Physical environments of water containers and Aedes sp larvae in dengue-endemic areas of Tanjungpinang Riau

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Abstract

Purpose: This study aimed to determine the relationship of the container environment's type and condition to the existence of Aedes sp larvae in Tanjungpinang Timur District. **Methods:** An observational study with a cross-sectional approach involved 401 houses with containers in Tanjungpinang Timur District, Tanjungpinang City. Data on the existence of larvae was performed using the single larvae method. Data on container type and container environmental conditions (water pH, water temperature, air temperature, air humidity) and larvae's presence were collected by observing and measuring. **Results:** 863 containers were observed, 138 of them (15.99%) were found larvae of Aedes sp, containers inside the house (65.57%), and not closed (88.53%). The types of containers were controllable sites (95.13%), disposable sites (3.36%), and under controllable sites (1.51%). The measurement of water pH (76.13%) and water temperature (82.73%) of the containers were categorized as good. Container temperature 98.38% showed results with a range of unfavorable conditions (<200C &> 300C) and air humidity of 99.07% with a range (<81.5% &> 89.5%). Type, location, condition of container closure, water pH, water temperature, and air temperature of containers were related to larvae in Tanjungpinang Timur District (p-value <0.05), while the variable humidity was not related to the existence of larvae. **Conclusion:** Physical environmental factors strongly support the reproduction of DHF vectors in the East Tanjungpinang District. It is necessary to increase public knowledge and routine home eradication of mosquito nests (PSN), especially controllable site containers widely used as water reservoirs.

Keywords: Aedes; dengue; environmental factors; larvae; endemic areas

INTRODUCTION

Dengue hemorrhagic fever (DHF) is an infectious disease transmitted through mosquito bites, which is found in many tropical and subtropical areas around the world. Dengue infection is the fastest emerging disease of all vector-borne diseases, a serious threat to 2.5 billion people worldwide. In the last 50 years, the incidence of DHF has increased 30-fold, affecting more than 120 tropical and subtropical countries. WHO estimates that every year, 50-100 million new dengue infections occur globally [1].

DHF is endemic in several areas, including Africa, America, the East Mediterranean, Southeast Asia, and the western Pacific, threatening more than 2.5 billion people [2]. Dengue hemorrhagic fever (DHF) is endemic in 10 out of 11 countries in the WHO Southeast Asia Region (WHO South-East Asia Region) except for the Democratic People's Republic of Korea. About 50% of the regional population is at risk of dengue [1].

The incidence of arboviral infection is usually sensitive to changes in rainfall and temperature [3]. As one of the tropical countries with high humidity, Indonesia triggers the breeding of mosquitoes such as Aedes aegypti, which is one of the dengue vectors. The morbidity rate due to dengue fever in Indonesia in the last five years has fluctuated. In 2016 there was an increase in the incidence rate (IR) of DHF by 78.85 compared to 2015, which was 50.75 per 100,000. This downward trend in IR also occurred in 2017 and 2018, with IRs 26.10 and 24.75 per 100,000 population, respectively. In 2019 there was an increase to 51.4 per 100,000 population. The problem that needs to be considered is the morbidity rate and the mortality rate caused by DHF. In the last five years, DHF death has ranged from 900 to 1500 people per year [4].

The DHF epidemic cycle in Riau Islands usually occurs every nine-ten years. In other words, every 9-10 years, there will be a drastic increase in DHF cases compared to the previous year. The dengue situation occurred in Riau Islands Province in 2016, with the Incidence Rate (IR) of DHF per 100,000 population reaching 107, then decreased in 2017, which was only 39 per 100,000 population. The latest data shows that in 2018 it was 56.35 per 100,000 population. Of the seven districts/cities in the Riau Islands, Bintan Regency was the highest IR area in 2017, namely (55.73 / 100,000 population at risk). In Batam City (46 / 100,000 people are at risk), while the IR DBD of Natuna Regency and Anambas Islands Regency is 0 / 100,000 at risk. In 2017, no DHF cases were found in Natuna, and for Anambas District, only 5 cases were found [5].

