# Competence Aedes as Vectors Based on Viological Characteristics and Vulnerability of Dengue Virus in Semarang City-Indonesia

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# Competence *Aedes* as Vectors Based on Biological Characteristics and Vulnerability of Dengue Virus in Semarang City-Indonesia

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*Background*: Semarang city of central Java Province is one of the cities that have a very high incidence of dengue. In an effort to control dengue vector accurate data is needed. This study aimed to describe the profile of dengue vector *Aedes* sp. based on the density index and index *transovarial* transmission (ITT) and its relation to the incidence of dengue in the city of Semarang. *Method*: This research is a cross sectional survey with 18 samples of urban villages in the city of Semarang selected by random technique. To measure the density of *Aedes* larvae use survey techniques, installation *ovitrap*, and a survey of adult mosquitoes. Each village surveyed 15 homes and placed *ovitrap* inside and outside the home. Installation *ovitrap* attractant using a solution of 10% hay bath. *Result*: The results show the density of larvae in Semarang is very high based on larval density index HI = 42.4%, CI = 21.3%, BI = OI = 58.9% and 33.9%, so it can be said Semarang including areas with high risk of dengue. Type *Ae. albopictus* is still found in the city, especially in areas where the use of land for crops is still quite extensive. *Ae gonotropik* cycle time. *aegypti* 2.8 days, biological cycles 286.1 hours, and age a lot of mosquitoes belonging to old age. Transovarial index gained by 40.97%, indicating the status of *endemicity* in Semarang is getting longer. *Conclusion*: The physical environment, larvae density, density of the adult mosquito influenced the transmission of the dengue fever in Semarang City.

**Keywords:** DHF, *Aedes sp*, Dengue, Transovarial Infection.

## 1. INTRODUCTION

Dengue Hemorrhagic Fever (DHF), an infectious disease caused by dengue virus, is transmitted from one person to another by *Aedes* (*Ae*.) sp. Reports of dengue cases tend to increase from year to year, even more widely spread. WHO reports more than 40% of the world population at risk of dengue and it is estimated there are 50 million new infections per year.[1] In 2008, DHF incidence was 58.94/100,000 population and Case Fatality Rate (CFR) of 0.86%.[2] Although *incidence* decreased compared to 2007, but the parameter is still quite high compared to the national target is equal to 50/100,000 population.

Central Java Province is one of the regions endemic in Indonesia. Health Office of Central Java Province in 2009 has reported 18,877 cases or incidence of 57.9/100,000 and CFR 1,42%. While in Semarang City, *Incidence* dengue reached 367.5/100,000 in 2010, because of it, Semarang was a second highest on national level after Bali. In 2012 Semarang has still become the second highest *incidence* after Jakarta (Data from Health Office in Semarang).

Increasing cases in some areas indicated there has been the environment changes (global warming), such as temperature, rainfall, and humidity. Changes in the environment caused by human activity. Human activities have an impact on tropical forest destruction and gas emissions into the air higher, resulting in global temperature increase to an average of about 1,0–3,5 °C.[3] Changes in the environment will affect species on ecosystems and the pattern of spread of the vector and the virus so that it can increase the incidence of dengue transmission.

Temperature and humidity affect the viability of the vector.[4] Such changes will also affect the life cycle of mosquitoes, especially the behavior of *Aedes* sp. Life cycle of Mosquito from egg phase into adult mosquitoes was getting shorter. Low temperatures can suppress the development of the larvae and eggs

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of *Aedes* spp that dengue transmission will be interrupted.[5] At a temperature of 26 °C virus requires 25 days for a mosquito to infect the virus is in the saliva glands and is ready to be distributed to vulnerable human beings, and it may take as long as mosquitoes are still alive (period extrinsic). Conversely takes a relatively short time of 10 days at a temperature of 27 °C. In a short period it can be said that the age of the vector is a critical determinant of the capacity of the vector to move the dengue virus to susceptible host.[6]

Mosquito lifespan could reach 1 month if it is in optimum air conditions and the longer the lifespan of mosquitoes increasingly effective as the capability of transmitting. Instead *Aedes* mosquito can become a vector role when environmental conditions are adequate. Competence vector *Aedes* describe of the potential transmission of dengue in the region.[7,8] Parameter increase efficient mosquito vectors are affected by the mosquito population density, cycle rate *gonotropic*, extrinsic incubation as well as the readiness of the virus in the body of the vector for transmission. Parameter represents a potential vector competence of adult mosquitoes as vectors.

