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Entomological indicator and susceptibility status of *Aedes aegypti* (L.) to temephos in dengue-endemic regencies/cities in West Sumatera

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Abstract
Dengue is a vector-borne disease that has rapidly spread in many countries. Controlling dengue vectors can be assisted by knowing the data of entomological indicators and monitoring the status of susceptibility to frequently used insecticides. This study aims to determine the risk of dengue transmission, House Index, Container Index, Breteau Index, and susceptibility status to temephos 0.012 mg/L in five dengue-endemic regency/cities in West Sumatra Province. This study was conducted at six research locations. The Density Figure value showed that five locations have a medium risk of transmission and one location has a high risk of transmission. The results of the susceptibility test with temephos showed that the larval population of *Ae. aegypti* is still susceptible in KDP Karakah, tolerant in Salido Pesisir, and has been resistant in Gu Pangilun, P. Punjung, Campago Ipuh, and Pasir Pariaman. There is no correlation between resistance status and the risk of dengue spreading.

Keywords: *Ae. aegypti* L., larvae, endemic, entomological indicators, insecticide resistance, temephos

1. Introduction

Dengue is the fastest spreading mosquito-borne disease in the world [1]. Dengue transmission is known to have occurred in at least 128 countries [2]. The disease is endemic in most tropical countries by an estimated 96 million cases causing symptoms each year [3]. Various serotypes of dengue virus (DENV-1, DENV-2, DENV-3, and DENV-4) are transmitted to humans through the bite of infected Aedes mosquitoes, mainly by *Ae. aegypti*. These dengue vectors are widespread in tropical-subtropical regions and also in urban-rural areas [1].

Indonesia is one of the dengue-endemic countries which has undergone a 700-fold increased incidence over the last 45 years [4]. Indonesia is also the second country with the highest dengue hemorrhagic fever (DHF) cases among 30 other endemic countries [5]. National data has shown that during 2010-2016, the number of regencies/cities affected by DHF has increased from 400 to 463 [6].

West Sumatra is one of the provinces in Indonesia that has high dengue cases. In 2016, this province was ranked 14th out of 34 for DHF incident rate [7] since 3,952 cases were found [8]. Some regencies/cities in this province are classified as dengue-endemic areas. Among them are Padang, Pariaman, Bukittinggi, Pesisir Selatan, and Dharmasraya [9].

Dengue vector control strategy is a factor that affects the risk of transmission [10]. Surveillance can monitor the effectiveness of the dengue vector control [11]. One of the widely used dengue vector survey methods is larval sampling [12]. This method observes all potential containers as breeding grounds for Aedes mosquitoes, both inside and outside the house [13]. The level of dengue vector infestation can be determined using three entomological indicators, namely the house index (HI), the container index (CI), and the Breteau index (BI). HI describes the percentage of houses infested with larvae and/or pupae. CI describes the percentage of water-holding containers infested with larvae or pupae. Meanwhile, BI describes the number of positive containers per 100 houses inspected [11]. The data obtained can be used further as considerations in the management of habitat vectors of dengue.

Generally, dengue vector control in Indonesia involves the use of insecticides [14]. Especially temephos insecticides for the pre-adult stage (larvae) [15].

Therefore, monitoring of susceptibility status is necessary to consider the right steps in dengue vector control strategies [11]. This research aims to identify the entomological indicators and susceptibility status of *Ae. aegypti* larvae to temephos in six research locations in West Sumatra. This study is expected to provide information regarding indicators of entomology and susceptibility status at the six research locations. The information obtained may help to determine dengue vector control strategies further.

2. Materials and Methods

This is descriptive research with a cross-sectional design. Entomological data and larvae of *Ae. aegypti* were obtained from 6 research locations in 5 regencies/cities in West Sumatra (Padang, Pesisir Selatan, Dharmasraya, Bukittinggi and Pariaman). The following are the research locations and their population codes: Kubu Dalam, Padang {KDP Karakah}, Salido, Pesisir Selatan {Salido Pesisir}, Gunung Pangilun, Padang {Gu Pangilun}, Pulau Punjung, Dharmasraya {P. Punjung}, Campago Ipuh, Bukittinggi {Campago Ipuh} and Pasir, Pariaman {Pasir Pariaman}. Larvae identification and susceptibility test of *Ae. Aegypti* was conducted at the Animal Physiology Research Laboratory, Department of Biology, FMIPA, Andalas University. The research data was obtained from 2017 to 2018 and larvae collections were carried out in 100 houses in every location. Containers were observed inside and outside the house and the larvae were observed with a single larvae method.

