Influence of Religious Temple Environments on Mosquito Species Abundance and key Breeding sites: A Comparative Study of Thai and Chinese Temples in Trang,Thailand

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Abstract

Mosquito species abundance and key breeding sites are influenced by human activities, including religious practices and maintenance behaviors. This study focuses on: **(1) comparing mosquito species abundance and key breeding sites in Thai and Chinese temples in Trang, Thailand,** and **(2) exploring the impact of mosquito control and mitigation practices on mosquito abundance and key breeding sites within these temple settings.** Through field observations, the research identifies common mosquito breeding sites, such as water basins, ponds, and ritual offering areas, and examines how maintenance routines influence mosquito populations. By investigating the relationship between temple environments and mosquito proliferation, this study provides insights into how religious and cultural practices contribute to vector breeding. The findings highlight potential public health risks and offer recommendations for culturally sensitive mosquito control strategies while preserving the religious significance of temple environments.

Keywords: Mosquito ecology, GLOBE Mosquito Habitat Mapper, species abundance, breeding sites, religious temples

1. Introduction

The presence of mosquitoes, particularly *Aedes aegypti* and *Aedes albopictus*, is strongly influenced by ecological and environmental factors that determine suitable breeding conditions. These conditions often include water-filled containers and specific socio-environmental factors that support mosquito populations (Ruairuen et al., 2022; Silva & Scalize, 2023). In the context of Thai and Chinese temples, various elements such as ornamental water features, discarded containers, and human activities may contribute to mosquito abundance and diversity (Thongsripong et al., 2013). These temple environments can create favorable breeding habitats, making them important areas for studying mosquito populations.

Research on mosquito vector diversity in central Thailand has shown that human-induced ecological changes, particularly in urban and rural settings, significantly affect mosquito species distribution and abundance. *Aedes aegypti* and *Culex quinquefasciatus* are often more prevalent in areas experiencing such disturbances (Thongsripong et al., 2013). Furthermore, environmental design factors, including building density and vegetation, can influence mosquito breeding by altering light intensity and humidity levels, both of which are essential for mosquito development (Hildegardis et al., 2024; Zhang et al., 2023). The availability of breeding containers, often shaped by human activities and land use, is another critical factor sustaining mosquito populations, as observed in urban areas like Bangkok (Daudé et al., 2024). Given the distinctive socio-cultural and ecological characteristics of temple environments in Trang, these locations likely provide suitable conditions for mosquito breeding. As a result, it is essential to implement targeted vector control strategies that consider both the environmental and cultural aspects of these religious sites.

This study aims to explore the relationship between temple environments and mosquito species abundance in Trang, Thailand. Specifically, it seeks to:

1. Compare mosquito species abundance and key breeding sites in Thai and Chinese temple environments.

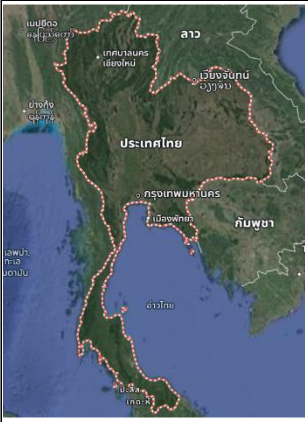
2. Assess the impact of cleaning practices on mosquito populations and breeding sites within these temple settings.

By mitigation practices such as water source management, vegetation cover, and temple maintenance routines, this research will provide valuable insights into how religious and cultural practices influence mosquito breeding patterns. The findings will support the development of culturally sensitive vector control strategies that help reduce public health risks while maintaining the religious significance of these temple sites.