DHF prevention efforts have been made but not yet provide optimal results. Some of the factors that led to the failure of prevention of dengue fever in Indonesia is still weak human resources involved in terms of the number and the mastery of science and technology, vector surveillance system, technical and managerial implementation of vector control is still weak.[9] Vector control was priority to control of dengue in the community, because of the drug and vaccine were still no available. So, the study of *Ae. aegypti* as the vector of dengue is very necessary, especially on the nature of vector biology and susceptibility to viruses and virus types.

This research describing bionomics profile and vulnerability vector in Semarang are still limited. This study aims to determine the competence of *Aedes* vectors in Semarang based on the biological characteristics (bionomics) and vulnerability to dengue virus infection, and to make a model of the vector determined DHF incidence in Semarang.

## 2. METHOD

This study by type is descriptive observational study using cross sectional method. The population in this study are all urban villages in the city of Semarang totaling 177 villages. The study was done in February–November 2013. The sample was 10% of the total villages in the city of Semarang. Each village is determined 15 homes. Each house arrest and installation ovitrap adult mosquitoes. Selected homes are homes that are or have been suffering from dengue cases in 2013 January and February, and the neighboring house (as many as 14 houses with a distance of less than 100 m). To support the research, it takes a brief interview with the respondents about the presence of mosquitoes. The variables in this study included mosquito density from larvae to adult mosquito (HI, BI, CI, OI, and RR), species of mosquito, parousity, age mosquitoes, cycle gonotropic, transovarial infection rates, and the type of virus. It also measured environmental variables such as temperature, humidity, rainfall. Measurement of the physical environment variable was done at the time of the survey.

## 3. RESULTS

The high case of DHF in Semarang is determined by many factors, including physical environmental factors and vector competence. Measurement of environmental parameters in the study sample Semarang which include population density, land use and physical environment, each at 9.04 people/km$^2$, land for dwelling has reached 70% of the area. Environmental parameters measured at the time of the survey showed an average temperature of 32.47 °C, humidity 64%, rainfall of 266.89 mm, and a rainy day at 13.78 today.

Surveys conducted in 18 villages in the city of Semarang showed that the picture larval density index (HI, BI, CI and OI) in Semarang is very high, respectively HI = 42.4%, CI = 21.3%, BI = 58.9% and OI = 33.9%. Resting Rate (RR) adult mosquito of Aedes sp per house of 1.15 mosquito/house. RR is calculated based on the number of *Aedes* sp captured divided by the number of homes surveyed. *Ae. aegypti* females in the house caught by 64.9%, and *Ae. albopictus* in the house by 25%. Adult mosquitoes were caught mostly used for the measurement cycle gonotropic, biological and parousity status. The results of measurements of biological cycles *Ae. aegypti* was observed for 216.9 hours or 11.9 days, 2.8 days and parousity category status >2 (or never spawn at least 2 times) amounted to 18.2%.

Aedes sp susceptibility to the virus are known to the percentage of positive by IHC examination. Dengue virus infection in *Aedes* sp in Semarang reached half (49.6%) of mosquitoes captured through surveys and ovitrap larvae survey. Similarly, *Ae. albopictus* were also positive, but with half the percentage of the primary vector (*Ae. aegypti*). Confirm with PCR showing from 18 villages were examined only one positive villages Den-3 virus strains, namely mosquitoes captured in a village in Kalibanteng Kidul Semarang.