Tanjungpinang City is a dengue-endemic area with IR figures in 2017 of 30.95 per 100,000 population at risk, meaning that Tanjungpinang City is the 3rd highest area after Bintan Regency and Batam City. The fluctuation of DHF cases in Tanjung Pinang City in the last five years based on data on the incidence of DHF from the City Health Office (2018) shows that in 2013 there were 168 cases, which increased drastically to 559 cases and one person died in 2014. In 2015 there were 358 cases and one death. In contrast to 2016, DHF cases reported 308 cases with one death. Meanwhile, in 2017 there was a decrease in 79 people, but there was still one death due to a dengue attack. However, from 2018 to early 2019, dengue fever cases increased in Tanjungpinang City, and at the beginning of this year, there were already deaths due to dengue disease [6].

Transmission plays a vital role in the increase in dengue cases. The risk of dengue transmission will increase with increasing vector density (mosquitoes) [7]. Entomological indicators generally measure the density level of immature mosquitoes (larvae) in the form of the House Index (HI), Container Index (CI), and Breteau Index (BI), which produces density figure data [8]. The larva free number (ABJ) is also used. Entomological indicator data explain the risk of transmission in an area. This data's weakness is the measurement of risk globally in a community without considering the potential of each house/building to become a place for mosquito breeding [9]. Data on entomological indicators per village and even per RW are essential for a mosquito control program's benefit.

Data on entomological indicators, which are usually in the form of an index, can explain the risk of breeding mosquitoes and know the determinants. It is known that the determinants of mosquito breeding are related to their use in making public health policies, planning disease control strategies, and providing health services. The determinant of the presence of mosquitoes is influenced by the presence of breeding places for Aedes sp. One of the factors that influence mosquito breeding is water storage. The shelter is influenced by the type, color, material, water source, location, water storage closure conditions, water sources, as well as container environmental conditions such as water pH, air temperature, water temperature, and air humidity [10,11]. In addition, determinants in the form of mosquito nest eradication behavior also affect the presence of Aedes larvae, including draining containers, closing containers, burying used goods, using abate, maintaining larvae eating fish in water reservoirs, replacing vase water and animal drinking places, repairing drains and gutters [12].

Every year, Tanjungpinang Timur District is the most contributor to DHF incidence. Based on data for the last five years in 2013, there were 66 cases, 317 cases in 2014, in 2015 there were 216 cases. The 2016 report shows 120 cases and 2017 as many as 37 cases. During the last five years, dengue deaths have always occurred in Tanjungpinang Timur Subdistrict, with the last incident in early 2019. So it is necessary to research to determine the determinants of the presence of Aedes sp larvae based on the type and environmental conditions of containers.

METHODS

This type of research was an observational study with a cross-sectional approach. The study involved 401 houses with containers in Tanjungpinang Timur District, Tanjungpinang City. The data on the presence of larvae was carried out using the single larvae method, namely by taking a sample of larvae observed in the container then the larvae were identified in the vector laboratory of the Health Polytechnic of the Ministry of Health, Tanjungpinang. Data on container types and container environmental conditions (water pH, water temperature, air temperature, humidity) and larvae's presence were collected by observing and measuring. Data collection was carried out from June to July 2019. Univariate analysis was used to determine the frequency distribution of container environmental conditions (water pH, water and air temperature, humidity) and container type. A chi-square test was conducted to see the statistical correlation between the container's environmental conditions and container types in the presence of larvae. Before the bivariate analysis, an examination of the expected table value was carried out. If 75% of the expected table value is smaller than 5, the analysis used an exact fisher test.

RESULTS

Table 1 shows frequency distribution of environmental conditions and containers and the presence of larvae in each sub-district in Tanjung-pinang Timur District. The data were collected from five sub-districts, including Pinang Kencana Village, Air Raja Village, Batu IX Village, Melayu Kota Piring Village, and Kampung Bulang Village. In this study, there were 863 containers observed; 138 of them (15.99%) were found larvae Aedes sp. Based on the location and closed condition, more containers were inside the house, namely 65.57% and not closed (88.53%). The containers found in the field were mostly containers included in the controllable site category (95.13%), disposable sites by 3.36%, and the rest were under controllable site containers (1.51%).