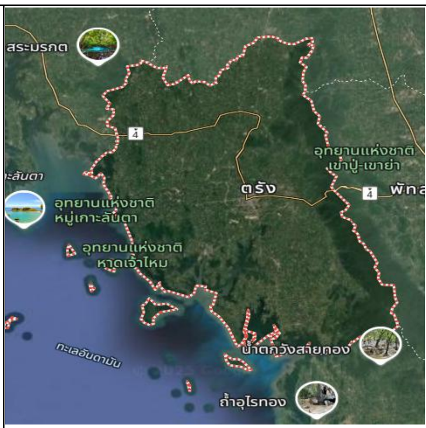
2. Materials and methods

2.1 Study site

In February 2025, a mosquito larvae survey was conducted in the province of Trang, Thailand (14.86242° N, 101.06671° E). Trang province has three seasons: summer (mid-February to mid-May), rainy (mid-May to mid-October), and winter (mid-October to mid-February).

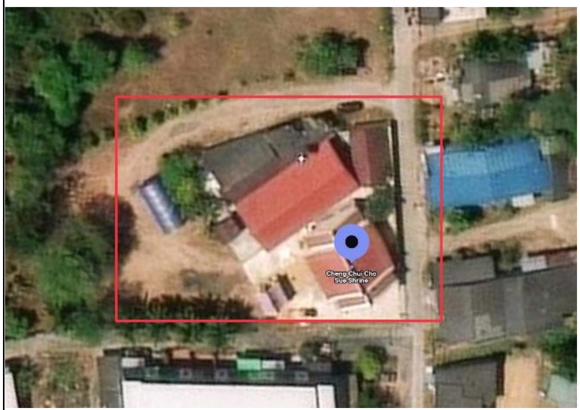


a. Map of Thailand



b. Map of Trang

(c) Map of Matchimmaphum Temple



(d) Map of Chang Chui Cho Sue Shrine Temple

(e) Map of Tantiya Phirom Temple

(f) Map of San Chao Kew Ong Aia Temple

Figure 1. (a) Map of Thailand, (b) Map of Trang, (c) Map of Matchimmaphum Temple, (d) Map of Chang Chui Cho Sue Shrine Temple, (e) Map of Tantiya Phirom, and (f) Map of San Chao Kew Ong Aia Temple.

2.2 Sampling of mosquito larvae

In February 2025, a mosquito larvae survey was conducted in Trang, Thailand (14.86242° N, 101.06671° E). Trang province has three seasons: summer (mid-February to mid-May), rainy (mid-May to mid-October), and winter (mid-October to mid-February).

Figure 2. GLOBE Observer: MHM App

2.2.1 Survey Thai and Chinese Temples in Trang province (Fig. 1), then collect samples of larvae and larval predators for classification.

2.2.2 Inspect every natural water source and container, both with and without water.

2.2.3 Check whether the container has a lid or not.

2.2.4 Scoop up and put living things, including mosquito larvae and predators, into plastic bags.

2.2.5 Use the MHM app to find the latitude and longitude coordinates of the area where mosquito larvae were found and save the information into the GLOBE Observer MHM app (Figure 2).