Model incidence of dengue in the city of Semarang in this study as in Figure 1. This modeling was analyzed using PLS method. The analysis showed $R$-Square value > 0.0, which means that structural models are acceptable (Ghozali, 2011). While the significance of the results between exogenous and endogenous influences the amount indicated on rainy days to temperature change ($t = 2.906$), the land use of the temperature ($t = 1.9989$), the magnitude of the rain against moisture ($t = 2.785$), the population density on land use ($t = 3.354$), the rainfall to the density of larvae ($t = 2.249$), and the density of adults to the amount of incidence of DHF ($t = 2.327$), complete as in Table I.

## 4. DISCUSSION

Incidence of dengue in the city of Semarang is very high, therefore the Semarang City National ranks second after the city of Bali. This research seeks to analyze the factors associated with the incidence of dengue fever, especially on the capability of the mosquito vector, environmental factors and viral strains develop. The analysis of the ability of vector mosquitoes become one of them in terms of the nature of bionomics, the ability to reproduce, and mosquito susceptibility to dengue viruses. These results indicated that the density of the vector in Semarang is quite high. Mosquito density was measured using an index such as HI, CI, and BI. All of the index exceeds the standard of health programs (HI and CI < 5%, and BI < 20%).

To get an idea of the vector population, in this study also uses ovitrap index (OI). Mosquito attractant or pull compounds are

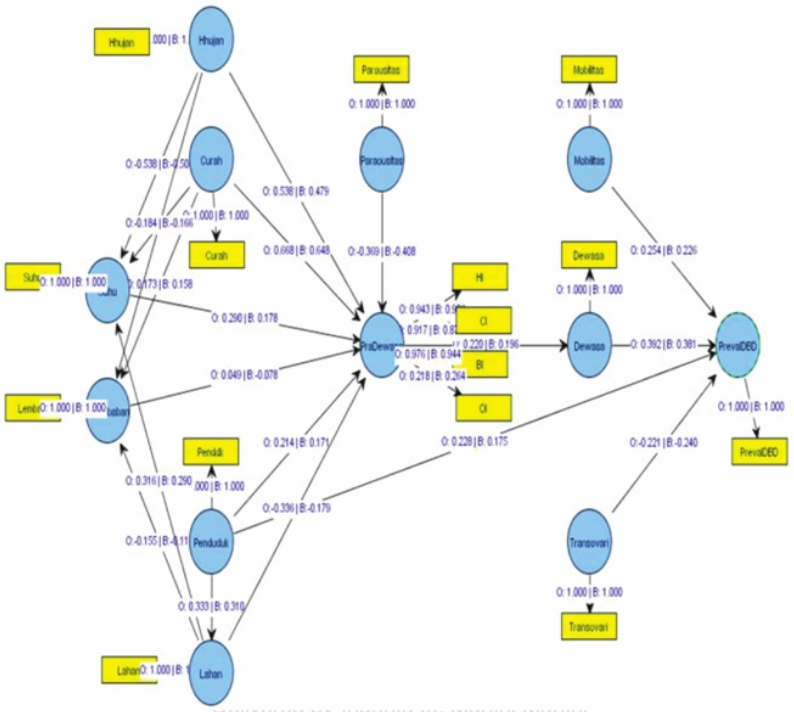




**Fig. 1.** Vector capacity determine DHF incidence.

used with immersion straw ovitrap is 10%. Use of the method of soaking hay attractant ovitrap with 10% can increase the value of the vector density in a region. Previous research has shown that the ovitrap better technique in measuring the density of larvae (pre-mature).[10] Some researchers also stated that ovitrap an effective tool to monitor the density of *Ae. aegypti* and often used in vector surveillance,[11] sensitive to measure the presence of the vector in the population is low,[12] and can be applied to a wide area and in a relatively short time.

The density of larvae (pre-adult mosquitoes) and the density of adults show a linear quantification. Adult stage mosquito density increases with increasing density of mosquito larva (pre-mature).

