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MORPHOLOGICAL DEVELOPMENT AND LIFE CYCLE OF *AEDES AEGYPTI* IN DIFFERENT WATER MEDIA

Perkembangan Morfologi dan Siklus Hidup *Aedes aegypti* pada Berbagai Media Air

Aulia Pebrian, Tetty Barunawati Siagian*

College of Vocational Studies, IPB University, Jl. Kumbang No. 14, Babakan, Central Bogor, Bogor 16128, Indonesia

*Corresponding author email: tettybarunawatisiagian@apps.ipb.ac.id

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Abstract

Aedes aegypti is the primary vector of dengue fever, and its life cycle is influenced by environmental conditions, including the type of water used as a breeding medium for the larvae. This study aimed to compare the morphological development and life cycle of *Ae. aegypti* in four different water sources: tap water, *Saccharomyces cerevisiae* yeast water, rainwater, and well water. A descriptive-comparative experimental approach was employed using four treatments, each comprising 50 *Ae. aegypti* eggs. The observed parameters included egg hatching success, developmental duration from egg to adult, morphological characteristics at each developmental stage, and pH of each water medium. The results showed that yeast water produced the fastest development, requiring approximately 6 days from egg to adult, followed by tap water (8 days), whereas rainwater and well water required approximately 10 days. Nearly all eggs hatched in yeast water and tap water, whereas approximately 75% hatched in rainwater and well water. The pH of the water ranged from 6.47–6.87. In conclusion, different water media influenced the developmental duration of the *Ae. aegypti* life cycle, with yeast water supporting the fastest development under the conditions of this study.

Keywords: *Ae. aegypti*, egg hatching, life cycle, morphological development, water media

Abstrak

Aedes aegypti merupakan vektor utama penyakit demam berdarah dengue yang perkembangan siklus hidupnya dipengaruhi oleh kondisi lingkungan, termasuk jenis media air sebagai tempat perkembanganbiakan. Penelitian ini bertujuan membandingkan perkembangan morfologi dan siklus hidup *Ae. aegypti* pada empat jenis media air, yaitu air ragi *Saccharomyces cerevisiae*, air berasal dari Perusahaan Air Minum (PAM), hujan, dan sumur. Penelitian menggunakan rancangan eksperimental deskriptif-komparatif dengan empat perlakuan, masing-masing diawali menggunakan 50 butir telur *Ae. aegypti*. Parameter yang diamati meliputi keberhasilan penetasan telur, lama perkembangan dari telur hingga nyamuk dewasa, karakter morfologi pada setiap stadium perkembangan, serta nilai pH masing-masing media air. Hasil penelitian

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menunjukkan bahwa media air ragi menghasilkan perkembangan tercepat, yaitu sekitar 6 hari dari telur hingga nyamuk dewasa, diikuti media air PAM selama 8 hari, sedangkan media air hujan dan air sumur memerlukan waktu sekitar 10 hari. Hampir seluruh telur menetas pada media air ragi dan air PAM, sedangkan pada media air hujan dan air sumur tingkat penetasan sekitar 75%. Nilai pH media berkisar antara 6,47–6,87. Berdasarkan hasil penelitian dapat disimpulkan bahwa jenis media air memengaruhi lama perkembangan siklus hidup *Ae. aegypti*, dengan media air ragi menunjukkan perkembangan paling cepat pada kondisi penelitian ini

Kata kunci: *Ae. aegypti*, media air, penetasan telur, perkembangan morfologi, siklus hidup

INTRODUCTION

Mosquitoes are the primary vectors for the spread of various diseases in tropical regions. One mosquito species that plays a significant role in disease transmission is *Aedes aegypti*, which is the primary vector of the dengue virus and causes dengue hemorrhagic fever (DHF) (Muhamat & Guawan, 2023). *Ae. aegypti* mosquitoes exhibit repeated biting behavior (multiple biters), which means that they can bite several individuals in succession within a relatively short period of time (Zahid *et al.*, 2023). This behavior occurs because mosquitoes are highly sensitive to environmental disturbances, causing them to easily switch hosts when the blood-feeding process is interrupted. This trait increases the likelihood of dengue virus transmission to more than one individual at a single location (Ustiawaty *et al.*, 2020).

