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Survey on aedes mosquito density and pattern distribution of *aedes aegypti* and *aedes albopictus* in high and low incidence districts in north sumatera province

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Abstract. Transmission and control of dengue hemorrhagic fever are related to its vectors. This study investigated vector density and distribution patterns of *Aedes aegypty* and *Aedes albopictus* in Medan and Langkat as high and low incidence district, respectively. An entomological survey was carried out in 304 households both in Medan and Langkat. The results showed that adult *Ae. aegypti* were predominantly in Medan, while adult *Ae. albopictus* was only in Langkat. Larvae indices (HI, CI, BI) for *Aedes* in Medan (35,13 and 43) were higher than langkat (22,8 and 30). Adult indices (AHI, AD, RR) for *Ae. aegypti* in Medan and for *Ae. albopictus* in Langkat were 20,38,24 and 3,5, and 5, respectively. Pattern distribution of *Aedes* larvae and adult mosquitoes in both district had similar pattern. *Aedes* larval indices and adult indices both in HIDs and LIDs were above the critical level, indicating potential high risk for DHF transmission. By multiple regression analysis, HI is predictor for DHF transmission in North Sumatera. Thus, in designing an effective control measures for dengue hemorrhagic fever, monitoring distribution and vector density is crucial.

Keywords: Aedes mosquito density, high and low incidence district, pattern distribution

1. Introduction

Dengue hemorrhagic fever (DHF) as Vector-borne diseases are global public health risks. DHF is caused by the dengue virus, which is transmitted by the bite of a female mosquito. The disease is found in the tropical and subtropical region with an approximately 50-100 million cases of dengue fever occur annually and 25,000 deaths [1]. North Sumatera Province is one of endemic area, and the Ministry of Health of Indonesia (2011) reported that North Sumatera ranked the third highest for DHF cases with 16 dengue endemic district [2]. The incidence of DHF annually increased from 24/100,000 population in 2007 to 66.2/100,000 in 2015 [3].

The factors are responsible for the incidence of DHF are complex. The dynamic of dengue infection are driven by complex interaction between host, vectors and viruses that are influenced by environmental. Furthermore, environment affects the *Aedes* mosquito breeding site as the main vector that plays a role in disease transmission. Many studies had been conducted and described the behavior of these vectors [4,5]. In addition, few indices were found to be useful as indicators of their abundance and linked to event relates to dengue fever and DHF. Among them are house index (HI), Breteau index (BI) and container index (CI). These indices are used to monitor *Aedes* population for dengue virus transmission [6,7,8]. In addition, adult mosquito density also calculated to measure *Aedes* density, including adult house index (AHI), adult density (AD) and the resting rate (RR) [9,10,11].

The lack of available vaccines and drugs, makes vector control has been the right choice for the prevention and control of dengue hemorrhagic fever [12]. Various efforts related to the eradication of vectors had been conducted in the prevention of dengue, such as mosquito nest eradication (PSN), health education and the use of insecticide fogging and Abatisasi, but the results have not been as expected.

In North Sumatera Province, DHF still endemic with incidence increased annually. Various efforts had been conducted however, have not optimum include the vector monitoring have not been continuously that might result in uneffective control strategies. In designing effective strategies for dengue hemorrhagic fever, one approach is the eradication of vectors. A better understanding regarding habitat, pattern distribution and vector density is crucial. Therefore, this study was undertaken to provide information regarding *Aedes* density to help health organizations develop effective control strategies for dengue hemorrhagic fever.

2. Methods

In this study, an entomology survey was carried out in Medan, a district with high DHF incidence and Langkat, a district with low DHF incidence, in North Sumatera province from 5th April, 2011 to 16th May, 2011. Entomology survey including larval survey and adult *Aedes* survey .

The larval survey was conducted to determine larval density. It was done based on WHO procedure by inspection of containers both indoor and outdoor in selected houses for the presence of *Aedes* larvae. For each positive, a larva was pipetted into a plastic cup or plastic bag as shown in Figure 1 and brought back to the laboratory for identification. The House Index (HI), Container Index (CI) and Breteau Index (BI) were calculated to determine the larval density.

