Jurnal Biodjati 4(1):40-49, May 2019

e-ISSN : 2541-4208
p-ISSN : 2548-1606

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

EFFECT OF WATER TEMPERATURE TO SURVIVAL AND DEVELOPMENT OF LARVAE OF TWO LOCAL *Aedes aegypti* STRAINS

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Received : December 20, 2019
Accepted : February 28, 2019

DOI: 10.15575/biodjati.v4i1.3843

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Abstract. *Global warming has been reported in last decades. Changes in average Earth's temperature may affect the physiology of many insect species, especially the ones which act as a human disease vector, like Aedes aegypti. In this study, the effect of increasing water temperature on physiological components related to development period, sex ratio, and body size of two distinctively strains, VCRU (Vector Control Research Unit) and Pangandaran. Thirty larvae of each strain kept inside distilled water with the temperature of 25°C, 27°C, 30°C, 33°C, 35°C, 40°C which replicated three times. Observations were conducted until all larvae metamorphed into adults or all larvae dead. Development rate and time were analyzed by frequency dependent mean. The result showed that the optimum temperature for larvae development of VCRU strain was 27-30°C with a survival rate of 84% while it was 30°C for Pangandaran strain, with the survival rate of 83%. Larvae of both strains showed 100% mortality rate when kept inside a container with water temperature exceed 33°C. Both strains showed the highest and the lowest male:female ratio at similar water temperature which were 33°C and 30°C, respectivelly. Highest and lowest ratio of VCRU was 1.25 and 0.6, respectively, while it was 1.4 and 0.6 for Pangandaran. In general, larvae lived in increasing water temperature showed reducing wing width.*

Keywords: *Aedes aegypti, development, sex ratio, survivorship, water temperature*

Citation
Putra, R. E. & Trinuroni, G. (2019). Effect of Water Temperature to Survival and Development of Larvae of Two Local *Aedes aegypti* Strains. *Jurnal Biodjati*, 4(1), 40-49

INTRODUCTION

In the last decades, the climate condition showed the trend of increasing mean temperature of Earth's surface (Revich et al., 2012; Bai et al., 2013). It has been forecasted that the average temperature of the Earth's surface, by the end of the 21st century, will increase by 1–6.4°C (IPCC, 1995; Githeko et al., 2000).

Warming of atmosphere and surface of the earth could affect the variety of physical (Parry et al., 2007) and biological systems (Githeko et al., 2000; Parry et al., 2007). Changes in both physical and biological may determine the their habitats of many arthropod species (Van Lieshout et al., 2004) which some of them, like mosquitoes, acts as human disease vector (Reiter, 2001).

One of the most known mosquito species, due to its competency as a vector of some of the most deadliest human diseases, is *Aedes aegypti* (Gubler et al., 1995; Scott et al., 1997;

Lourenco-de-Oliveira et al., 2002; Nene et al., 2007; Morison et al., 2008). This species spend their early stage in the aquatic habitat and their distribution and physiology are highly effect by physical condition of their aquatic habitat (Bar-Zeev, 1958; Rueda et al., 1990). Reports showed that water temperature less than 10°C prevent the development (Slosek, 1986; Hopp & Foley, 2001). Increasing water temperature, at the optimum range, resulting in (1) shorter development time (Bayoh & Lindsay, 2003, 2004; Yang et al., 2009; Costa et al., 2010; Couret et al., 2014), (2) virus incubation period (Focks et al., 2000, Hopp & Foley, 2001), (3) change the sex ration of adult mosquitoes (Tun-Lin, 2000; Mohamed & Chadee, 2011) and (4) size of adult mosquitoes (Reisen et al., 1984; Siddiqui et al., 1976; Tun-Lin et al., 2000; Schneider et al., 2004).

