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Research Article

Aedes Distribution and Meteorological Effect on Ovitrap Index in Coastal Area of Besut, Terengganu: An Entomological Study

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Introduction:*Aedes* species are a major public health concern due to their ability to be efficient vectors of dengue, and other arboviruses. Ovitrap is an entomological surveillance tool designed to measure the density of *Aedes*. Ovitraps used for monitoring can detect *Aedes* mosquito populations, thus acting as an early warning system to prevent dengue outbreaks. Meteorological factor such as temperature and rainfall played great role in affecting the abundance of *Aedes* mosquitoes. This study aimed to assess the presence and abundance of *Aedes* species, and to determine the correlation of meteorological factors with Ovitrap index. Methodology: A cross-sectional study was conducted in coastal area of Besut district, Terengganu state of Malaysia. The study samples were 3120 Ovitraps placed in only occupied premises. Data were collected from Besut Meteorological Department database and respective Ovitrap sentinel stations. The independent variables were environmental temperature and rainfall density, while the dependent variable was Ovitrap index which served as the indicator for *Aedes* density. Descriptive and correlation analysis were employed for assessing the Ovitrap index, and determining the correlation of Ovitrap Index with temperature, and rainfall distribution. A p-value <0.05 was considered statistically significant. Results:*Aedes* distribution study showed that *Aedesaegypti* were more prevalent than *Aedes albopictus*, with 2,383 larvae of Aedes aegypti being recorded compared to 2,198 larvae of Aedes albopictus. The findings also revealed a significant correlation between the Ovitrap index and temperature (r=0.82, p=0.03) but the analysis showed no statistically significant correlation between the Ovitrap index and the rainfall distribution, with (r=0.15, p=0.62). Conclusion: Temperature plays important role in determining Aedes distribution. The high population of Aedes aegypti highlights the need for proper control actions such as Aedes source reduction.

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Introduction

Aedes (Stegomyia) *albopictus* (Skuse), also known as the Asian tiger mosquito, and *Aedes* (Stegomyia) *aegypti* (Linnaeus), are the principal vectors of dengue fever and dengue hemorrhagic fever in tropical and subtropical regions[1]. They have become the primary vectors for the transmission of these diseases[1]. In 2022, Malaysia documented approximately 64,078 cases of dengue fever nationwide, compared to 26,365 cases in 2021 and 90,304 cases in 2020. In terms of fatalities, a total of 73 deaths from dengue-related complications were recorded by October 2023, compared to 29 deaths during the same period in 2022[2].

Adult *Aedes aegypti* and *Aedes albopictus* are active both indoors and outdoors. They do not fly long distances and thus tend to remain within a close vicinity throughout their lifespan. Both *Aedes* species exhibit a preference for biting after sunrise and before sunset[3]. The population dynamics of *Aedes aegypti* and *Aedes albopictus* are greatly influenced by environmental factors, given their expansive geographical distribution[3]. The climate of Peninsula Malaysia is defined by four seasons, which include two monsoons and two inter-monsoon periods[4]. The northeast monsoon season, running from November to February, is followed by an inter-monsoon period between March and April. In contrast, the southwest monsoon season, lasting from May to August, is succeeded by another inter-monsoon period between October and November[4].

The transmission of dengue is influenced by several interconnected factors, including meteorological factors[5]. For meteorological factors, climate change would directly impact disease transmission by altering the geographic range of vectors, increasing their reproductive and biting rates, and shortening the pathogen incubation period[6]. Temperature plays a direct role in influencing the development rate of different mosquito life stages and dengue viral replication. Elevated ambient temperatures boost virus replication and shorten the extrinsic incubation period (EIP) in vectors, thus heightening vectorial efficiency[6]. In many regions endemic to *Aedes* mosquitoes, the mosquito populations demonstrate a pronounced seasonal pattern linked to temperature and rainfall. Heavy rainfall is correlated with widespread egg hatching and a surge in mosquito numbers[7]. While vector population densities are typically high at the onset of the rainy season, virus amplification primarily occurs towards the end of the rainy season[7]. During the onset of the rainy season, vector population densities tend to be high, while virus amplification primarily takes place towards the end of the rainy season[7].