2.2.6 The captured organisms were returned to be classified as species and recorded.

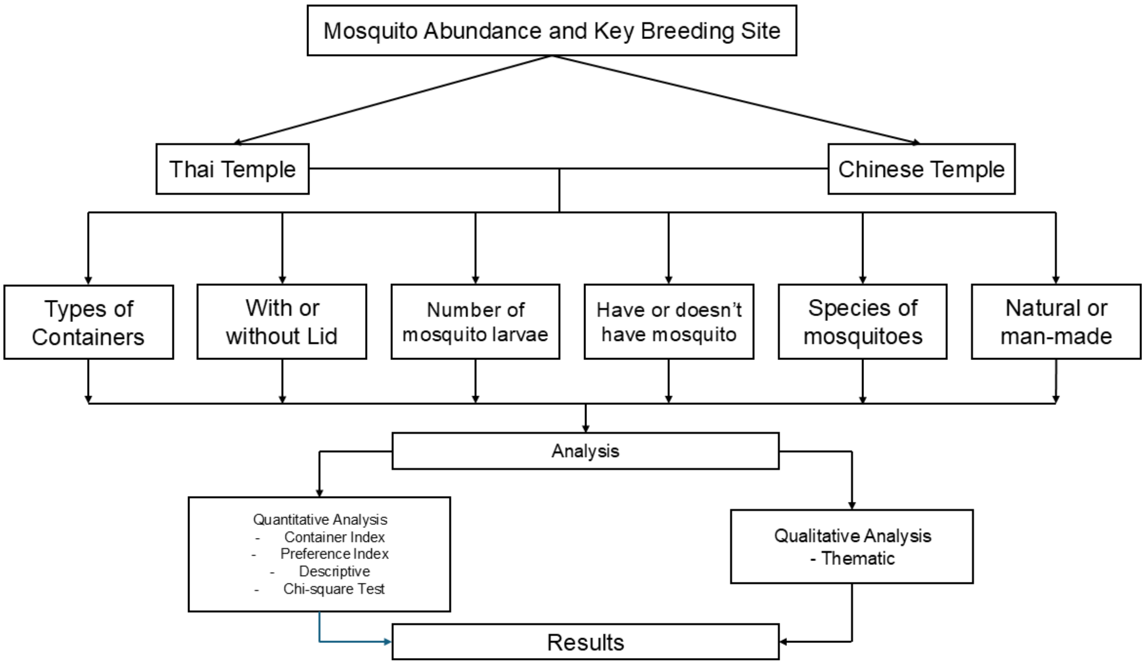
2.2.7 Scoop up the collected larvae from the plastic bag.

2.2.8 Put the larvae in a small dish with some water.

2.2.9 Clean the glass slide and coverslip with ethanol to remove any dust.

2.2.10 Use the microscope to examine and take a photo of the specimen.

2.3 Conceptual Framework



The study focuses on mosquito abundance and key breeding sites in Thai and Chinese temples. It examines different factors influencing mosquito breeding in these locations. For Thai and Chinese temples, the study considers the types of containers used, whether they have lids, and the number of mosquito larvae present, whether a site has mosquitoes or not, the species of mosquitoes found, and whether the breeding sites are natural or man-made. The collected data undergoes both quantitative and qualitative analysis using the container index, preference index, descriptive statistics, chi square test and thematic analysis. Finally, the results provide insights into mosquito breeding patterns in both temple types.

2.4 Data collection

For this study, data were obtained directly through field observations conducted in Trang, Thailand, focusing on mosquito species diversity in temples. Historical data from 2018-2020 provided baseline records, while newly collected data were gathered through field surveys at selected Thai and Chinese temples. Students participated in mosquito larvae collection using standard dipping techniques from artificial containers and natural containers such as tires, trash containers, and plant clumps. The collected larvae were identified based on morphological characteristics, and GPS coordinates were recorded using the GLOBE Observer: Mosquito Habitat Mapper (MHM) app to map mosquito distribution. The newly collected data were then compared with historical records to assess trends in species diversity, detect potential ecological shifts, and contribute to a better understanding of mosquito populations in these distinct habitats.

2.5 Entomological studies

This study integrates mosquito larval data collected directly from Wat Tantiya Phirom, Matchimmaphum Temple, San chao Kew Ong Aia and Cheng Chui Cho Sue Shrine with data from the GLOBE Mosquito Habitat Mapper for Trang's historical data. Larval collection followed a standardized protocol: smaller containers were emptied and filtered, while larger containers were sampled using nets, ensuring comprehensive coverage (Indriyani et al., 2024). Collected larvae were preserved and identified as species using Rattanarithikul and Panthusiri's keys. Early instar larvae and pupae were excluded due to identification challenges. The study involved a total of 7 container categories and 23 total containers. Plastic water containers were further divided into two groups: large plastic containers designed for water storage (>100 L) and plastic bottles (i.e., 0.5–2.0 L water bottles). Earthen jars were also classified into two categories: small earthen jars with a volume of ≤100 L and large earthen jars exceeding 100 L in volume. The GLOBE data, contributing broader spatial coverage, were used to analyze mosquito species distribution, breeding site preferences, and container indices across selected Thai and Chinese temples. Combining these datasets allowed a more comprehensive understanding of mosquito ecology and the factors influencing their regional populations.