Figure 1. Activity in Larva survey

Adult *Aedes* survey was conducted to determine adult density and species of the mosquito. Aspirators were used to collect adult *Aedes* mosquitoes from the selected human dwellings, both inside and outside the house or premises where the mosquitoes found resting during the day time (9.00 am until 5.00 pm) as shown in Figure 2. The collected *Aedes* mosquitoes were kept in paper cups covered with gauze and fed with glucose while being transported to the laboratory for inspection and identification.

Adult house index (AHI), adult density (AD) and the resting rate (RR) were calculated to determine adult density.

Figure 2. Collection of *Aedes* mosquito using aspirator in adult survey

2.1 Sample

In this study, Multistage sampling was used to select the study population that was households in both districts with high DHF incidence (HIDs) and low DHF incidence (LIDs). In the first stage, one district with high DHF incidence (Medan) and one district with low DHF incidence (Langkat) were purposively selected based on DHF data in the previous year. In the second stage, two subdistricts, one with the highest and the other with the lowest DHF cases were again purposively selected for each district. In Medan, entomological survey was conducted in Marelan and Maimun, subdistricts with high and low DHF cases respectively. Like wise in Langkat, it was conducted in Stabat and Berandan. In the third stage, the same criteria as above were applied to select two villages from the subdistricts. For each village, two sub-villages were randomly selected. In the high subdistrict, households were systematically selected among the households with reported cases from the health office registry, whereas, in the low subdistrict, households were selected using systematic sampling based on the registry of the household from the sub-district administrative office.

2.2 Sample size

In this study sample size was calculated using the two-proportion formula[13]. An average proportion of DHF cases in the three districts with high DHF cases (P1) of 0.156 and an average proportion of DHF cases in the three districts with low DHF cases (P0) of 0.017. An allowable error of 5% and a power of study of 80%. By multistage sampling, the sample size was multiplied by the design effect of 2. Therefore, 304 households for districts with both high and low DHF cases were included in this study.

2.3 Study instruments

The tools used in the larval survey included a survey form, pipettes, plastic bottles, plastic bags, a specimen vial with stoppers, pens, a label and a flashlight. All of the indoor and outdoor containers at the selected houses had been inspected and from each positive container, a larva was pipetted into a plastic cup or plastic bag and brought back to the laboratory for identification. The findings were recorded on the survey form. Three larval indices, the House Index (HI), Container Index (CI) and Breteau Index (BI) were calculated. The HI is defined as the percentage of houses positive for *Aedes* larvae. The CI is defined as the percentage *of* containers positive for *Aedes* larvae. BI is defined as the number of containers positive for *Aedes* larvae per 100 houses examined.

The tools used in the adult survey include survey form, aspirator, flashlight, plastic cup/tube, paper cup covered with gauze and cotton and labels (masking tape). Aspirators were used to collect adult *Aedes* mosquitoes from the selected human dwellings, both inside and outside the house during the day time (9.00 am until 5.00 pm). The collected *Aedes* mosquitoes were kept in paper cups covered with gauze and fed with glucose and transported to the laboratory for identification. Adult house index (AHI), adult density (AD) and the resting rate (RR) were calculated to determine adult density. AHI is defined as the percentage of houses positive for *Aedes* mosquitoes. AD is defined as the number of *Aedes* mosquitoes per 100 houses examined. RR is defined as the number of female *Aedes* mosquitoes per 100 houses examined

2.4 Statistical analysis
The Statistical Package for Social Science (SPSS) program was used for data analysis (Release 22.0, SPSS Inc., Chicago, Illinois, USA). Larval *Aedes* indices and adult indices were calculated and tabulated for descriptive statistics. Multiple logistic regressions were used to analyze the association between larvae indices and adult indices with DHF transmission.

