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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. An 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 factors such as temperature and rainfall play a 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 the Ovitrap index. Methodology: A cross-sectional study was conducted in the coastal area of Besut district, Terengganu state of Malaysia. The study samples were 3120 Ovitraps placed in only occupied premises. Data were collected from the Besut Meteorological Department database and respective Ovitrap sentinel stations. The independent variables were environmental temperature and rainfall density, while the dependent variable was the Ovitrap index, which served as the indicator for *Aedes* density. Descriptive and correlation analyses were employed for assessing the Ovitrap index and determining the correlation of the Ovitrap index with temperature and rainfall distribution. A p-value <0.05 was considered statistically significant. Results: The *Aedes* distribution study showed that *Aedes aegypti* was 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 an 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 Peninsular 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 are an entomological surveillance tool designed to measure the density of *Aedes*[8][9]. They are mosquito traps 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 on the relationship between the Ovitrap Index and meteorological variables in the Terengganu state of Malaysia. 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 the Ovitrap index.

Materials and Methods

We carried out this cross-sectional study in 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 the Besut district, Terengganu state of Malaysia. One of the factors is that 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 the Perhentian Islands, a renowned tropical paradise in Malaysia, which poses a serious public health threat should a dengue outbreak not be 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 with *Garis panduan pengawasan Aedes di stesen sentinel menggunakan Ovitrap* (Protocol for *Aedes* control in sentinel stations using ovitraps)[13].

The ovitraps setting and collection procedures were as follows:

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 collected and replaced with new ones on 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 collection was done using data from 1) the Besut Meteorological Department Database; and 2) the analysis form for *Aedes* eggs and larvae at the sentinel station. The independent variables for this study included environmental temperature and rainfall distribution, while the outcome of this study was *Aedes* density as demonstrated by the reading of the Ovitrap index.

This study employed both descriptive and inferential methods. For the descriptive part, the Ovitrap index (%) was calculated based on the fraction of the total number of positive ovitraps (*Aedes spp*) over the total number of ovitraps in good condition. Meanwhile, in the inferential study, Pearson correlation analysis was used to determine the correlation of the Ovitrap Index with temperature and the correlation of the 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 ovitrap readings, the 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*, the majority of both *Aedes aegypti* and *Aedes albopictus* were found in outdoor areas, as shown in Figure 2.

