Entomological indicators with the existence of dengue virus, and the risk of DHF transmission in Mempawah District, West Kalimantan

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Abstract

Background: The incidence rate of Dengue Hemorrhagic Fever (DHF) in Mempawah District was recorded as 51 per 100,000 populations in the year 2017, with 2.6% Case Fatality Rate. The research was conducted in Pulau Pedalaman and Sungai Bakau Kecil Villages, Antibar Subdistrict, Mempawah Regency. Aims: This study aims to determine the entomological indicators, with the presence of dengue virus in Aedes aegypti larvae, and the risk of DHF transmission in Mempawah Regency. Methods and Material: Larvae survey by cluster sampling technique was used in this research. The clusters include four and three neighborhoods of Pulau Pedalaman and Sungai Bakau Kecil Villages, and were conducted in 152 and 153 houses of the survey locations, respectively. The Polymerase Chain Reaction was used to detect the existing dengue virus in Aedes aegypti larvae. Results: The results showed that the survey location was peat area, with sufficient supply of clean or rainwater reservoir in large jug, torn, and bucket. The entomology indicators in Pulau Pedalaman Village were as follows, HI (House Index) =56.25%, CI (Container Index) =14.87%, and BI (Breteau Index) =116.25, while that of Sungai Bakau Kecil included HI=29.49%, CI=6.06%, and BI=41.67. Therefore, both villages had a high risk of DHF transmission. The Aedes larvae were observed in the clean water container of large jug made from cement, torn, and bucket, and were mostly found in outdoors of Sungai Bakau Kecil (66%) and indoors of Pulau Pedalaman (59%). Meanwhile, as much as 95% of the containers were not properly maintained by cleaning or draining. Conclusions: Pulau Pedalaman and Sungai Bakau Kecil villages have a high risk of DHF transmission.
Keywords: DHF, water container, vector, Aedes aegypti

Key Messages:
The results suggested that HI<5% or ABJ<95% and transovarial transmission are important mechanism for maintaining the spread of DHF in Pulau Pedalaman dan Sungai Bakau Kecil. Also, it is possible to generate control measures and amplify the monitoring system for the DHF in endemic areas.

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Introduction

The transmission of dengue virus through mosquitoes' bite, such as female Aedes aegypti causes more mortality and morbidity in humans than are transmitted by arthropods. Furthermore, the recent spread of Dengue fever is associated with the globalization of trade and travel, urbanization, the expansion of vector-breeding habitats, and warm temperatures. Globally, one in 100 people are infected annually with one or more of the four-dengue virus serotypes (DENV1–4), and approximately 390 million residents of tropical countries contract this disease.

Since it was first discovered in Surabaya in 1968, 58 people were infected and 24 of them died (Mortality Rate: 41.3%). DHF continues to spread throughout Indonesia. In 2015, DHF has infected all provinces in Indonesia (34 provinces) with the number of districts / cities infected with 436 out of 514 districts / cities in Indonesia (84.82%). In addition, there was also an increase in the number of DHF cases, in 1968 only 58 cases became 158,912 cases in 2009. The increase and spread of DHF cases were probably caused by high population mobility, urban development, climate and density changes, and distribution. However, population and other epidemiological factors still require further research. Presently, according to the World Health Organization (WHO), Asia Pacific covered 75 % of the world's dengue burden between 2004 and 2010, while Indonesia was reported to be the second with the largest cases among 30 endemic countries. The incidence rate of DHF in Indonesia per 100,000 population in 2010-2019 are 65.70, 27.67, 37.11, 68.22, 39.80, 50.75, 78.85, 22.55, 24.73, and 35.33.

In 2017, DHF cases in West Kalimantan Province were 52.61 per 100,000 population, which was second in national ranking. The incidence rate (IR) in 2018 increased by 61.92 per 100,000 population with a mortality rate of 0.81%. Meanwhile, Mempawah Regency is one of the dengue
endemic areas in West Kalimantan Province. The highest cases (581) occurred in 2014 with 5 deaths, and decreased until 2018. The number of dengue and death cases in Mempawah district from 2014-2018 were 581, 34, 95, 154, 79, and 5.0, 0, 0, 0, respectively.\(^9\)