Table 1. Frequency distribution of environmental conditions and containers and the presence of larvae in 5 kelurahan in Tanjungpinang Timur District

Variables	Pinang Kencana		Air Raja		Batu IX		Melayu Kota Piring		Kampung Bulang		Total	(%)
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)		
Existence of Larvae												
Yes	48	23.65	3	3.06	63	19.69	17	9.39	7	11.48	138	15.99
No	155	76.35	95	96.94	257	80.31	164	90.61	54	88.52	725	84.01
Container Location												
Inside the house	139	68.47	67	68.37	211	65.94	130	71.82	40	65.57	587	68.02
Outside the house	64	31.53	31	31,63	109	34.06	51	28.18	21	34.43	276	31.98
Container Condition												
Closed	18	8.87	10	10.22	34	10.63	29	16.02	8	13.11	99	11.47
Opened	185	91.13	88	89.80	286	89.38	152	83.98	53	86.89	764	88.53
Container Type												
Controllable Site	191	94.09	95	96.94	307	95.94	168	92.82	60	98.36	821	95.13
Disposable Site	9	4.43	1	1.02	11	3.44	8	4.42	0	0.00	29	3.36
Uncontrollable Site	3	1.48	2	2.04	2	0.63	5	2.76	1	1.64	13	1.51
Water Ph												
Poor	32	15.76	25	25.51	94	29.38	35	19.34	20	32.79	206	23.87
Good	171	84.24	73	74.49	226	70.63	146	80.66	41	67.21	657	76,13
Water Temperature												
Poor	49	24.14	8	8.16	60	18.75	26	14.36	6	9.84	149	17.27
Good	154	75.86	90	91.84	260	81.25	155	85.64	55	90.16	714	82.73
Air Temperature												
Poor	196	96.55	97	98.98	318	99.38	178	98.34	60	98.36	849	98.38
Good	7	3.45	1	1.02	2	0.63	3	1.66	1	1.64	14	1.62
Humidity												
Poor	197	97.04	97	98.98	320	100	181	100	60	98.36	855	99.07
Good	6	2.96	1	1.02	0	0.00	0	0.00	1	1.64	8	0.93

The environmental conditions include water pH, water temperature, air temperature, and humidity. The results of environmental conditions measurements are displayed in good and bad categories for optimal breeding of Aedes sp mosquito larvae in a container (Table 1). The results of water pH measurements in 863 containers showed that most of the containers (76.13%) were categorized as good (pH 6-7.8) as well as the water temperature of 82.73%, the container water temperature was categorized as good (<270C &> 30 0C). In contrast to the air temperature and humidity, each container is categorized as unfavorable. The container air temperature of 98.38% showed results with a range of unfavorable conditions (<200C &> 30 0C) and humidity of 99.07% with a range (<81.5% &> 89.5%).

Table 2 shows the bivariate analysis results to see the relationship between the variables of type, location, container conditions, and container environmental conditions (water pH, water and air temperature, and container air humidity) to the presence of larvae. There was a relationship between type, location, condition of container closure, water pH, water temperature, and air temperature containers with larvae in the East Tanjungpinang District (p-value <0.005). In contrast, the air humidity variable was not related to the presence of larvae.

Table 2. Relationship Between the Type, Location, Condition of the Container as well as the Environmental Conditions of the Container (Water pH, Water Temperature, Air Temperature, and Container Air Humidity) to the Existence of Larvae in Tanjungpinang Timur Village

Variables	Existence of Larvae						P-value
	Yes		No		Total		
	N	%	N	%	N	%	
Container Type							
Controllable Site	120	14.62	701	85.38	821	100	0.000
Disposable Site	18	62.07	11	37.93	29	100	
Undercontrolable Site	0	0.00	13	100	13	100	
Container Location							
Inside the House	75	12.78	512	87.22	587	100	0.000
Outside the House	63	22.83	213	77.17	276	100	
Container Condition							
Closed	5	5.05	94	94.95	99	100	0.002
Opened	133	17.41	631	82.59	764	100	
Water Ph							
Poor (<6 & >7.8)	45	21.84	161	78.16	206	100	0.009
Good (6-7.8)	93	14.16	564	85.84	657	100	
Water Temperature							
Poor (<27^{0}C&>30 ^{0}C)	41	27.52	108	72.48	149	100	0.000
Good (27-30 ^{0}C)	97	13.59	617	86.41	714	100	
Air Temperature							
Poor (<20^{0}C&>30 ^{0}C)	135	15.90	714	84.10	849	100	0.000
Good (20-30 ^{0}C)	3	21.43	11	78.57	14	100	
Humidity							
Poor (<81.5% & >89.5%)	136	15.91	719	84.09	855	100	0,621
Good (81.5% - 89.5%)	2	25.00	6	75.00	8	100	