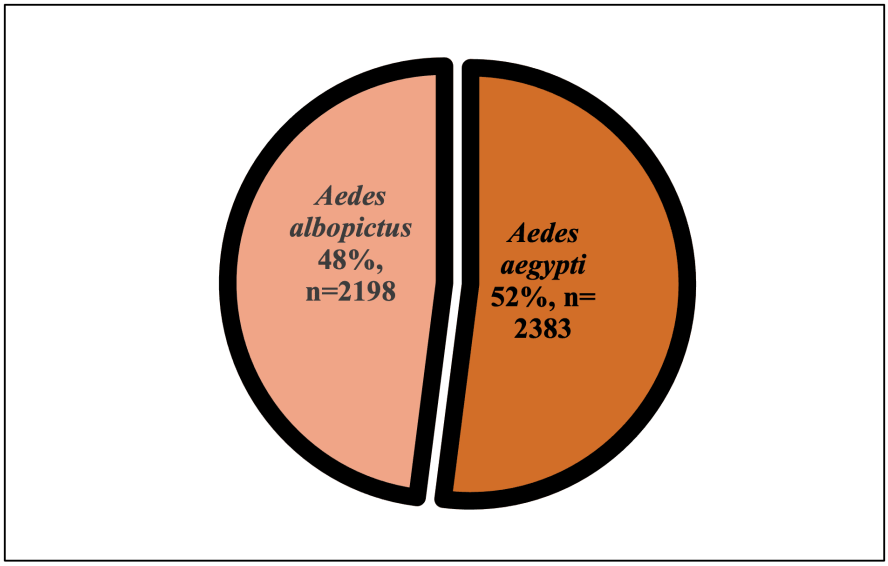

Figure 1. Percentage and density of *Aedes spp* in the Kuala Besut coastal area

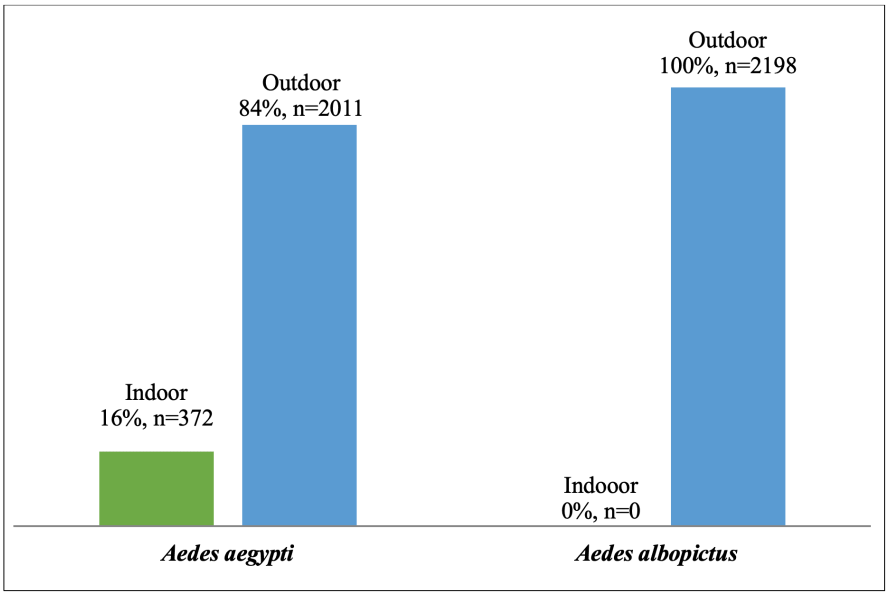

Figure 2. Distribution of *Aedes spp* in the Kuala Besut coastal area

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

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

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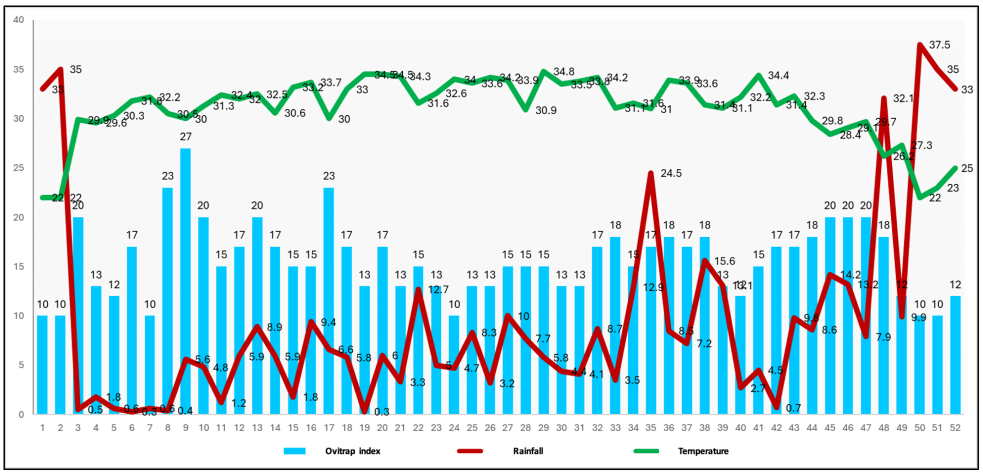

Figure 3. Relationship between the ovitrap index and temperature and rainfall

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 the ovitrap index and temperature and rainfall

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

Table 2. Correlation analysis between the ovitrap index and temperature and rainfall

*Pearson correlation

Discussion

Aedes aegypti was found to be the dominant species in our study involving the coastal area of Kuala Besut. It is well-documented in a previous local study that *Aedes* species were found predominantly in a 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 the predominant larval species found in outdoor settings. *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 a significant correlation with the ovitrap index, and temperatures within the range of 30°C - 32°C contributed to the highest percentage of the ovitrap index (27%), the highest number of

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Aedes species (n=155), the highest number of *Aedes aegypti* (n=86), and the highest number of *Aedes albopictus* (n=74). Temperature is the main factor that affects the normal cycle, especially at the larval stage[1]. The study by Rozilawati *et al*. 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.* also supports the idea that high temperatures negatively impact egg hatching and larval survival[18].

From our study, there is a weak correlation between rainfall and the 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 in finding hosts and suitable breeding sites[20].

Conclusion and recommendations

The presence of *Aedes* species in the Kuala Besut locality was *Aedes aegypti* and *Aedes albopictus*. *Aedes aegypti* showed dominance as a species and mostly bred outdoors. Temperature plays an 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, more focus should be given to eliminating or managing these habitats. The involvement of the community in identifying and eliminating potential breeding sites is important as well. As meteorological factors are non-modifiable, 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

Ethical Approval

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

Data Availability

The datasets generated during the current study are available from the corresponding author on reasonable request. Meteorological data were obtained from the Besut Meteorological Department database.

Author Contributions

Conception- H.A., S.F.M.M., M.K.J.; Writing- 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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