2.6 Statistical analysis

This study employed a combination of quantitative and qualitative approaches to analyze mosquito distribution and the impact of mosquito control and mitigation practices within two temple settings (Thai and Chinese temples). The key methods used included the Container Index (CI), Preference Index (PI), Descriptive Statistics, Chi-Square Test of Independence, and Thematic Analysis.

1. Quantitative Analysis

- Container Index (CI): The CI was calculated to determine the percentage of water-holding containers infested with mosquito larvae in each temple. This helped assess breeding site availability and infestation levels.

$$CI = \left(\frac{\text{Number of containers with larvae or pupae}}{\text{Total number of containers inspected}}\right) \times 100$$

- Preference Index (PI): The PI was used to identify species preferences for different container types, providing insights into breeding site selection and habitat preferences.

PI = larvae count in container type total larvae found in species x 100

- Descriptive Statistics: Descriptive statistics summarized species diversity and breeding site data, categorizing findings by region and habitat type. Tables organized species distribution and breeding site frequencies
- Chi-Square Test of Independence: A Chi-Square analysis examined the association between mosquito genus and temple locations.

2. Qualitative Analysis

- Thematic Analysis: To explore the impact of mosquito control and mitigation practices on mosquito abundance and key breeding sites within the temples (Thai and Chinese), a thematic analysis was conducted based on interviews, observations, and field notes.

3. Results

Distribution of Mosquito Species by selected Chinese and Thai temple in Trang

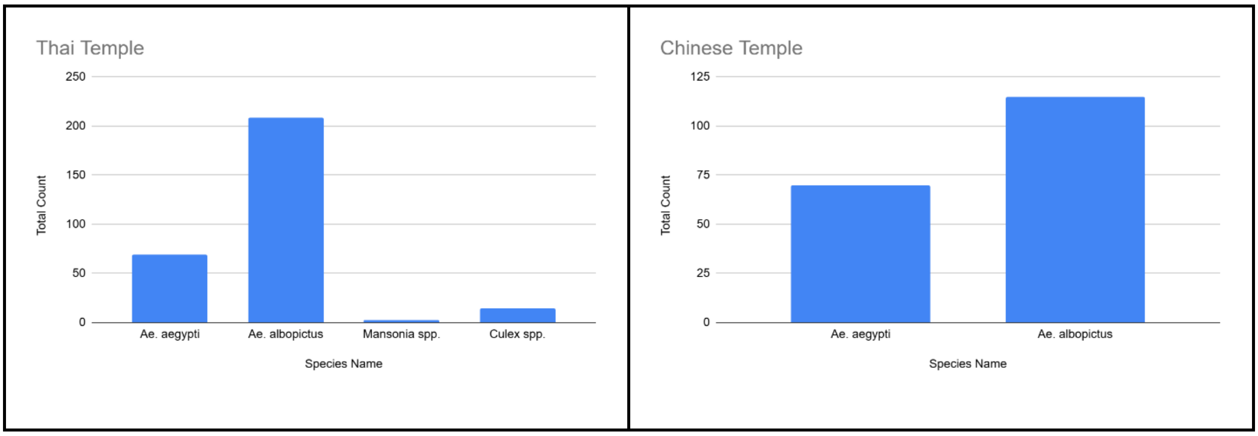


Table 1. Distribution of Mosquito Species by sites in Trang

Table 1 illustrates the distribution of key mosquito species across selected Chinese and Thai temples in Trang. In the Chinese temples, we found 2 species of Mosquito from 185 mosquitoes. *Aedes aegypti* (70) and *Aedes albopictus* (115) were observed, with no records of other species. Meanwhile, in the Thai temples, we found 4 species of Mosquitoes from 295 mosquitoes. We found *Aedes aegypti* (69) and *Aedes albopictus* (209) were present in significant numbers. Additionally, *Culex spp.* (15) and *Mansonia spp*. (2) were also recorded. These findings suggest variations in mosquito species distribution between Chinese and Thai temple environments, potentially influenced by ecological and environmental factors in Trang.