Ae. aegypti mosquitoes are widespread across various regions of Indonesia, particularly in areas where dengue fever is endemic, such as East Java, Sumatra, South Sulawesi, and Central Java (Nurjanah *et al.*, 2022). The reproduction of *Ae. aegypti* mosquitoes is greatly influenced by environmental conditions, particularly the availability of water as a site for laying eggs and the development of pre-adult stages (Montgomery *et al.*, 2025). Variations in water sources, whether from clean water sources or water containing organic matter, can affect egg hatching success, larval development, and the life cycle of *Ae. aegypti* mosquitoes (Shah *et al.*, 2022). In addition to serving as larval habitats, water sources possess distinct physical and chemical characteristics, such as pH, organic matter content, minerals, and nutrients, which can potentially influence the growth rate and morphological development of *Ae. aegypti* (Rasjid *et al.*, 2024; Montgomery *et al.*, 2025).

Several studies have reported that the quality of water affects the development of *Ae. aegypti* larvae. Repelita *et al.* (2024) reported that *Ae. aegypti* develops optimally in water media with specific physical and chemical conditions, such as appropriate pH, temperature, and ammonia, nitrate, and sulfate levels. Furthermore, Dwiyanti *et al.* (2023) showed that variations in the pH of the water medium can affect larval growth, with excessively acidic water inhibiting their development.

These studies generally focus on the physical and chemical characteristics of water or evaluate only one type. Information comparing the morphological development and life cycle of *Ae. aegypti* in different water media commonly found in the environment, such as tap water, rainwater, well water, and yeast water, is limited. Furthermore, information on the duration of development at each life stage of *Ae. aegypti* across various water media has not been extensively reported, thus failing to provide a comprehensive picture of the developmental response of mosquitoes to different water sources. Therefore, this study was conducted to compare the morphological development and life cycle duration of *Ae. aegypti* reared in four different types of water: tap water, yeast water, rainwater, and well water. The results of this study are expected to provide information on the development of *Ae. aegypti* in various water media and serve as supporting data for environmental management in efforts to control dengue fever (DF) vectors.

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RESEARCH METHODS

Equipment and Materials

The equipment used in this study included an Olympus CX23 microscope and a Dino-Lite Digital Microscope ino-Eye stereo microscope with up to 40x magnification for observing the morphology of eggs, larvae, pupae, and adult mosquitoes. Other supporting equipment included rearing buckets, ovitraps, flannel cloths, Petri dishes, dropper pipettes, microscope slides, sample bottles and gloves. The research materials consisted of *Ae. aegypti* eggs, water media including tap water (from the water utility company), rainwater, well water, and *Saccharomyces cerevisiae* yeast water, and commercial fish pellets.

Study Design

This experimental study used a descriptive-comparative approach to compare the morphological development and life cycle of *Ae. aegypti* in four types of water: tap, yeast, rain, and well water. A total of 200 *Ae. aegypti* eggs were used as research samples and divided into four treatment groups, each consisting of 50 eggs reared in a single bucket containing 3 L of the respective water medium. The treatments consisted of P1 (tap water from a water utility company), P2 (*Saccharomyces cerevisiae* yeast water), P3 (rainwater), and P4 (well water). During rearing, the larvae were fed 1 g of commercial fish pellets per bucket once daily in the afternoon. Observations were conducted daily from the time the eggs began hatching until all individuals in each treatment group reached the adult stage. The maximum observation period in this study was 10 days, which was adjusted according to the development time in each water medium. The parameters observed included egg hatching success, duration of development from egg to adult mosquito, morphological characteristics at each developmental stage (larval instars I–IV, pupae, and adult mosquitoes), and pH of each water medium used for the experiment.

The observational data were analyzed using descriptive-comparative methods and are presented as tables, figures and narrative descriptions. The results were interpreted by comparing each parameter across different water media to describe the morphological development and life cycle of *Ae. aegypti*. As this study used a single rearing unit for each treatment, the data were not analyzed using inferential statistics but were presented and interpreted descriptively, according to the study design.

This study was conducted in accordance with the research ethics guidelines and laboratory biosafety standards. This study did not involve human subjects or vertebrate animals; therefore, no specific ethical approval was required. All procedures were performed with due regard for workplace safety and in accordance with the relevant institution’s authorization for using the laboratory facilities.