Ovitraps is an entomological surveillance tool that is designed to measure the density of *Aedes*[8][9]. It is a mosquito trap designed to mimic natural mosquito egg-laying sites, used for monitoring and controlling mosquito populations, particularly *Aedes* mosquitoes, by attracting females to lay eggs, which are then collected and analyzed[10]. Ovitraps used for monitoring can detect *Aedes* mosquito populations, thus acting as an early warning system to prevent dengue outbreaks[11].

To the best of our knowledge, there is no well-published study between Ovitrap Index with meteorological variables in Terengganu state of Malaysia setting. Therefore, this study was conducted to assess the presence and abundance of Aedes species, and to determine the correlation of meteorological factors (rainfall and environmental temperature) with Ovitrap index.

Materials and Methods

We carried out this cross-sectional study at Kuala Besut adjacent to the coastal area (Coordinates: N5.833272, E102.556879). Kuala Besut was selected as the study locality due to several factors. The locality is situated in Besut district, Terengganu state of Malaysia. One of the factors is Kuala Besut has experienced outbreaks and cases of dengue fever in the past five years. Additionally, Kuala Besut serves as a stopover point for trips and tourists before heading to Perhentian Islands, a renowned tropical paradise in Malaysia, which posed serious public health threat should dengue outbreak is not well-controlled[12].

The study samples were 3120 ovitraps which were allocated in thirty occupied premises for 52 weeks throughout the year 2023. Unoccupied and unauthorized premises were excluded from this study. The sample size was calculated in accordance to *Garis panduan pengawasan Aedes di stesen sentinel menggunakan Ovitrap* (Protocol for *Aedes* control in sentinel station using ovitraps)[13].

The ovitraps setting and collection procedures were as follow:

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1. Sixty ovitraps were placed in 30 premises after obtaining permission from the homeowners.
2. Two ovitraps were placed in each house (indoor and outdoor).
3. The ovitraps were collectedd and replaced with new ones on the day 7.
4. Counting and identifying process on day 7.
5. Counting and identifying process on day 11.
6. Calculation and report were done

Data collections were done using data from 1) Besut Meteorological Department Database; and 2) analysis form for *Aedes* eggs and larvae at sentinel station. The independent variables for this study included environmental temperature and rainfall distribution, meanwhile the outcome of this study was *Aedes* density as demonstrated from the reading of Ovitraps index.

This study employed both descriptive and inferential studies. For descriptive part, ovitraps index (%) were calculated based on the fraction of total number of positive ovitrap (*Aedes spp*) over total number of ovitraps in good condition. Meanwhile, in the inferential study, Pearson correlation analysis was used to determine the correlation of Ovitrap Index with temperature and the correlation of Ovitrap Index with rainfall distribution. A *p*-value <0.05 was considered statistically significant.

Results

A total of 3120 ovitraps were placed throughout this study. Based on ovitraps reading, majority of *Aedes spp* found were *Aedes aegypti* (2383, 52%) and the rest were *Aedes albopictus* as shown in Figure 1. As for the distribution of *Aedes spp*, majority of both *Aedes aegypti* and *Aedes albopictus* were found in outdoor areas as shown in Figure 2.