Container Index

Sites	Container Index
Thai Temple	57.89473684
Chinese Temple	100
GLOBE Data	46.70846395

The Container Index (CI), which measures the percentage of water-holding containers positive for larvae, varied across different sites, highlighting differences in mosquito breeding risks. Chinese temples had the highest CI at 100%, indicating a significantly greater potential for mosquito breeding compared to Thai Temples, which had a CI of 57.89%, and the overall GLOBE dataset average of 46.71%. The high CI at Chinese Temples suggests a need for targeted mosquito control measures to mitigate the risk of vector-borne diseases.

Preference Index by different site (Chinese and Thai temple)

Table 2. Preference index by mosquito in Chinese Temple.

Chinese

(a)

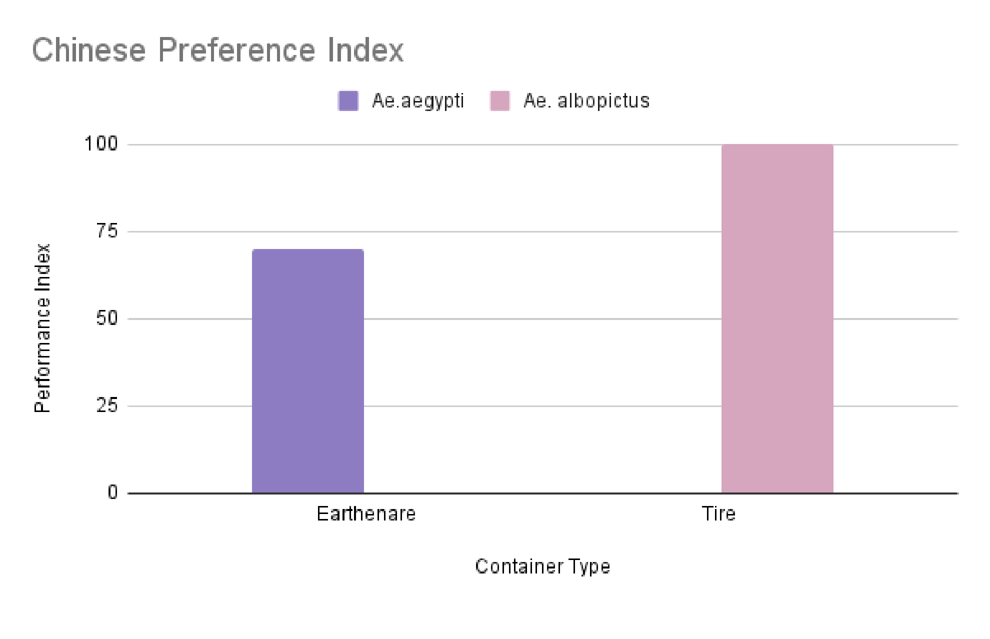
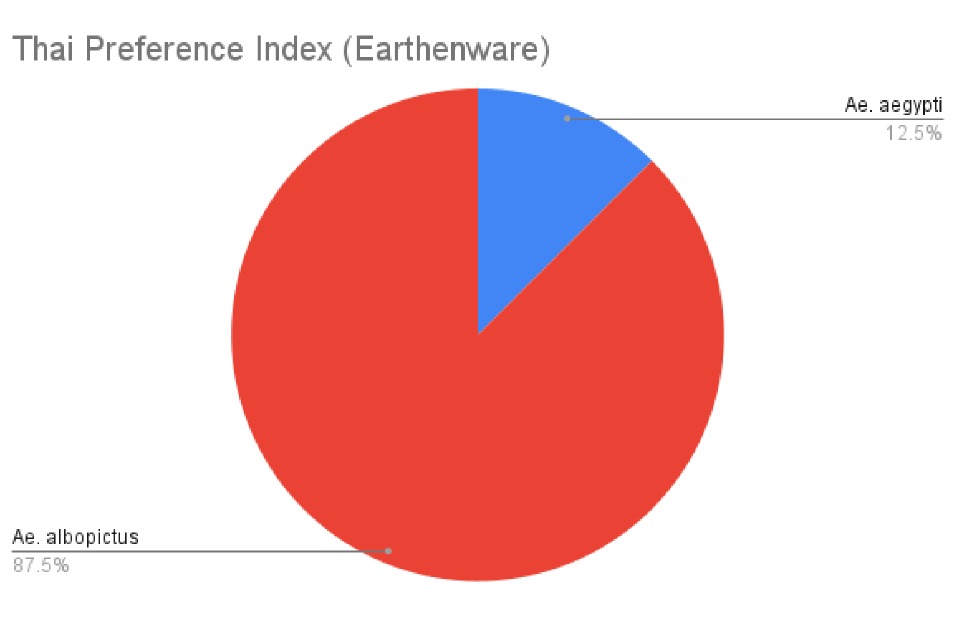