3. Results and Discussion
3.1. Results
The entomological survey had been conducted in Medan and Langkat district. The results revealed that larval indices (HI, CI and BI) for *Aedes* were higher in Medan than Langkat (35, 13 and 43 and 22, 8 and 30, respectively). Furthermore, *Aedes aegypti* larvae were predominantly found in Medan, whereas, *Aedes albopictus* larvae were predominantly found in Langkat. The larval indices (HI, CI and BI) for *Aedes aegypti* were higher in Medan than Langkat (33, 12 and 39 and 11,2 and 9 respectively), whereas, for *Aedes albopictus* were higher in Langkat than Medan (13, 5 and 18 and 3, 1 and 3, respectively) (Table 1).

Table 1. *Aedes* larvae indices in high and low incidence district in North Sumatera Province

	High incidence district			Low incidence district		
	Aedes spp	*Aedes aegypti*	*Aedes albopictus*	*Aedes spp*	*Aedes aegypti*	*Aedes albopictus*
Number of households	152	152	152	152	152	152
Number of positive households	55	50	5	33	16	19
Number of containers	519	519	519	594	594	594
Number of positive containers	65	60	5	45	14	28
Larval index						
HI	35.0	33.0	3.0	22.0	11.0	13.0
CI	13.0	12.0	1.0	8.0	2.0	5.0
BI	43.0	39.0	3.0	30.0	9.0	18.0

Then larval indices was compared to the WHO standard to determine density figure (DF) of larvae as shown in Table 2. The amount of HI, CI and BI scores divided by 3 and expressed on a scale of 1 -9 and categorized into DF = 1: low density, DF = 2-5: medium density and DF = 6 -9: high density. The result of this study showed that density figures for larval indices in Medan and Langkat were 4.7 and 2, respectively. It means that have a higher risk of DHF transmission. Furthermore, HI in both high and low DHF incidence districts were more than 10, indicates a high-risk of DHF transmission.

Table 2. Density figure of mosquito larvae

Density figure	House Index (HI)	Container index (CI)	Breteau index (BI)
1	1-3	1-2	1-4
2	4-7	3-5	5-9
3	8-17	6-9	10-19
4	18-28	10-14	20-34
5	29-37	15-20	35-59
6	38-49	21-27	50-74
7	50-59	28-31	75-99
8	60-76	32-40	100-199
9	77+	41+	200

Source: Queensland Government [14]

The presence of *Aedes* mosquitoes inside and outside the houses, a number of *Aedes* mosquitoes and females were detected and calculated as vector indices (AHI, AD, RR) were presented in Table 3. Adult indices (AHI, AD, RR) for *Aedes aegypti* in Medan were higher than Langkat district (20,38,24 and 9,13,10, respectively). It is supported that *Aedes aegypti* mosquito predominantly found in Medan. While adult *Aedes albopictus*, was only caught in Stabat and Berandan, two subdistrict in Langkat district. It might due to *Aedes albopictus* which preferred Berandan subdistrict with geographically more plants. The adult mosquito indices was 3, 5, 5 respectively.

Table 3. *Aedes* mosquito indices in high and low incidence district in North Sumatera Province

	High incidence district			Low incidence district		
	Aedes	*Aedes aegypti*	*Aedes albopictus*	*Aedes*	*Aedes aegypti*	*Aedes albopictus*
Number of households	152	152	152	152	152	152
Number of positive households	31	31	0	18	13	5
Aedes collected						
F	37	37	0	22	15	7
M	21	21	0	5	4	1
Adult index						
AHI		20	0		9	3
AD		38	0		13	5
RR		24	0		10	5

Furthermore, the larval indices (HI, CI, BI) and adult indices (AHI, AD, RR) were analyzed to determine if they were associated with DHF transmission. Of Simple Logistic Regression analysis revealed that larval indices (HI, CI, BI) and adult indices (AD, AHI, RR) were significantly associated with DHF transmission (Table 4). However, using the Multiple Logistic Regression analysis, house index

(HI) was the only significant factor for DHF transmission in North Sumatera Province as shown in Table 5.