The most prevalent virus spread by this species is Dengue Fever (DF) which estimated the worldwide number of annual cases is 100 million (Bhatt et al., 2013). In Indonesia, the total number of death caused by this disease could reach 1000 death per year (Ahmad et al., 2007; Kemenkes, 2016).

The effect of the water temperature to the life cycle of *Ae. aegypti* have been investigated in many regions (Bar-Zeev, 1958; Keirans & Fay, 1968; Rueda et al., 1990; Kamimura et al., 2002; Mohammed & Chadee, 2011; Richardson et al., 2011). These studies provided baseline information to develop future strategies to regulate ecobiology of *Ae. aegypti* at natural habitat and other habitats near human dwelling (Williams et al., 2014; Campbell et al., 2015; Marinho et al., 2016; Zapletal et al., 2018).

Unfortunately, similar study quite rare in Indonesia where variation in ecological condition and anthropogenic stress caused mosquitoes had developed several strains which varied in physiological characterictics. In this study, we observed the effect of water temperature to development period, sex ratio, and size of two *Ae. aegypti* strains, VCRU (a lab strain) and Pangandaran (field strain).

MATERIALS AND METHODS

Research Period

The study was conducted at Toxicology and Entomology Laboratory of School of Life Sciences and Technology, Indonesia. The average room temperature was 23-27°C with average humidity about 75-90%.

Mosquitoes

In this study, two mosquito strains were applied as a research subject, namely VCRU and Pangandaran Strains. VCRU (Vector Control Research Unit) was originated from Universiti Sains Malaysia which kept as standard strain at Laboratory of Entomology, School of Life Sciences and Technology, Institut Teknologi Bandung. On the other hand, Pangandaran Strain (PS) was originated from Pangandaran region, a shore area at south of West Java.

Keeping the Mosquitoes

400 Mosquito eggs were kept inside a container (17 x 12 x 16 cm) filled with 500 mL distilled water. 30 hatched larvae collected by pipette and kept inside 250 mL glass jar filled with 100 mL distilled water. Larvae were fed *ad libitum* with commercial fish feed. Jars kept inside water bath with designated temperature. Water changed daily and fresh fish feed added after the water was changed.

Heat Treatment and Mortality

In this study, larvae of each strain were kept at a water temperature of 25°C, 27°C, 30°C, 33°C, 35°C, 40°C. Mortality rate observed at 24 hours and the observation was conducted for all larvae metamorphosed into pupae. All treatements were replicated three times.

Measuring the Size of Mosquitoes

Adult size was determined by measuring length of wing (Packer & Corbet, 1989; Briegel et al., 1990a,b; Lounibos et al., 1990; Livdahl & Wiley, 1991; Blackmore & Lord, 2000; Briegel & Timmermann, 2001; Armbruster & Hutchinson, 2002). Studies by Carron (2007) and Petersen et al. (2016) showed the positive correlation between wing length and weight of adult which made this methods as one of the simplest method for rapid measurement of mosquitoes weight.

Data Analysis

Development duration of *Ae. egypti* measured by *frequency means dependent*. Development period was calculated by 1/ average of development duration. Sex ratio calculated by dividing a total number of adult male and female. Survivorship calculated by comparing a number of surviving adult mosquitoes and total observed mosquitoes. All data analyzed by Kolmogorov-Smirnov test for normality followed by ANOVA (for normaly distributed data) and Mann-Whitney (for data which not normaly distributed) with confidence level of P<0.05. Tukey post hoc test was applied for data with a significant result.

RESULTS AND DISCUSSION

Survivorship

Larvae of both strain unable to live at water temperature above 33°C with VCRU strain has the lower survival rate at that temperature. At the lower temperature, there was no difference between both strains (Figure 1).

The result is contradictive with recent studies showed the absence of *Ae. aegypti* immature in the container with water temperature exceed 32°C (Bond & Fay, 1969; Chadee & Rahaman, 2000; Chadee, 2003; Hemme et al., 2009). It seems, higher temperature (33°C) more likely to prevent eggs from hatch and increase the mortality of early instar (Padmanabha et al., 2011). The higher survival rate of Pangandaran strain might be related to the habitat condition of Pangandaran where the average temperature could exceed 35°C.