Collection of *Ae. aegypti* Mosquito Eggs

Ae. aegypti mosquito eggs were collected using ovitraps placed in the CIFOR SIG Area, Bogor (Figure 1). The ovitraps consisted of buckets filled with water and lined with flannel as a substrate for laying eggs. After seven days, the flannel cloth containing the eggs was transferred to the rearing medium according to the treatment group. In the yeast-water medium, hatching was stimulated using 1 g of yeast dissolved in 3 L of water and homogenised for 2–3 min before being used as the hatching medium.

Identification of *Ae. aegypti*

Species identification was performed during the larval stage and reconfirmed during the adult stage. Larval identification was based on the Rapid Identification Guide for Container Aedes

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(Farajollahi & Price, 2013), using morphological characteristics such as the presence of a single antenna seta (PA-single) in *Ae. aegypti* larvae. The identification of adult mosquitoes was based on the morphological characteristics of the lyre-shaped thorax, scale pattern on the scutum, and presence of a longitudinal white line on the mid-femur, as described in previous studies.

Morphological Examination

Morphological examinations were conducted using an Olympus CX23 microscope and a Dino Eye stereo microscope with magnification of up to 40 ×. Observations were conducted daily for each developmental stage of *Ae. aegypti*, including eggs, instars I–IV larvae, pupae, and adult mosquitoes. The morphological characteristics observed included changes in body shape at each developmental stage, which served as the basis for identifying the life stages of *Ae. aegypti*. The results were documented using a camera integrated with the microscope.

Rearing and Observation

The larvae were reared in their respective water media until they reached the adult stage. Daily observations were conducted on the development of eggs, instar I–IV larvae, pupae, and adult mosquitoes until the entire life cycle was completed. Each stage was documented using a stereo microscope to identify morphological changes during development.

RESULTS AND DISCUSSION

Results

All individuals successfully reared to the larval and adult stages exhibited morphological characteristics consistent with those of Ae. aegypti. In the larval stage, a single seta was found on the antenna (PA-single) (Figure 1), consistent with the guidelines of Farajollahi and Price (2013). Confirmation at the adult stage revealed a lyre-shaped pattern on the thorax and a longitudinal white stripe on the mid-femur, which are characteristic features of *Ae. aegypti* (Figure 2).

Based on these observations, the life cycle of *Ae. aegypti* varied across different water media (Table 1). Yeast water media showed the fastest development time, taking approximately 6 days from the egg to the adult stage. In tap water, development took approximately 8 days, whereas in rainwater and well water, it took approximately 10 days.

All experiments were initiated with 50 eggs. Nearly all eggs in the yeast water medium hatched on day 0 after transferring the flannel cloth containing the eggs to the rearing medium. In the tap water medium, most eggs hatched between day 0 and 1. In rainwater and well water media, only approximately 75% of the eggs hatched between days 0 and 1. Observations were conducted continuously until all individuals reached the adult stage. However, the number of individuals at each developmental stage was not recorded quantitatively because some individuals died or were damaged during the observation process, making it impossible to accurately record their numbers at each stage. Therefore, the research results focused on egg hatching success, life cycle duration, and morphological changes at each developmental stage.

The measurement results showed that all water samples had pH levels that were relatively close to neutral. The highest pH was recorded for the tap water sample (6.87), followed by the yeast water sample (6.82), well water (6.77), and rainwater (6.47). These differences in pH values indicate that each sample had distinct chemical characteristics.

Morphological observations indicated that *Ae. aegypti* undergoes complete metamorphosis (holometabolism), consisting of the egg stage (Figure 3A), larval instars I–IV (Figures 3B–E), pupal stage (Figure 3F), and adult mosquito stage (Figure 3G). Each stage exhibits distinct changes in body shape during the developmental process until the adult stage is reached.

Morphological documentation for each stage is presented as a result of visual observations conducted during the study.

Discussion

Based on the study results, the type of water medium used for rearing affects the duration of the *Ae. aegypti* life cycle. Larvae reared in a *Saccharomyces cerevisiae* yeast water medium completed their development from egg to adult in approximately six days, which was faster than that of larvae reared in tap water, rainwater, or well water. These differences in developmental duration are believed to be related to the characteristics of each medium, particularly the availability of organic matter that can serve as a nutrient source for larvae. The addition of yeast is thought to increase the organic matter content, which supports the activity of microorganisms as a natural food source for larvae, thereby accelerating their growth and metamorphosis. These findings are consistent with those of Souza *et al.* (2019), who reported that rearing media rich in microorganisms can enhance the growth and development of *Ae. aegypti* larvae. Similarly, Martini *et al.* (2019) stated that the availability of nutrients in the rearing medium plays a crucial role in the successful development of larvae into adults.