Vector control remains the main preventive strategy in some dengue endemic areas as an integrated effort in controlling DHF, even after the vaccines were found.\(^10\) The vector control program includes reducing the source of transmission, eliminating the habitat of \(Ae. aegypti\) larvae from residential environments, by increasing community involvement.\(^11\) However, the current entomological indicators are not reliable, due to the DHF transmission risks, and the early prevalence of the disease.\(^12\)

Presently, several research results have not shown a consistent relationship between the entomological indicators with the incidence of DHF\(^13\). This is probably because (1) there is no set limit for the density of \(Ae. aegypti\) that increase the risk of being infected with the virus.\(^14\) (2) The entomological survey technique was carried out on a household basis, and the density index was calculated from a prevalence measure, not from continuous monitoring. (3) The pre-adult surveys require consideration of vector dynamics\(^15\) and spatial relationships\(^16\), however, the data obtained did not include daily productivity from larval development to adulthood.\(^17\)

The principal vector of DENV is the \(Ae. aegypti\) mosquito, an anthropophilic species that has adapted extremely well to the urban environment, which is found both indoors and outdoors in close proximity to human dwellings.\(^18\) The WHO recommends increasing vector surveillance for achieving and evaluating DHF vector control activities.\(^19\) The \(Ae. Aegypti\) surveillance was first used in yellow fever control activities in the 20th century\(^20,21\), since then, entomological indicators have been proposed to measure its abundance. The entomological indicator monitoring data is usually collected from households, and carried out routinely. Meanwhile, DHF vector surveillance is carried out in all life stages of a mosquito (egg, larva, pupa or adult), depending on the availability of infrastructure and data collection process.\(^19\)

Although only adult female Aedes mosquitoes are directly involved in dengue transmission, the entomologic surveillance has been based on different larval indices.\(^15\) The house index (HI, percentage of houses positive for larvae) and the Breteau index (BI, number of positive containers per 100 houses) have become the most widely used indices\(^12\), however, their critical threshold has never been determined for dengue fever transmission.\(^22,23\) Since HI≤1% or BI≤5 was proposed to prevent yellow fever transmission, these values have also been applied to stop the spread of dengue without much evidence.\(^17,24\) The vector density, below which dengue transmission does not occur, continues to be a topic of much debate and conflicting empiric evidence. For example, dengue outbreaks occurred in Singapore when the national overall HI was <1%.\(^25\) In contrast, the research in Fortaleza, Brazil, found
that dengue outbreaks never occurred when HI was <1%.\textsuperscript{26} However, different geographic levels are used to calculate the indices in various studies, while the appropriated level for entomologic indices is an issue of debate.\textsuperscript{27} Furthermore, the appropriateness of larval indices has been questioned, recently as alternative, while that of pupal was developed by Focks et al to better reflect the risk for transmission.\textsuperscript{28} In this study, the usefulness of larval indices for identifying high-risk areas for dengue virus transmission was assessed.

**Subjects and Methods**

This study is a further analysis of a report "Riset implementasi model juru pembasmi jentik (Jurbastik) dalam Penanggulangan DBD (Multicenter 2019) di Kalimantan Barat". Meanwhile, the ethical approval was obtained from the Ethics Commission of the Health Research and National Development of the Indonesian Ministry of Health with number LB.02.01/2/KE.296/2018. And was carried out mainly in Pulau Pedalaman and Sungai Bakau Kecil district Mempawah from January to November 2019. The entomological data were collected by door-to-door survey, and was carried out for one months (September 2019) to ascertain Aedes breeding using larval dipper.

The larva or pupa collected from each locality were transported to the entomology laboratory in Banjarnegara Health Research and Development Unit, and reared up to adults and identified using keys. The surveyed particles of houses, containers, and the number of breeding Aedes larva were recorded by the standard indices of House, container, and Breteau, while Breeding Preference Rattio (BPR) were calculated using the respective formulae.\textsuperscript{30}

The DHF confirmed cases and mortality data were collected from Mempawah district / city Health Office, and were analyzed descriptively including the secondary data taken from the last two years records. The examination of dengue virus in mosquitoes was carried out using the RT-PCR method.\textsuperscript{31} The results were kept in the entomology laboratory of the Banjarnegara Research and Development Center, until they became adults then identified based on determination key.\textsuperscript{32}

\textbf{House Index (HI):} percentage of houses infested with larvae and/or pupae.