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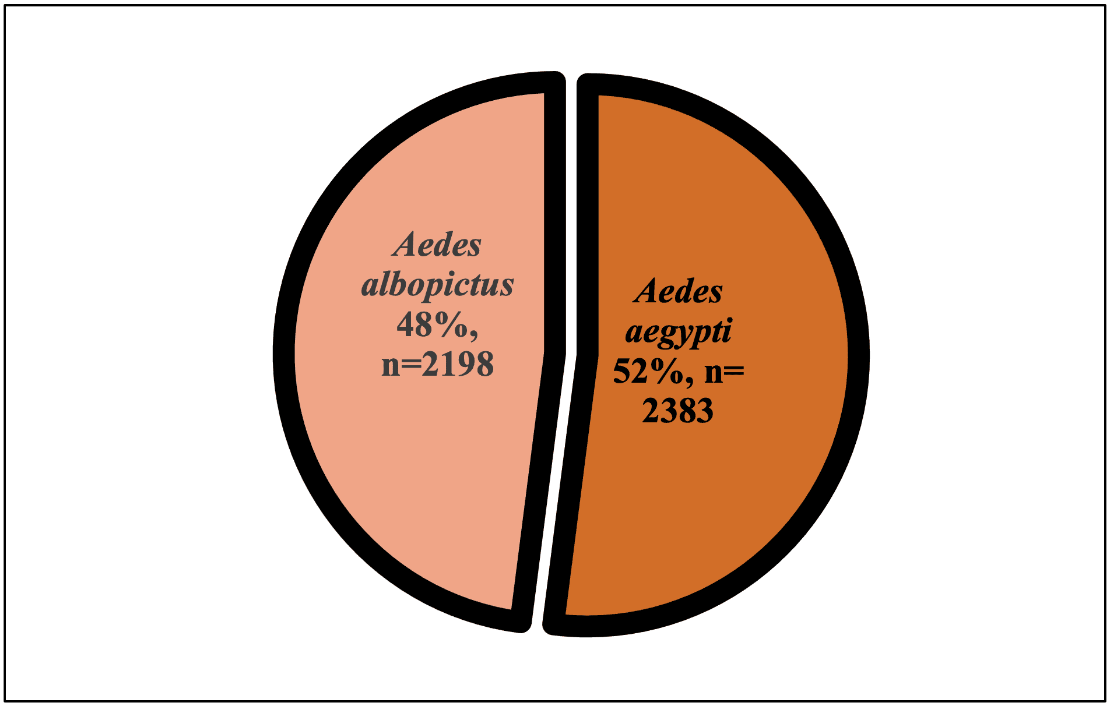