The data obtained were then processed to determine the value of the entomological indices. According to WHO [11], the formula of entomological indicators (HI, CI, BI) are:

$$HI= \frac{\text{number of positive houses}}{\text{number of houses inspected}} \times 100\%$$

$$CI= \frac{\text{number of positive containers}}{\text{number of container inspected}} \times 100\%$$

$$BI= \frac{\text{number of positive containers}}{\text{number of houses inspected}} \times 100\%$$

Density Figure (DF) is determined based on the values of HI, CI, BI and then are compared with the larval indices table. The risk of transmission is low when DF is less than 1, moderate when DF is 1-5, and high when DF is more than 5.

The susceptibility test procedure was performed according to WHO [16] using the insecticide temephos 0.012 mg/L. The susceptibility status was determined based on the percentage of mosquito mortality as follows:

- mortality between 98-100% = susceptible
- mortality between 91-97% = tolerant
- mortality <90% = resistance

3. Results

The number of positive houses and containers at each location can be seen in Table 1. The number of entire containers found was 4.816 containers while the positive containers were 326 containers.

Table 1: The data of the number of houses and containers in six locations.

Research Location	Number of Houses		Number of Containers	
	inspected	positive houses	inspected	positive containers
KDP Karakah	100	34	372	46
Salido Pesisir	100	18	737	27
Gu Pangilun	100	28	475	49
P. Punjung	100	38	1724	55
Campago Ipuh	100	29	388	33
Pasir Pariaman	100	68	1120	116

The data of larvae entomology indicators and DF values in the six locations can be seen in Table 2. The DF value obtained indicates that the risk of dengue transmission is at a moderate level in five locations, while one location is already at a high level.

Table 2: Entomological indicators of *Ae. aegypti* larvae, DF value, and risk of dengue transmission in six research locations

Research Location	Entomological indices						Average value of DF	The risk of dengue transmission
	HI		CI		BI			
	%	DF	%	DF	%	DF		
KDP Karakah	34	5	12,37	4	46	5	4,7 ≈ 5	Moderate
Salido Pesisir	18	4	3,67	2	27	4	3,33	Moderate
Gu Pangilun	28	4	10,32	4	49	5	4,3 ≈ 4	Moderate
P. Punjung	38	6	3	2	55	6	4,7 ≈ 5	Moderate
Campago Ipuh	29	5	8,61	3	33	4	4	Moderate
Pasir Pariaman	68	8	10,35	4	116	8	6,67	High

The susceptibility status of *Ae. aegypti* larvae against the insecticide temephos 0.012 mg/L showed varying results (Table 3). The only population of *Ae. aegypti* which is still susceptible to temephos is KDP Karakah. Meanwhile, Salido Pesisir is tolerant and four other locations are resistant to temephos.

Table 3: Percentage of mortality and susceptibility status of *Ae. aegypti* larvae against the insecticide temephos 0.012 mg/L

Research location	% mortality in temephos 0,012 mg/L	Susceptible status
KDP Karakah	100 ± 0,00*	Susceptible
Salido Pesisir	91,67 ± 3,33	Tolerant
Gu Pangilun	61,7 ± 0,20*	Resistant
P. Punjung	47 ± 7,63	Resistant
Campago Ipuh	13,33 ± 7,63	Resistant
Pasir Pariaman	83,3 ± 1,00**	Resistant

(*) [17]
(**) [18]

Discussion

Breaking the chain of transmission is still an effective dengue control effort because the vaccine or the effective drug to cure the disease has not been found yet [19].One indicator of the effective management of Aedes spp. can be assessed by the entomological indicators of an area [20]. Entomological data have relevance to the dynamics of disease transmission and can be used to monitor the effectiveness of vector control [11].

HI is used for monitoring the infestation levels of the dengue vector. The risk of dengue transmission in an area is high when the HI value is >5% and the risk is low when the HI value is < 1%. The percentage of HI in these locations showed that all of them are above 5% and the highest HI value is in Pasia Pariaman. Most people in Pasir Pariaman stores water in buckets for their daily needs so that there are many positive houses in this location. A high value of HI also indirectly describes that this area has a high mosquito density. In other words, the HI value is proportional to the density of mosquitoes aside from the risk of disease transmission [21].