\[
HI = \frac{\text{Number of houses infested}}{\text{Number of houses inspected}} \times 100
\]

\textbf{Container index (CI):} percentage of water-holding containers infested with larvae or pupae.

\[
CI = \frac{\text{Number of positive containers}}{\text{Number of containers inspected}} \times 100
\]

\textbf{Breteau index (BI):} number of positive containers per 100 houses inspected.

\[
BI = \frac{\text{Number of positive containers}}{\text{Number of houses inspected}} \times 100
\]
Results

The survey results from Pulau Pedalaman, showed that out of the 160 houses, there were 13 types of containers, such as 1252 consisted of water, 186 with Aedes larvae, and 107 with pupae. While, in Sungai Bakau Kecil, there were 13 types of containers, such as 1072 consisted of water, 168 with Aedes larvae, and 18 with pupae.

From the survey conducted in the Pulau Pedalaman and Sungai Bakau Kecil, almost all the temporary and permanent water bodies, both indoors and outdoors in the residential areas were Aedes breeding habitats, namely tub, toilet, drum, tank, tempayan, bucket, etc. The distribution of Aedes larvae species with particular emphasis to the preference in different breeding habitats was shown in Table 1.

In Pulau Pedalaman, among all the habitats, the maximum Breeding Preference Ratio (BPR) of Aedes larvae was recorded in secondhand (3.9), followed by aquarium (2.9), others/not TPA (1.9), drum (1.4), baskom (1.3), and bucket (1.2). While in Sungai Bakau Kecil, the maximum BPR was recorded in secondhand (8.2), tank (4.1), tub (2.0), and drum (1.2) (Table 1).
Table 1. Breeding Preference Ratio (BPR) of Aedes mosquitoes in Pulau Pedalaman and Sungai Bakau Kecil West Kalimantan 2019

<table>
<thead>
<tr>
<th>Types of Breeding habitats</th>
<th>Pulau Pedalaman</th>
<th>Sungai Bakau Kecil</th>
<th>BPR (Y/X)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of container with water</td>
<td>with Aedes larvae</td>
<td>Y (%)</td>
</tr>
<tr>
<td>Tub</td>
<td>149</td>
<td>23</td>
<td>12,4</td>
</tr>
<tr>
<td>Toilet</td>
<td>64</td>
<td>10</td>
<td>5,4</td>
</tr>
<tr>
<td>Drum</td>
<td>78</td>
<td>16</td>
<td>8,6</td>
</tr>
<tr>
<td>Tank</td>
<td>16</td>
<td>2</td>
<td>1,1</td>
</tr>
<tr>
<td>Crock</td>
<td>440</td>
<td>40</td>
<td>21,5</td>
</tr>
<tr>
<td>Bucket</td>
<td>439</td>
<td>76</td>
<td>40,9</td>
</tr>
<tr>
<td>Basin</td>
<td>16</td>
<td>3</td>
<td>1,6</td>
</tr>
<tr>
<td>Others (TPA)</td>
<td>22</td>
<td>4</td>
<td>2,2</td>
</tr>
<tr>
<td>Ablution Place</td>
<td>1</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Flower vase</td>
<td>1</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Aquarium</td>
<td>7</td>
<td>3</td>
<td>1,6</td>
</tr>
<tr>
<td>Secondhand</td>
<td>12</td>
<td>7</td>
<td>3,8</td>
</tr>
<tr>
<td>Others (not TPA)</td>
<td>7</td>
<td>2</td>
<td>1,1</td>
</tr>
<tr>
<td>Coconut shell</td>
<td>0</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>To Drink animal</td>
<td>0</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Dispenser</td>
<td>0</td>
<td>0</td>
<td>0,0</td>
</tr>
</tbody>
</table>

Total: 1252 / 186

Table 2. Container conditions in residential areas on the Pulau Pedalaman and Sungai Bakau Kecil, Mempawah Regency, West Kalimantan

<table>
<thead>
<tr>
<th>Indicator of Entomology</th>
<th>Pulau Pedalaman</th>
<th>Sungai Bakau Kecil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>value</td>
<td>Density figure</td>
</tr>
<tr>
<td>Container Index (CI)</td>
<td>14.86%</td>
<td>5</td>
</tr>
<tr>
<td>House Index (HI)</td>
<td>56.25%</td>
<td>7</td>
</tr>
<tr>
<td>Breteau Index (BI)</td>
<td>116.25</td>
<td>8</td>
</tr>
<tr>
<td>Angka Bebas Jentik (ABJ)</td>
<td>43.75%</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Entomological indicator in Pulau Pedalaman and Sungai Bakau Kecil, Mempawah Regency, West Kalimantan 2019