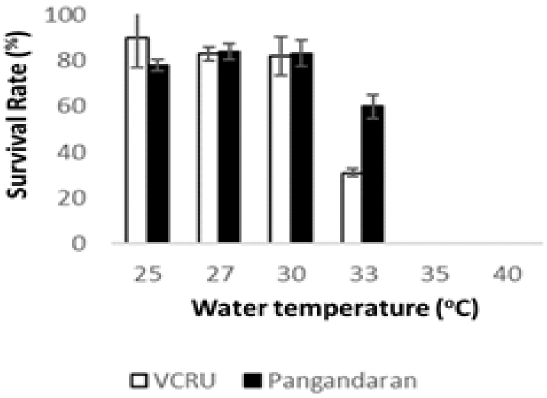

Figure 1. The survival rate of VCRU and Pangandaran strains

Development Duration

Increasing water temperature reduced the development time of both strains and VCRU strain had slightly shorter development period (ANOVA, P>0.05) (Fig.2).

Like another arthropods, insect needs particular temperature range to develop which highly affected by their genetic make-up (Chadee, 2004; Gillot, 2005).

Development Rate

The highest development rate was recorded at a water temperature of 30°C. On average, development rate of VCRU was higher than Pangandaran (Fig. 3).

The results supported previous result on the positive correlation between temperature and development rate of mosquito (Rueda et al., 1990; Bayoh & Lindsay, 2003; Loetti et al., 2011, Ciota et al., 2015).

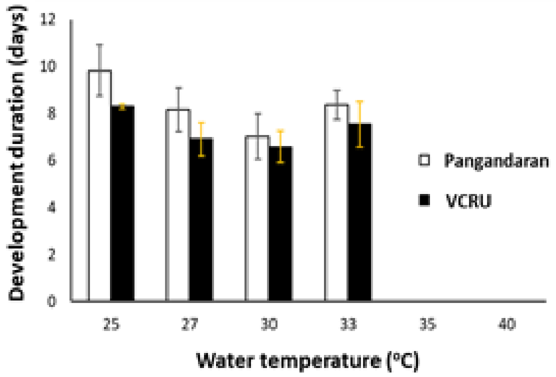

Figure 2. Average development duration of VCRU and Pangandaran

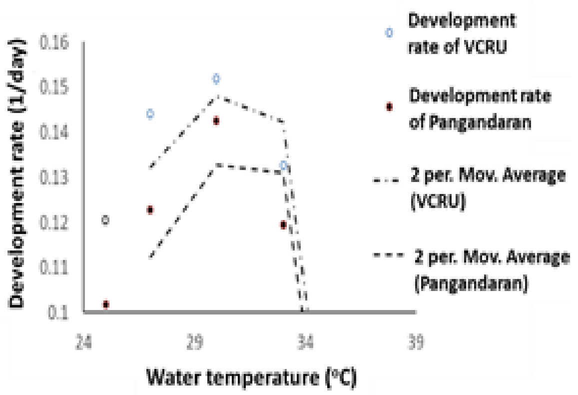

Figure 3. Development rate of *Aedes aegypti* of VCRU and Pangandaran Strain

Adult Wing Length

Larvae kept in higher water temperature had shorter wing length. The impact of water temperature to wing width was more prominent in female ($p<0.05$) than male ($p>0.05$) (Fig. 4).

Lower mosquito size at higher habitat temperature also reported by previous studies (Chambers & Klowden, 1990; Rueda et al., 1990; Chadee & Beier, 1997; Gunay et al., 2011).