Meanwhile, CI provides information on the proportion of positive containers. An area is classified as high risk in dengue transmission when CI value >5%, and when the value is <5%, the area is classified as low risk [21]. The percentage of CI in all of the research locations showed that four locations have a high risk of DHF transmission and two locations showed otherwise. KDP Karakah is the location with the highest CI value.

Interestingly, P. Punjung is the research location with the most containers found but has the lowest CI value when compared to the other 5 locations. Based on observations, people in P. Punjung usually store water for drinking in large containers, but these containers are covered. Thus, the mosquitoes cannot lay their eggs in the containers.

Moreover, dispenser containers almost always contain *Ae. aegypti* larvae due to their small size, and usually out of attention, so that it is rarely cleaned. Consequently, the container facilitates the breeding of dengue vectors. However, containers need to be concerned both inside and outside the house such as used tires, plastic cups, and containers filled with rainwater which can become breeding grounds for mosquitoes [22].

Compared to the two previous indices, the BI value is the best index for estimating vector density because BI combines houses with containers [23]. When the BI value is >30-50%, the risk of dengue transmission is high and when the BI value is 5-20%, the risk is low [21]. The highest BI value was found in Pasir Pariaman which is corresponds to the number of positive containers in this location. These results describe the importance of education related to dengue transmission in society so that they have a role in maintaining environmental sanitation.

Aside from entomological indicators, chemical insecticides have been used widely to control mosquitoes over the past 40 years [11]. So that, monitoring of the susceptibility of dengue vectors to insecticides is needed. Based on susceptibility tests in six locations, KDP Karakah was the only research location where the larvae population of *Ae. aegypti* is still susceptible to temephos (0.012 mg/L). People in KDP Karakah mention that they have never used temephos previously so insecticide resistance has not developed in this location yet. The larval susceptibility of *Ae. aegypti* in Salido Pesisir has shown a tolerant status which indicates that the frequency of using temephos in this area is already higher and needs more attention to prevent insecticide resistance further. Meanwhile, in four other locations, the larvae of *Ae. aegypti* has shown resistance status to temephos. This information can be used as an evaluation material for policymaking in further dengue vector control.

Based on the DF values obtained at the six research sites, five locations have a moderate risk of dengue transmission, while one location already has a high risk of transmission. However, the risk of dengue transmission is not affected by the level of resistance in an area. Even though the KDP Karakah location has susceptible resistance status as previously stated [17] (Table 3), the DF value still shows that this location has a moderate risk of transmission, while the Campago Ipuh location with a larval mortality percentage of only 13.33 ± 7.63, has a moderate risk of transmission. The low level of resistance does not generate a low risk of transmission as well. In other words, there is no correlation between resistance status and the risk of spreading dengue.

Multiple factors affect the risk of dengue transmission. Apart from vector control strategies, other influencing factors include are trade in goods and human mobility, population density, urbanization, climate, presence of invasive vector populations, virus evolution, and vector density [10]. Hence, awareness and active participation from both the community and government sectors are required for maintaining a clean environment so that dengue transmission can be suppressed.

Dengue morbidity can be reduced by implementing better outbreak prediction and detection through coordinated epidemiological and entomological surveillance. Dengue vector control can be implemented, especially by eliminating the containers that are preferred by mosquitoes for laying eggs also in development in the aquatic phase [24]. So that dengue transmission and the outbreak of dengue cases can be prevented.

6. Conclusions

Entomological indicator data at six research sites in West Sumatra province showed that five research sites (KDP Karakah, Gu Pangilun, Campago Ipuh, P. Punjung, and Salido Pesisir) had a moderate risk of dengue transmission while Pasir Pariaman was at high risk. The HI rate ranges from 28-

68%, the CI ranges from 3-12.37% and the BI ranges from 27-116%. The results of the larval susceptibility test of *Ae. aegypti* against temephos showed varying results where KDP Karakah was still susceptible and Salido Pesisir was tolerant. The larvae population of *Ae. aegypti* in Gu Pangilun, Punjung Punjung, Campago Ipuh and Pasir Pariaman the status is already resistant. There is no correlation between resistance status and the risk of dengue spreading.

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