<table>
<thead>
<tr>
<th>Types of Container</th>
<th>Pulau Pedalaman</th>
<th>Sungai Bakau Kecil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>In door</td>
<td>558</td>
<td>44.6</td>
</tr>
<tr>
<td>Out door</td>
<td>694</td>
<td>55.4</td>
</tr>
<tr>
<td>Closed</td>
<td>411</td>
<td>32.8</td>
</tr>
<tr>
<td>Open</td>
<td>841</td>
<td>67.2</td>
</tr>
<tr>
<td>With fish</td>
<td>16</td>
<td>1.3</td>
</tr>
<tr>
<td>Drained once week</td>
<td>83</td>
<td>6.6</td>
</tr>
<tr>
<td>With temephose</td>
<td>23</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Table 3. Showed that the values of the entomological indicator in Pulau Pedalaman were higher than that of Sungai Bakau Kecil. The values of HI, CI, BI and ABJ in the Pulau Pedalaman are 56.25%, 14.86%, 116.25, and 40%, while in Sungai Bakau Kecil, they were 29.49%, 6.06%, 41.67%, and 70.51%. These indicators were used in determining the risk of transmission based on the density figure (DF). Low-density category was observed when DF= 1, moderate when DF= 2-5, and high when DF= 6-9. Therefore, Pulau Pedalaman was more at risk of DHF transmission than Sungai Bakau Kecil.

Figure 1. Dengue virus examination results on Aedes aegypti larvae using the RT-PCR method in Mempawah Regency, West Kalimantan Province (n=162)
The Ae.aegypti larvae detected by dengue virus were found more in Pulau Pedalaman (7.41%) than in the Sungai Bakau Kecil. The distribution location of dengue larvae on Pulau Pedalaman was as follows, RT 2, 3, and 4 with 2, 2, and 4 samples, respectively. Meanwhile, in Sungau Bakau Kecil it was mostly found in Rt 18 (1 sample). The distribution mapping of Ae.aegypti larvae with dengue virus was shown in Figure 2.

Figure 2. The mapping of distribution Aedes aegypti larvae with dengue virus di Mempawah Regency West Kalimantan Province

Pulau Pedalaman

Sungai Bakai Kecil

The results of data collection from the Mempawah District Health Office and information showed that there were 10 cases of DHF in Puskesmas Antibar in 2017 and three in Sungai Bakau Kecil. Furthermore, in 2018, there were nine cases in the Puskesmas Antibar and none in Sungai Bakau Kecil area (Figure 3).

Figure 3. Cases and deaths of DHF in Puskesmas Antibar and Puskesmas Sungai Bakau Kecil, Mempawah Regency, West Kalimantan

Discussion

DHF is a disease caused by the dengue virus and transmitted through the bite of female Aedes spp. The life cycle of this species starts from the eggs that are placed on the wall of the vessel/container filled with water, which then hatches into larvae. It develops in the next stage from instar I, II, III, and IV into pupa and adult mosquitoes. The Aedes spp mosquitoes breed in water reservoirs that are not directly related to the soil, whether inside, outside or around the house and public places. The results showed that Aedes aegypti larvae were found in eleven types of containers, namely bath and toilet tubs, drums, toren, jars, buckets, basins, other water reservoirs, ablution places, flower vases, ponds/aquariums, used goods and not shelters.

Mempawah Regency was included in the category of dengue endemic areas in West Kalimantan Province with an incidence rate of 3 years and 154 cases in 2017, and 79 in 2018 with a mortality rate of 0%. Antibar and Sungai Bakau Kecil Health Center were the main research location. The highest incidence of DHF in the working area of Puskesmas Antibar occurred in the last two years before this research was conducted, and also in Sungai Bakau Kecil Health Center, although, with lower cases. Therefore, the probability of an increase in dengue cases in the two Puskesmas areas in Mempawah Regency in the future was predicted, when appropriate vector control efforts are not made to reduce larvae density. The Container Index (CI) was evaluated by the percentage of positive containers harboring larva divided by the total number of vessels. The CI value of Pulau Pedalaman (Puskesmas Antibar work area) was 14.86%, that of Sungai Bakau Kecil was 6.06%. The CI indicator at a value of ≤ 10% was a low risk area for dengue transmission.