DISCUSSIONS

In this study, 95% of the containers examined were controllable sites, then 3.4% were disposable sites, and 1.5% were under controllable sites. Containable sites and disposable sites for mosquito breeding are possible. Controllable Sites (CS) are containers used in households, and their conditions can be manipulated concerning their potential to become mosquito breeding sites, including containers used to carry or collect water. Disposable Sites (DS) are containers that are generally outside the home, wasted or placed outside, are not used in households, and have the potential to collect rainwater so that they can become breeding grounds for mosquitoes. Under Controllable sites (US) are containers whose conditions are always under control (not potential as mosquito breeding sites) because they are habitats for fish and other larvae predators. Examples of under-controllable sites are fish ponds, aquariums, and baths filled with fish. Research data shows that the US that is often found in the field are aquariums and fish ponds [9].

There was a statistical relationship between the type of container, the container's location, and the condition of the container with the presence of larvae. In this study, the type of container was dominated by controllable sites, with the most types of containers being buckets, bathtubs, and water storage drums. These containers are influenced by the community's habit of collecting clean water for their daily needs. Buckets and bathtubs are potential breeding grounds for mosquitoes because they are rarely closed and the habit of Asian people who bathe to accommodate them without using a shower [13]. Interestingly, the dispenser is another controllable site that found many positive larvae in this study. Many people use bottled and refilled drinking water dispensers as family drinking water. However, sometimes standing water in the dispenser is not regularly monitored due to inaccuracy, so that it becomes a breeding ground for Aedes mosquitoes. So it can be concluded that the behavior factor of eradicating mosquito nests is critical for the presence of larvae in the controllable site container. The community should be more vigilant and always practice PSN by routinely draining water reservoirs.

In this study, based on the location, it was dominated by containers inside the house. Likewise, the presence of larvae is more commonly found in containers inside the house. There are more containers containing larvae in containers inside the house than outside the home. Inside the house is a conducive place for the reproduction of the vector mosquito that spreads dengue fever. Regular water used for daily needs is usually placed in the house for drinking, cooking, bathing, and washing [13].

A well-closed water container has a lower percentage of larvae. The many and various types of shelters have the potential for Aedes aegypti mosquitoes to lay eggs and breed. The population's behavior in terms of collecting water for daily needs is not only in one place, and rarely cleaning water reservoirs allows Aedes aegypti mosquitoes to have more opportunities to lay eggs. In this study, there is a relationship between the condition of container closure and the presence of larvae. The findings are the same in research conducted in the working area of the Posia Public Health Center, Kendari City, where the percentage of uncovered containers was found more. Also, there is a statistical relationship between container closure conditions and larvae's presence in the study [14].

Environmental factors associated with larvae's presence in this study are water pH, water temperature, and air temperature. In contrast to air humidity, there is no relationship between air humidity and the presence of larvae. Environmental factors that influence vector life are abiotic and biotic. Abiotic factors such as climate (rainfall, temperature, humidity, and evaporation) can affect the number of eggs, larvae, and mosquitoes' pupae to become imago. Likewise, biotic factors such as predators, parasites, competitors, and food interacting in containers as pre-adult aquatic habitats also greatly influence their success in becoming an adult [14]. These results show that in East Tanjungpinang District, physical environmental factors such as water pH, water temperature, and air temperature are conditions that support the breeding process of the Aedes sp. Mosquito.