Shorter wing span of adult is related to shorter development time which has been reported by many previous studies (Bar-Zeev, 1958; Rueda, 1990; Lyimo et al., 1992; Tun Lin et al., 2000; Alto & Juliano, 2001; Mourya et al., 2004; Mohammed & Chadee, 2011). Interestingly, the wing length of male and female was quite similar at 30°C treatment group. It seems, 30°C was the optimum temperature for development for both sexes. Smaller size probably as result of increasing growth efficiency (Rashed & Mulla, 1989) which allow the larvae to reach critical mass for pupation in shorther time (Atkinson & Sibly, 1997).

Some studies showed the positive correlation between wing width to reproductive success rate of locating host, fecundity, life span, etc. (Packer & Corbet, 1989; Briegel, 1990a, 1990b; Lounibos et al., 1990; Livdahl & Wiley, 1991; Blackmore & Lord, 2000; Briegel & Timmermann, 2001; Armbuster & Hutchinson, 2002). Since both strains could be considered as susceptible strain, the increasing temperature could produce negative implication to their population in laboratory and field.

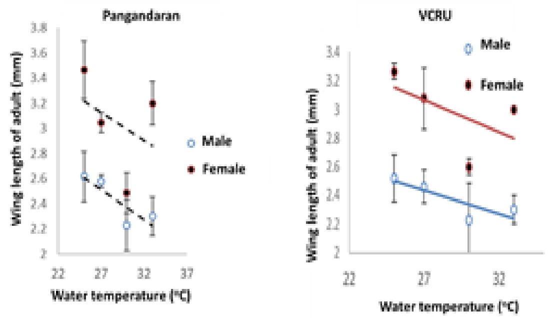

Figure 4. Comparison of Average wing width between male and female adult Aedes aegypti of Pangandaran and VCRU strain reared at different water temperature.

Sex Ratio (Male : Female)

This study showed the impact of water temperature on male/female (M/F) sex ratios.

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The Lowest M/F ratio was recorded at 30°C and the highest at 33°C (Fig. 5).

The result was similar to another study in India (Mourya et al., 2004). There was no correlation between habitat temperature and M/F ratios which identical to previous studies (Bar-Zeev, 1958; Tun-Lin et al., 2000; Mohammed & Chadee, 2011).

However, higher M/F ratio recorded at higher temperature was disagree with the pattern of M/F ratio reported by previous studies (Mourya et al., 2004; Mohammed & Chadee, 2011). It has been hypothesized that mosquito sex ratio is modulated by a meiotic driver which preference to produce more male at specific temperatures (Cha et al., 2006). Thus, there is a possibility that habitat provides selection forces which determine the sex determination which recommended as a further study.

This study showed possible physiological effect of increasing water temperature, which in related to the average environmental temperature, to field and lab mosquitoes. Both showed some significant effect in reducing the development time, development rate and size of adult mosquitoes. This condition may created change in term of mosquito and disease distribution. The lower development time and rate could create more overlapping generation, a more rapid population proliferation and increase rate of mutation through mating among those population. On the other hand, the smaller mosquito may lead to more concentrate mosquito populations due to limitation in dispersal and available energy of smaller mosquitoes. Further studies are required to observe the effect increasing water temperature to virulence of DF virus to provide a better understanding of possible DF outbreak in the future due to global warming.

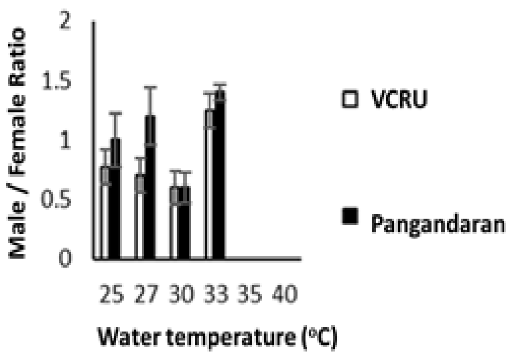

Figure 5. Male and Female Ratio of VCRU and Pangandaran

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