Determinant factors related to control measures for vector *Aedes sp.* breeding places

Table 5 shows the determinant factor that affects the presence of dengue vectors (*Ae. aegypti* and *Ae. albopictus*) in Customary Village.

Table 5. Determinant factors for the presence of dengue vectors in Customary Village

	β	Sig.	Exp (β)	95% C.I.for Exp (β)	
				Lower	Upper
Traditional House	1.108	0.005	2.138	1.232	2.876
Humidity	1.113	0.009	1.764	1.122	2.738
Temperature	1.089	0.011	1.650	1.136	3.322
Mixed Type House	0.871	0.067	1.413	0.832	2.165
Constant	-3.488	0.014	.086		

Note: Exp (β)= Exponent Beta; Sig= Significance; CI for Exp (β)= Confidence Interval for Exponent Beta. The result of the function quality assessment based on the calibration parameters of the Hosmer and Lemeshow Test showed 0.782 score, which means that the acquired function has a decent calibration because p-value > 0.05. The discriminant value based on Area Under Curve (AUC) was 0.782 (78.2%= close to 100%).

The determinant factor that affects the presence of dengue vectors (*Ae. aegypti* and *Ae. albopictus*) in Customary Village is the traditional type house. The 70-90% humidity, 25-30 ºC house temperatures, and mixed-type house strengthen this factor. These are the probability and function results to predict the high presence of *Aedes sp.* vector in Customary Village (1). This equation shows that non-routine physical measures, knowledge of the head of the family about DHF are traditional type houses, 70-90% humidity, 25-30 ºC house temperatures, and mixed-type community houses contribute 78.23% to the high presence of vectors *Aedes sp.* in the Customary Village.

Equation (y) = -3.488+ 1.108 (Traditional House) + 1.113 (Humidity) + 1.337 (Temperature) + 1.218 (Mixed Type House) = 1.288

$$\text{Probability (P)} = \frac{1}{(1+e^{-y})} = \frac{1}{(1+2{,}7^{-1{,}288})} = 0.548\text{x } 100 = 78.23\% \quad (1)$$

Notes:
P= the probability of an event occurring; e = natural number = 2.7; y = Constant

The results of this study show that there is a relationship between traditional house types and mixed house types with the presence of *Aedes sp.* in the Customary Village. The buildings in the Customary Village use natural materials that are easily found in the surrounding area, such as the walls of the building using woven bamboo which can provide good air circulation through the gaps of the woven bamboo. The roof of the building used reed material which can protect from the hot sun and warmth at night and the higher floor of the house can provide warmth for the occupants of the house [34], [46]. Walls and roofs with woven bamboo that are not tight are a favorite place for mosquitoes to rest and become accessible for mosquitoes to enter the house [24], [47]. Customary houses also do not have partitions, so the kitchen, bedroom, and dining room become one. This condition increases the risk of household occupants coming into contact with mosquito vectors. This study is confirmed by the results of previous studies which state that full-house screening is effective in reducing indoor vector density so if the screening is only on the roof, the integrated tropical disease control program will be neglected [48]. Customary house types built over 20 years are associated with the presence of mosquitoes [49], [50]. Changes in house construction patterns can help prevent human-mosquito contact and potentially reduce the transmission of vector-borne diseases through a local approach. In the alert phase, a community-based approach is needed to improve and maintain the condition of the house and the peridomestic environment, carry out surveillance activities, and apply simple self-protection methods such as using mosquito nets while sleeping, using household insecticides, repellents, and others [47].

The results of this study show that there is a relationship between temperature and humidity with vector abundance of *Aedes sp.* This condition can be influenced by the physical construction of the traditional and mixed-type houses described previously. There are several studies in Indonesia and other countries that show that temperature is one of the key factors for mosquito spread and DENV transmission [46], [51]. Temperature modulates the DENV epidemic impacting reproduction numbers and generation intervals [53]. The speed of the dengue epidemic is affected by increasing temperature, not only because there are more infections per generation but also because generations are getting faster [52] with increasing temperature, the extrinsic incubation period decrease, the frequency of biting increases, and the average life span of mosquitoes increase [53], [54]. The thermodynamic model predicts that when the mean temperature is <18 °C, the DENV transmission increases as the diurnal temperature range (DTR) increases, whereas when the mean temperature is >18 °C, the DENV transmission decreases [55]. Previous studies have shown that relative humidity is also a contributing factor to vector abundance and DENV [55]. Temperature dictates a reasonable range of transmission and humidity within that range reinforces that potential [55].

3.7. Study Limitation

This study was limited by data collected in the household and surrounding environment for the presence of *Aedes sp.* and excluded other habitats in non-domestic environments. Detection of DENV in mosquitoes was not carried out; if available, it may provide valuable additional information about the potential risk of dengue transmission in Customary Village. Despite these limitations, this study can provide basic information to plan effective control programs without having to change the traditions of the customary community.

4. CONCLUSION

The study revealed that the vector density level of *Aedes sp.* was in the high category and had a high risk of becoming a potential breeding place for vectors. The determinant factor that affects the presence of dengue vectors in the Customary Village is the traditional type of house. This factor is strengthened by the 70-90% humidity, 25-30 ºC house temperatures, and mixed-type house. These findings contribute to the development of an early warning system regarding the potential spread of *Aedes.* vector-borne diseases, increase awareness of the public and tourists, promote prevention and control measures in the community and individuals about DHF, and its vectors to realize healthy tourism in Indonesia.

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