DHF involves three organisms: the dengue virus, environment, and hosts (humans and mosquitoes). These three groups of organisms individually or in populations are influenced by the biological environment, physical environment, and immunity rather than the host. The physical environment, in general, is closely related to the characteristics of the vector habitat, such as humidity temperature, water temperature, and degree of acidity (pH). The water's pH influences mosquito eggs' hatchability; the more acidic it is, the hatchability of Ae mosquito eggs. aegypti will be less and less. Several studies on the effect of pH of brooding water on breeding Ae. aegypti reported that mosquitoes were found more than acidic or alkaline pH [15–17].

In general, mosquitoes will lay their eggs at temperatures around 20-300C. Tolerance to temperature depends on the mosquito species and geographic location, such as tropical, subtropical, equatorial, and cold regions. Water temperature also affects feeding activity and the rate at which eggs develop into larvae; larvae become a pupa, and pupae become imago. Temperature and rainfall factors are related to evaporation and micro temperature in the container.

Temperature and surface water have an important influence on infectious disease insect vectors, including the mosquito vectors that transmit dengue and yellow fever malaria. Mosquitoes need access to stagnant water for breeding, and adult mosquitoes need moist conditions for their survival. Warm temperatures increase vector reproduction and reduce the maturation period of pathogens in vector organisms. Meanwhile, very hot and dry conditions can reduce the survival of mosquitoes. Climate change causes changes in rainfall, temperature, humidity, air direction so that it affects terrestrial and marine ecosystems and affects health, especially on the proliferation of disease vectors such as the Aedes aegypti mosquito, malaria, and others. The temperature of 20-30oC is the ideal temperature for Aedes aegypti's life, the increase in air temperature causes the incubation period of mosquitoes to be shorter. As a result, Aedes aegypti will reproduce faster. Increasing the temperature will affect the disease agent's extrinsic incubation period to be shorter and the pattern of changes in the incidence of DHF[18] [18].

Human and environmental factors greatly influence the existence of Aedes aegypti larvae. Environmental factors associated with Aedes aegypti include the type of water storage (TPA), rainfall, air temperature, humidity, altitude, and the influence of wind. The water conditions also influence Aedes aegypti larvae at the breeding place, such as temperature, pH, and salinity. Meanwhile, human factors associated with Aedes aegypti are population density, population mobility, the distance between houses, light intensity, and PSN DHF behavior [19].

There was no significant relationship between air humidity and the presence of Aedes aegypti larvae in this study. Another study found a relationship between air humidity and the presence of larvae [10], which may relate to air humidity ranges that are smaller than 81.5% and larger than 89.5%. Even more, larvae are found than average humidity. Humidity ranging from 81.5 to 89.5% is the optimal humidity for the embryonization process and the survival of the mosquito embryos; at a humidity of less than 60%, the life of the mosquito will be short, and there is probably not enough time for the development of the virus in the mosquito's body [20]. Mosquitoes can become vectors if they meet several conditions, including the mosquito's age, density, contact with humans, susceptibility (resistance) to parasites, and a source of transmission. Other possible factors predominantly influence the presence of larvae in residents' homes in the Tanjungpinang Timur district.

The incidence of DHF always occurs every year, especially in this research area. Tanjungpinang Timur District is a district that contributes to DHF deaths every year. The community should understand that their area is endemic to DHF and be aware of the need to eradicate the Aedes mosquito's breeding place. It takes the initiative from the Puskesmas or the Regional Health Office to increase DHF awareness through the display of DBD-based spatial data so that it becomes the public's attention in improving the DHF prevention program in their places of residence. Efforts made in Sleman through village-based geographic-spatial data display in raising awareness of the public can increase awareness of DHF in the area [21]. The Tanjungpinang City Health Office or the Puskesmas in the East Tanjungpinang District can do the same thing. Human resources or specific training are needed so that public health program managers can perform DHF data-based visualization to increase awareness of this disease among communities.

CONCLUSION

The type, location, condition of container closure, water pH, water temperature, and container air temperature are related to larvae's presence, while the humidity variable is not related to the presence of larvae in East Tanjungpinang District. Given the physical environmental factors that strongly support the reproduction of DHF vectors in the East Tanjungpinang District. So, it is necessary to increase public knowledge and routine activities to eradicate mosquito nests (PSN) at home, especially controllable site containers widely used in the form of water reservoirs.

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