Tap water can also support the development of *Ae. aegypti*, although it takes longer than yeast water. This indicates that the characteristics of tap water are still suitable for supporting larval survival until they reach adulthood. The relatively slower development compared to yeast water is thought to be related to its lower organic matter content. In addition, the presence of chlorine residues in tap water is thought to affect the number of microorganisms that serve as a natural food source for the larvae, although it does not inhibit their development to the adult stage. These results are consistent with those of Shah *et al.* (2022), who stated that the characteristics of the water medium can affect the development of *Ae. aegypti* larvae through differences in organic matter and microbial content.

In contrast, larval development in rainwater and well water proceeded more slowly than in yeast water or municipal tap water. These conditions are thought to be related to the low content of available organic matter, which limits the larval food supply. Dianti *et al.* (2019) reported that media with low nutrient content results in prolonged larval development owing to limited food availability. Furthermore, Rasjid *et al.* (2024) explained that the physical and chemical characteristics of the water medium, including organic matter content, are important factors influencing the development of *Ae. aegypti* larvae.

The results of this study also showed that the pH values of all water media ranged from 6.47–6.87. This range is considered close to neutral and is suitable for supporting the development of *Ae. aegypti*. Although there were slight differences in the pH values among the media, these differences are not believed to be the primary factor causing variations in the development duration, as all media remained within a pH range suitable for larval growth (Banerjee *et al.*, 2022). Dwiyanti *et al.* (2023) reported that *Ae. aegypti* larvae optimally develop in media with a pH close to neutral, whereas conditions that are too acidic or alkaline can inhibit growth and development.

Morphological observations indicate that *Ae. aegypti* undergoes complete metamorphosis (holometabolism), consisting of the egg, larval instars I–IV, pupae, and adult stages. Morphological changes occur gradually until an adult mosquito is formed. The documentation of each stage provides a visual overview of the developmental stages of *Ae. aegypti* during the study and supports the results of the life cycle observations in each water medium used.

This study has limitations because each treatment used only one rearing unit; therefore, the results are presented descriptively without inferential analysis. Additionally, the number of

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individuals that successfully reached each developmental stage was not quantitatively recorded owing to mortality and damage to the individuals during the observation process.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results of the present study, the type of water medium affects the life cycle development of *Ae. aegypti*. The *Saccharomyces cerevisiae* water medium resulted in the fastest development, taking approximately 6 days from egg to adult mosquito, followed by tap water, which took approximately 8 days, and rainwater and well water, which required approximately 10 days. In addition, yeast and tap water media showed higher egg hatching success rates than rainwater and well water. Morphological observations indicate that *Ae. aegypti* undergoes complete metamorphosis (holometabolism), consisting of the egg, larval instars I–IV, pupa, and adult mosquito stages. All water media had pH levels relatively close to neutral (6.47–6.87), thus remaining suitable for the development of *Ae. aegypti* throughout the study.

Suggestions

Future studies should include biological replicates for each treatment so that the results can be analysed using appropriate statistical methods. Additionally, recording the number of individuals at each developmental stage, along with comprehensive measurements of water quality and organic matter content, is necessary to obtain a more comprehensive understanding of the effects of water media on the development of *Ae. aegypti*.

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Table

Table 1. Life cycle development of *Ae. aegypti* in various water media

Parameter	Tap Water	Yeast Water	Rainwater	Well Water
Initial egg count	50	50	50	50
Hatching success	Almost all	Almost all	±75%	±75%
Hatching day(s)	0–1	0	0–1	0–1
Development duration to adult stage (days)	8	6	10	10
pH	6.87	6.82	6.47	6.77

Figures

Figure 1. *Ae. aegypti* larvae in (a) tap water, (b) rainwater, (c) well water, and (d) yeast water.

Figure 2. Adult *Ae. aegypti* mosquitoes with a lyre-shaped pattern on the thorax and a longitudinal white stripe on the mid-femur, which are characteristic features of *Ae. aegypti*: (a) male mosquito, (b) female mosquito, and (c) female mosquito (Clemons *et al.*, 2020).