Table 4. Association between vector indices and dengue hemorrhagic fever transmission in North Sumatera Province by Simple Logistic Regression

Variable	HIDs n(%)	LIDs n(%)	Crude OR (95%CI)	p value of Wald
House index				
House (+)	54(35.5)	29(19.1)	1.093(3.035,3.935)	0.001
House (-)	98(64.5)	123(80.9)		
Container index				
Container (+)	65(12.6)	40(7.0)	1.271(3.917,4.125)	0.009
Container(-)	452(87.4)	527(93.0)		
Breteau index				
Container(+)	65(39.9)	40 (24.5)	1.005(1.622,6.222)	0.027
Container (-)	98(60.1)	123(75.5)		
Adult house Index				
House (+)	31(13.8)	18(11.8)	4.189(9.765,17.97)	0.045
House (-)	121(86.2)	134(88.2)		
Adult density				
Aedes adult(+)	58(32.4)	25(15.7)	3.642(2.752,4.818)	0.012
Aedes adult(-)	121(67.6)	134(84.3)		
Resting rate				
Female aedes(+)	37(22.2)	21(13.3)	2.097(0.000,1.265)	0.115
Female aedes(-)	130(77.8)	137(86.7)		

Table 5. Association between vector indices and dengue hemorrhagic fever transmission in North Sumatera Province by Multiple Logistic Regression.

Variable	HIDs n(%)	LIDs n(%)	Adjusted OR (95 % CI)	p value
House indices	54(35.5)	29(19.1)	1.093(3.035,3.935)	0.001
House (+)	98(64.5)	123(80.9)		
House (-)				

Forward LR Multiple Logistic Regression was applied. There was no interaction and multicollinearity Classification table (overall correctly classified percentage=58.2) Area under the ROC curve (58.2%) were applied to check the model fitness.

The distribution pattern of *Aedes* larvae and adult mosquitos are presented in Figure 3- 6. Based on BI-AHI, BI-RR, BI-AD and HI-AHI, HI-RR, HI-AD, and CI-AHI, CI-RR, CI-AD; showed high subdistrict had the similar pattern with low subdistrict both in Medan and Langkat Districts (Marelan and Maimun, Stabat and Berandan) as presented in Figure 3 and Figure 4. Likewise, high subdistrict in district with high DHF incidence (Marelan) and high subdistrict in district with low DHF incidence (Stabat); low subdistrict in district with high DHF incidence (Maimun) and low subdistrict in district with low DHF incidence (Berandan) also had the similar pattern as presented in Figure 5 and Figure 6.

Marelan (high subdistrict) Maimun (low subdistrict)

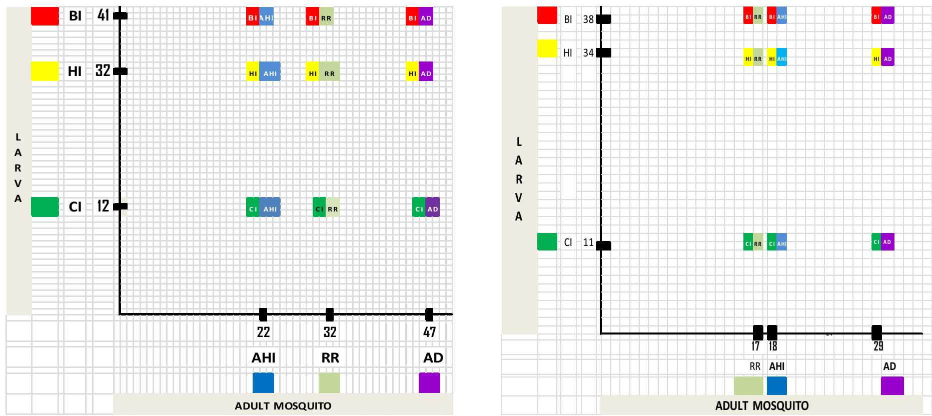

Figure 3. The distribution pattern of *Aedes* larvae and adult mosquito between high and low subdistrict in high incidence district.