The density figure showed that the two research locations, were included in the medium category of vector mosquito population. The ABJ value in these regions were 43.75% and 70.51%, which were lower compared to that of Ministry of Health (95%) 34. Therefore, when the ABJ in the research locations was still below the target of the Ministry of Health, the DHF cases were high. This increase in ABJ was carried out by providing Betta larvae eating fish in places that have the potential to be breeding grounds for the Aedes spp mosquito. In addition, the role of larva monitoring (jumantik) was important in early alertness for dengue fever.

The results showed that both study locations were risk areas for dengue transmission (HI ≥ 5%; BI ≥ 4). The house index at a value of ≤ 5%, or identical to the larva free rate (ABJ) equal to 95%, was a low risk area for dengue transmission. The ABJ value ≥ 95% was the target of the control program in Indonesia, as an effort to limit the DHF transmission 22; 37. Meanwhile, the value of BI was considered to have a low risk of dengue transmission with a value of ≤4 22; 38. Referring to the WHO density figure table based on HI, CI and BI values, the greater the number of levels, the greater the risk of dengue transmission. The values of HI, CI, and BI on Inland Island were at levels 5-8, while those in Sungai Bakau Kecil were at levels 3-5.

The rapid transmission was caused by an increase in population and number of vectors. The DHF vector data, such as container index (CI), house index (HI), and Breteau index (BI), which were entomological parameters were needed. When the HI value was > 10 %, CI> 10%, and BI was ≥50,
there was a high risk of 39. Based on the HI value, the two survey locations were at high risk of transmission, however, in Sungai Bakau Kecil, the CI and BI values were still below the high-risk area limit. Furthermore, when referring to the indicator requirements of the Ministry of Health of the Republic of Indonesia, the House Index value for healthy housing was below 5%, while the Larva Free Rate was above 95%, meaning that not all indicators in the research location met the requirements for these conditions.

The research conducted by Cruz et al in the Philippines stated that a high density of larvae had a high potential for dengue transmission. This should also be observed in the local health office, because based on the research of Sucipto et al in Semarang Regency, water reservoirs that flange had significant relationship with the incidence of DHF. The environment was closely related to the presence of Aedes spp. larvae. For example, humidity, presence of substandard rainwater channels and containers. The increase in rainfall raised the humidity and temperature, which supported all mosquito activities including extending their life and behaviour in reproduction. Aedes aegypti vector developed optimally at temperatures of 20–28°C.

Presently, the data of Ae.aegypti larvae in Pulau Pedalaman and ungai Bakau Kecil showed a transovarial transmission percentage for DENV infection in 5.5% of the samples analyzed. The viral monitoring of mosquitoes suggested that transovarial transmission rates (TOT) occurred at low levels in nature. These studies suggested that TOT rates were low in nature and the virus persistence reduced. However, failure in detecting TOT should be evaluated, as it occurred frequently. Several factors contributed to the failure in detecting TOT, including low sensitivity of the tests, inappropriate methodology, and mosquito sample maintenance issues, among others.

The results suggested that transovarial transmission is an important mechanism for maintaining the spread of DHF in Pulau Pedalaman and Sungai Bakau Kecil Regency. Using RT-PCR, it was possible to identify the four DENV serotypes in the larval samples.

The findings reported in this study showed that the natural transovarial infection by DENV 1-3 occurred in Ae.aegypti in the two study sites with a relatively high entomological indicator, promoting the birth of mosquitoes already infected with DENV at the beginning of epidemics. The entomological surveillance and data on the detection of infected mosquitoes were used to estimate DENV serotype frequency, with greater understanding of the factors influencing the occurrence of the disease among the population and further supported the development of vector control strategies.

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Competing interests:
The authors have declared that no competing interests exist.
References


6. Agniya Khoiri, 2016. Indonesia Peringkat Dua Negara Endemis Demam Berdara. CNN Indonesia


34. Infodatin 2018. Situasi Penyakit Demam Berdarah di Indonesia Tahun 2017