**Table I. Factors that influence the incidence of dengue in the city of Semarang.**

| Variabel | Original sample estimate | Mean of subsamples | Standard deviation | *t*-statistic |
|---|---|---|---|---|
| Rainy days → Temperature | −0.538 | −0.504 | 0.185 | 2.906* |
| Rainfall → Temperature | −0.184 | −0.166 | 0.200 | 0.922 |
| Use of agriculture land → Temperature | 0.316 | 0.290 | 0.159 | 1.989* |
| Rainy days → Humidity | 0.567 | 0.533 | 0.204 | 2.785* |
| Rainfall → Humidity | 0.173 | 0.158 | 0.155 | 1.115 |
| Population density → Humidity | −0.155 | −0.119 | 0.186 | 0.832 |
| Use of agriculture land → Humidity | 0.333 | 0.310 | 0.099 | 3.354* |
| Population density → Use of agriculture land | 0.538 | 0.479 | 0.327 | 1.648 |
| Temperature → Larvae density | 0.668 | 0.648 | 0.297 | 2.249* |
| Humidity → Larvae density | 0.290 | 0.178 | 0.489 | 0.592 |
| Rainfall → Larvae density | 0.049 | −0.078 | 0.407 | 0.121 |
| Parousity → Larvae density | 0.214 | 0.171 | 0.257 | 0.831 |
| Rainy days → Adult mosquito density | −0.336 | −0.179 | 0.336 | 1.000 |
| Rainfall → Adult mosquito density | −0.369 | −0.408 | 0.229 | 1.612 |
| Larvae density → Adult mosquito density | 0.220 | 0.196 | 0.191 | 1.151 |
| Temperature → Parousity | 0.228 | 0.175 | 0.178 | 1.286 |
| Adult → Incidence Dengue | 0.392 | 0.381 | 0.168 | 2.327* |
| Population density → Incidence Dengue | 0.254 | 0.226 | 0.182 | 1.400 |
| Transovarial → Incidence Dengue | −0.221 | −0.240 | 0.168 | 1.315 |

*Notes*: Description: *significant at $\alpha = 0.05$.

Means the development of the egg, larva, pupa to become adult mosquitoes can take place perfectly. Environmental factors such as temperature and humidity strongly supports vector in Semarang. The temperature will affect metabolic processes. Low temperature affects the development of the egg, otherwise the temperature rise can reduce the size of mosquito larvae and adult sizes. Small body size would increase the rate of metabolism, food intake, and in turn will increase the number of eggs produced.[13] Temperature and humidity are measured in the study with an average temperature of 32 °C and 64%. The measurement rainfall was 266.89 mm and 13.78 days. In other words, the study was carried out with the rainfall and rainy days are still quite high.

Characteristics of mosquito bionomics is genetically specific to a particular environment. It is seen competition *Ae. aegypti* and *Ae. albopictus* in the study area. *Ae. aegypti* dominate in all areas of the villages in the city, but *Ae. albopictus* is also still commonly found both indoors and outdoors. Domination *Ae. aegypti* showed vectors are often found to be active in outdoor. This indicates no change in the behavior of *Ae. aegypti* toward domestic fairy, namely behavioral change bionomics from indoor to outdoors.[14] The population of *Ae. albopictus* can also be found in the house. The survey results found the larvae breeding sites of *Ae. albopictus* in a container of water dispensers, which is located indoor, especially in the villages with the utilization of the yard and plantation still quite broad. Land use is compatible with the original habitat of *Ae. albopictus* which is a forest species that then have adapted to human settlements or the environment either in rural areas or urban (and rural to urban). The existence of the eggs and larvae of *Ae. albopictus* is also found in the house. *Ae. albopictus* active in indoor can cause increase capacity as vectors, both in terms of vector-host contact as well as the vector population density.[15] Changing patterns of behavior, especially the proliferation of *Ae. albopictus* from semi-domestic ecotypes be domestic, were also reported in India by researchers.[16] Some containers/ovitrap examined can be found in more than one species (mixed breeding), both outdoor and indoor.