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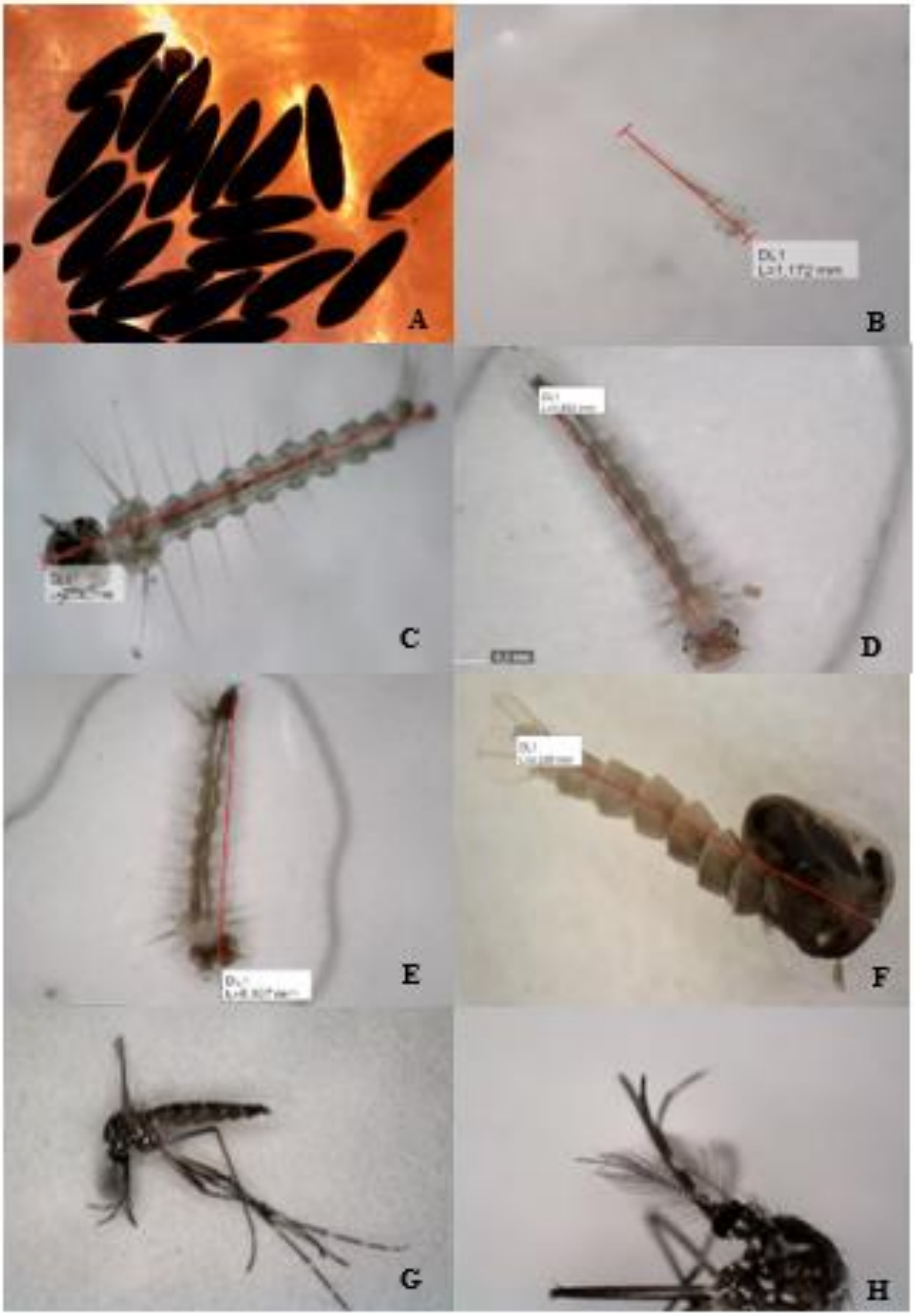

Figure 3. Morphological development of *Ae. aegypti* across life stages: (A) egg, (B) first-instar larva, (C) second-instar larva, (D) third-instar larva, (E) fourth-instar larva, (F) pupa, (G) adult mosquito, and (H) plumose antenna of a male mosquito.