Figure 1. Percentage and density of *Aedes spp* in Kuala Besut coastal area

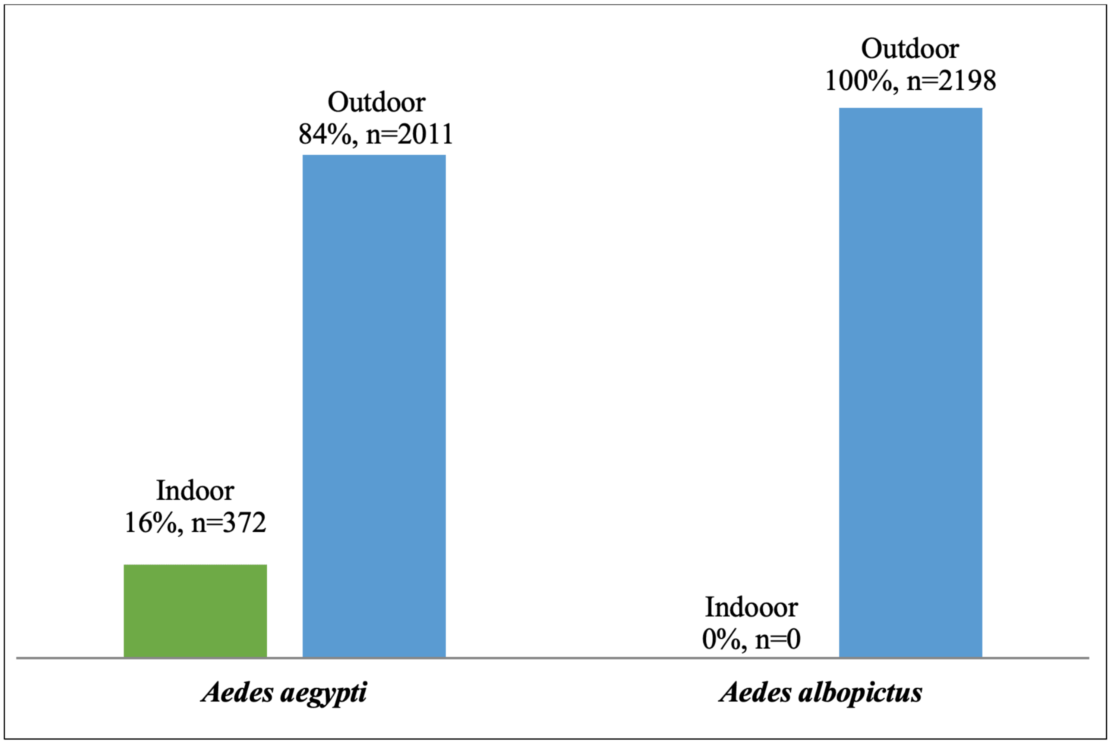

Figure 2. Distribution of *Aedes spp* in Kuala Besut coastal area

As for the relationship between ovitrap index (*Aedes* density) with meteorological factors, the fluctuation of *Aedes* density was heavily dependent on the fluctuation of temperature level and also rainfall distribution as shown in Figure 3, and further detailed information were demonstrated in Table 1.

As for the inferential study to determine the correlation of meteorological factors (rainfall and environmental temperature) with Ovitrap index, Pearson correlation revealed statistically significant correlation between ovitrap index (*Aedes* density) with temperature level changes (p=0.03) as shown in Table 2.

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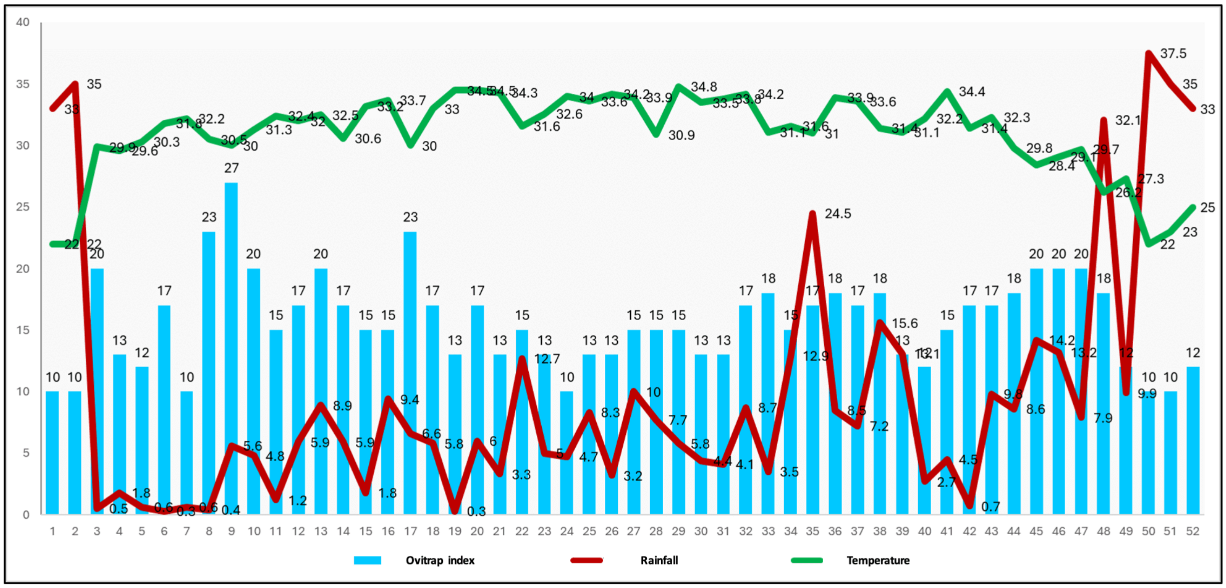

Figure 3. Relationship between Ovitrap Index with temperature and rainfall

Parameters	Average temperature (°C)	Average rainfall (mm)	Week
Highest Ovitrap Index (27.0%)	30.0	5.60	09
Highest number of *Aedes spp* (n=155)	30.1	6.60	17
Highest number of *Aedes aegypti* (n=86)	31.8	0.30	06
Highest number of *Aedes albopictus* (n=74)	30.1	6.60	17

Table 1. Relationship between Ovitrap Index with temperature and rainfall

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	r*	*p*-value
Ovitrap Index with temperature	0.82	0.03
Ovitrap Index with rainfall	0.15	0.62

Table 2. Correlation analysis between Ovitrap Index with temperature and rainfall

**Pearson correlation*

Discussion

Aedes aegypti was found as a dominant species in our study involving coastal area of Kuala Besut. It is well-documented in a previous local study that *Aedes* species was found predominantly in similar setting like Kuala Besut, involving areas of fishing villages and insular sites[14]. Both current and past studies involved fishing villages. Most of the buildings are one or two storey terraced houses built with wood and cement. The buildings are situated near the sea and have poor drainage and scattered vegetation (plants in pots) which served as favourable sites for mosquito breeding[14].