Stabat (high subdistrict) Berandan (low subdistrict)

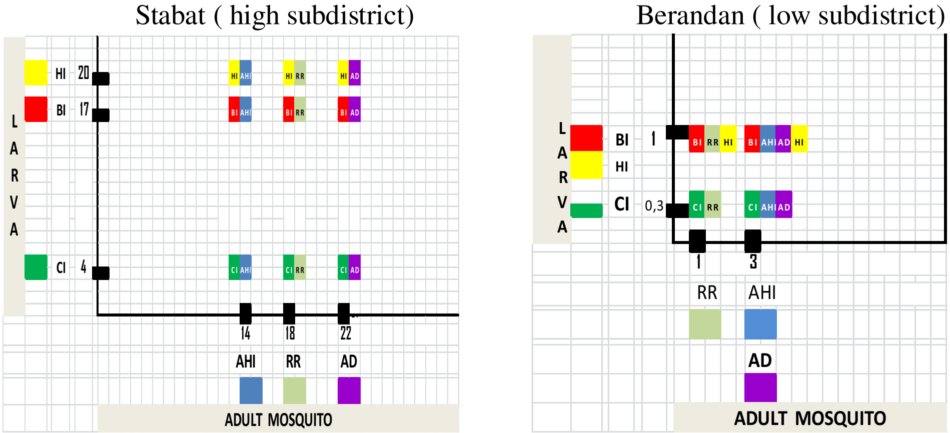

Figure 4. The distribution pattern of *Aedes* larvae and adult mosquito between high and low subdistrict in low incidence district

Marelan Stabat

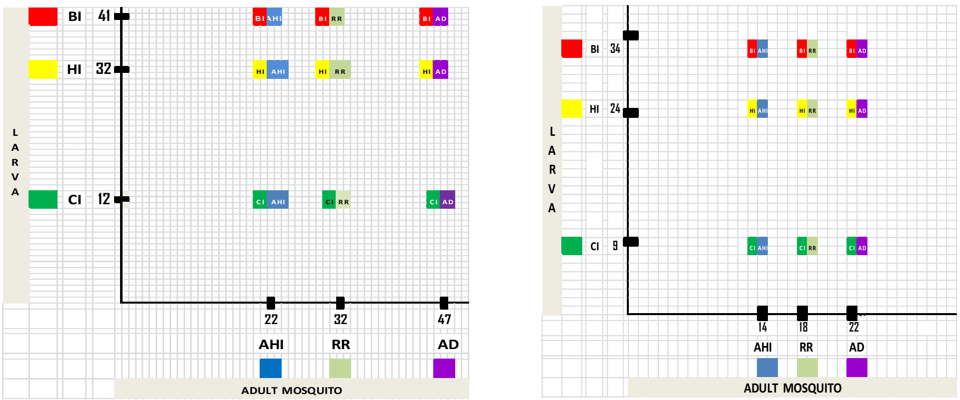

Figure 5. The distribution pattern of *Aedes* larvae and adult mosquito in high subdistrict between high and low incidence district

. Maimun Berandan

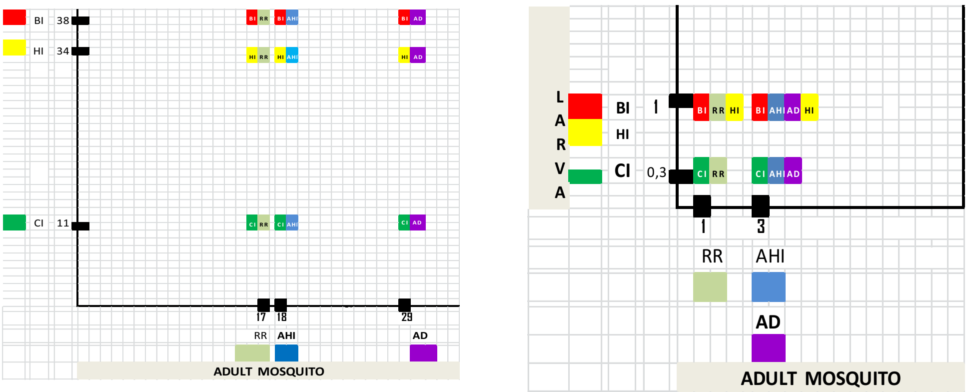

Figure 6. The distribution pattern of *Aedes* larvae and adult mosquito in low subdistrict between high and low incidence district.