In this studies have also shown that the biological cycle will determine mosquitoes mosquito. Mosquitoes age is strongly influenced by temperature and humidity environment. The age of mosquitoes are a critical determinant of the capacity of the vector, especially in its potential to move dengue virus to vulnerable hosts.[6]

Status parousity describe mosquito reproduction rate and mode of virus transmission. The survey results showed parous rate entomology mosquito in Semarang nearly three-quarters (66.7%) in reproductive condition (never spawn). This indicates that mosquitoes mostly relatively old. Age mosquitoes will determine the life chances of mosquitoes per day. Mosquito life is affected by many factors including intrinsic factors such as age and genetic and extrinsic factors such as nutrition, predators, and insecticides use.[17] Environment changes will increase mosquitoes activity to bite, especially in patients with dengue fever in the acute febrile phase/viremia. Mosquitoes will become infected and potentially spread the virus.

### 4.1. Vulnerability Status Vector

Vector susceptibility to the virus that is Characterized by positive IHC brown color through the examination either at *Ae. aegypti* and *Ae. albopictus*. The case showed that *Aedes albopictus* can be a vector. Value infection transovarialnya big enough for nearly 50% in Ae. 25% aegypti and *Ae. albopictus*. In confirmation with the PCR method identified a genetic marker of a particular virus strain, the which Den-3, but identified only one village. It is possible Den virus titers in mosquitoes in other villages is very low, or because of an infected mosquito do not shipped with the sampling. Additionally in this study used only a minimum number of 6 (six) thoracic mosquitoes. For that we need to use mosquito samples in considerable amounts.

Potentially Ovarial transmission can be as a supporter of endemicity of dengue in the region. The virus persistently Den Vertically transmitted to offspring 7th ($F$) $-7$.[18] If the 4 (four) virus serotype Den circulate throughout the year that may increase the risk of dengue transmission. Not all mosquitoes are infected by the virus Den can be a vector of dengue. Factors affecting the susceptibility of the vector including itself. Therefore, variations in vulnerability vector in an area, then the infection rate transovarial in an area will vary. Besides gender also determine the level of mosquito susceptibility to viruses Den. Transovarial infection in males is lower than the female.[19] This is related to the mechanism of infection between the sex of mosquitoes. In the male mosquito transovarial infection acquired from its parent, but the female mosquito infection mechanism can be obtained from a parent or acquired when mating (mating) with female mosquitoes. In this study does not differentiate transovarial infection rate in male or female gender.

### 4.2. Population of Mosquito Influence to DHF Incidence in Semarang

The analysis showed that the days of rain, temperature, humidity, residential density, land use residential and parousity status will affect the population density of larvae (pre-mature). Furthermore, the density of the pre mature adult can affect density. In this research has not been able to prove that all the variables tested affect the transmission of dengue fever, both at the level of the highlands and lowlands. This research was conducted at the end of the time period of the rainy season. However, the number of rainy days is still high, almost every day of rain. Descriptively showed that the density of larvae (pre-mature) in Semarang is very high. So that needs serious attention, given the density index above the standards set (HI > 5%). *A. albopictus* is still quite commonly found in the city, and by immunohistochemical examination *Ae. albopictus* is also susceptible to the virus Den. This raises a presumption that the dengue virus transmission can occur outside the home.

Structural equation model that has been arranged will illustrate the magnitude of the effect of exogenous variables (independent) against endogenous variable (dependent). In an effort DHF control, the structural model as a reference to determine priorities for promotive and preventive actions. Promotive and preventive efforts should be intensified, especially in the period before transmission. Dissemination to the public about dengue and its prevention methods are really still very necessary. An intensive effort appears not only in highly endemic areas alone but to the entire region in the city of Semarang. It is necessary for the health network in the community as optimal effort in controlling dengue in the community. The health department with a lot of programs that should be addressed make control efforts could not be simply pinned on the institution.

## 5. CONCLUSION

Vector competence according characteristic of bionomic, biology and the life opportunity of the mosquito is supported by the suitable environment condition that encourages mosquito to be a vector.

Modeling analyses showed that the physical environment, density of the larvae, density of the adult mosquito influenced the transmission of the dengue fever in Semarang City.

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