From our current study, *Aedes aegypti* and *Aedes albopictus* were predominant larvae species found in outdoor setting. *Aedes aegypti* mosquitoes, known for their association with human dwellings, primarily breed in man-made water containers, both indoors and outdoors, around human activities and dwellings. *Aedes aegypti* mosquitoes are highly anthropophilic, meaning they are closely associated with humans and their environments. While they can breed indoors, *Aedes aegypti* are more commonly found breeding outdoors in containers around human dwellings. They have adapted to thrive in urban and peri-urban areas, where they are readily available to breed in artificial containers[15][16][17].

From our study, temperature had significant correlation with ovitrap index, and temperature within the range 30°C -32°C contributed to highest percentage of Ovitrap index (27%), highest number of *Aedes* species (n=155), highest number of *Aedes aegypti* (n=86) and highest number of *Aedes albopictus* (n=74). Temperature is the main factor that affects normal cycle especially at the larval stage[1]. The study by Rozilawati *et al*. (2006) and our findings indicate that the optimal temperature range for Aedes larvae survival and development is between 28°C and 34°C[1]. At temperatures exceeding 35°C, drying and dehydration can occur, negatively impacting egg hatching and larval survival. Extreme temperatures can lead to reduced larval survival and developmental rates. Marinho *et al.* (2016) also supports the idea that high temperatures negatively impact egg hatching and larval survival[18].

From our study, there is weak correlation between rainfall and Ovitrap Index. Heavy rainfall can disrupt the *Aedes* reproductive cycle by "flushing out" the immature stages (larvae and eggs) from breeding sites, including ovitraps[1]. This "flushing" effect can lead to a decrease in the number of *Aedes* larvae and eggs, potentially reducing the overall mosquito population[19]. The excess water caused by heavy rainfall can also prevent female mosquitoes from laying eggs in the first place, as the water may be too deep or the breeding sites may be submerged[1]. Moreover, heavy rain accompanied by strong winds might disturb the flight activity of *Aedes spp* females, resulting in difficulties to find hosts and suitable breeding sites[20].

Conclusion and recommendations

The presence of *Aedes* species in Kuala Besut locality was *Aedes aegypti* and *Aedes albopictus*. *Aedes aegypti* showed dominant species and mostly breed outdoor. Temperature plays important role in determining *Aedes* distribution. The high population of *Aedes aegypti* highlights the need for proper control actions such as *Aedes* source reduction.

To control vectors in Kuala Besut, given the influence of temperature and rainfall, focus on environmental management, source reduction, and biological control. As mosquitoes breed in standing water, therefore more focus should be given on eliminating or managing these habitats. Involvement of the community in identifying and eliminating potential breeding sites are important as well. As meteorological factors are non-modifiable factors, we can consider using biological control methods like introducing fish that eat mosquito larvae or releasing mosquito-eating insects. Besides, we need to recognize that climate change can alter vector distribution and disease patterns. Therefore, we should adapt control strategies accordingly based on climate change.

Statements and Declarations

Conflicts of interest

The authors declared that we have no conflict of interest in term of financial, institutional, and other possible relationships.

Ethical approval

This study received approval from the Medical Review and Ethical Committee (MREC) from National Institute of Health (NIH), Ministry of Health Malaysia NMRR ID-2400267-QKW.

Contribution

Conception- H.A., S.F.M.M., M.K.J.; Writer- H.A., S.F.M.M.; Data collection and/or processing- H.A., S.F.M.M., I.K., M.R.O., N.A.M.A., N.H.N., I.I.L.N., M.K.J.; Supervision-H.A., M.K.J.; Analysis and/or Interpretation- H.A., S.F.M.M.

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Declarations

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