The percentage of resting rate (RR) of *Aedes aegypti* in the high subdistrict more than low subdistrict both in Medan district and Langkat district (Figure 3 and 4). Likewise, the percentage RR of *Aedes aegypti* mosquitos in district high DHF incidence more than district low DHF incidence. It was indicated that the probability of *Aedes aegypti* biting and be a vector for DHF in both district high and low DHF incidence were differed. Therefore, DHF incidence in both districts were also differ. On the other hand, AHI and AD for *Aedes aegypti* in Berandan were lower than Maimun as shown in Figure 6. However, it could indicated that Berandan had a chance for DHF transmission.

3.2. Discussion

Transmission of DHF is directly related to its vectors. *Aedes aegypti* is the main vector for DHF, whereas *Aedes albopictus* is the potential vectors. Vector density, species identification and breeding places are essential for effective vector control [15]. In this study, *Aedes aegypti* larval indices (HI,CI,BI) in HIDs were higher than LIDs. On the contrary, *Aedes albopictus* larval indices in LIDs were higher than HIDs. It might be due to *Aedes aegypti* more common in urban area (Medan district), while *Aedes albopictus* preferred Brandan (Langkat district) that had geographical more plants. In the present study, *Aedes aegypti* and *Aedes albopictus* were found breeding at the household level in both HIDs and LIDs. A study by Rajendran *et al*. (2006) in Sulurpet India found HI,CI and BI were 9.45, 23.61 and 13.39 respectively. *Aedes aegypti* and *Aedes albopictus* were co-existed in the study area [16].

Furthermore, in this study larval indices were significantly associated with DHF transmission. A similar finding was reported by Pham *et al*. (2011) in Dak Lak Province in The central highlands region of Vietnam found that the incidence of DHF was significantly associated with House indices, container indices and Breteau indices [17]. Also, in this study, both districts have *Aedes* larval indices and adult indices were above the critical level, it means that have potential high-risk DHF transmission. Likewise, Balakrishnan *et al*. (2006) study on the 60 houses selected from three affected villages and 118 houses in the affected municipal ward in Tiruppur India found that *Aedes* larvae indices and adult density were above the critical level, indicating that potential outbreak would occur in the future [18].

The increased number of female *Aedes* mosquitoes would increase the probability of biting, thus increasing risk of DHF transmission [19]. *Aedes aegypti* adult indices (AHI, AD, RR) in Medan were higher than Langkat. Although RR of *Aedes aegypti* and *Aedes albopictus* in LIDs are low, however, it had a chance be a vector for DHF transmission. In the present study, adult house indices (AHI), adult density (AD) and resting rate (RR) were significantly associated with DHF transmission. A study by Sahani *et al*. in Senawang Negeri Sembilan, Malaysia from July 2009 to February 2010 found that the density of *Aedes albopictus* was high and could be a potential vector for DHF transmission [5].

According to the Health Ministry of Indonesia, HI was used as an indicator for DHF transmission due to these larval indices further illustrated the extent of spreading of DHF. Likewise, The Pan American Health Organization used HI as an indicator for dengue transmission [6]. In this study, in both districts, high and low incidence district have HI level was higher than 10, indicates a high-risk of DHF transmission. Further analysis with multiple logistic regression, HI was a predictor for DHF transmission in North Sumatera. Of this study, it could conclude that monitoring of vector density is essential not only monitor vector distribution, but could predict probability DHF transmission. Furthermore, provide accurate information for vector eradication and effective control strategies.

4. Conclusions

This study revealed that the *Aedes* larval indices (HI, CI and BI) were higher in HIDs than in LIDs. *Aedes aegypti* mosquito is predominantly in Medan district , meanwhile *Aedes albopictus* mosquito only found in langkat district. Adult indices (AHI, AD, RR) for *Aedes aegypti* in Medan and for *Aedes albopictus* in Langkat were 20,38,24 and 3,5, and 5, respectively. Pattern distribution of *Aedes* larvae and adult mosquito in both district had a similar pattern. Furthermore, both districts had larval indices and adult indices were above a critical level, it means that have potential high-risk dengue transmission. For an effective control strategy, should focused on vector control. Therefore, monitoring vector density is essential as a basis for health professional in designing more effective prevention strategies.

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