Table 3. Preference index on Earthenware by mosquitoes in Thai Temple.

Thai

(b)(i)



(b)(ii)

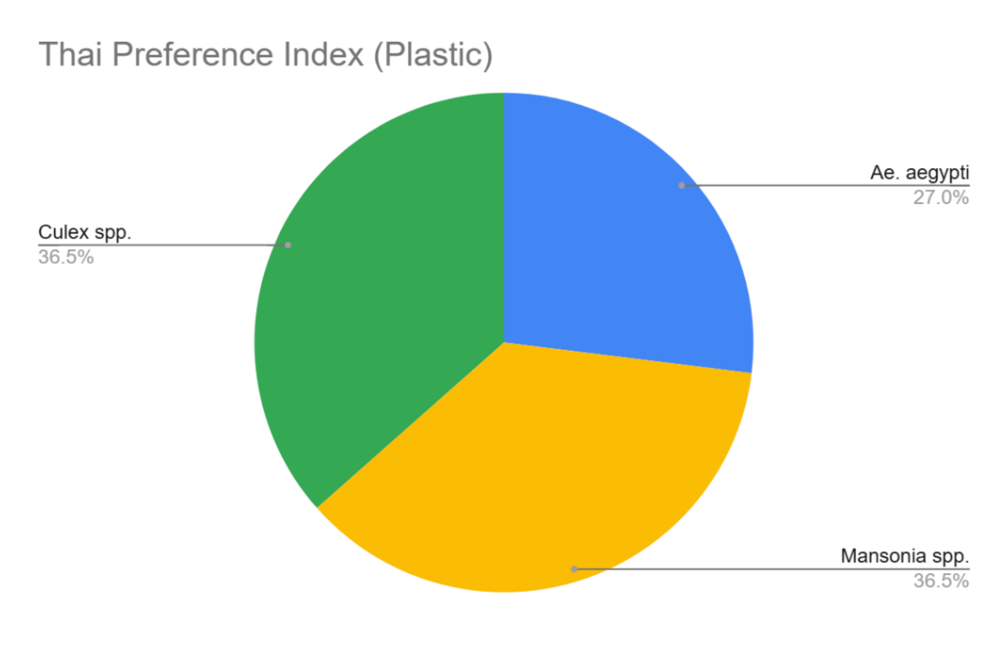


Table 4. Preference index on Plastic by mosquitoes in Thai temple

Table 2 shows the number of species of mosquitoes per container type in Chinese temples. We found that *Ae. aegypti* (100%) in cement and *Ae. albopictus* (100%) in earthenware were containers with the highest preference index. On the other hand, variations on container types preferred by mosquitoes were found in Thai temples from which *Aedes aegypti* (12.5%) and *Aedes albopictus* (87.5%) prefer earthernwares (Table 3) while *Ae. aegypti* (27%), *Mansonia spp.* (36.5%) and *Culex spp.* (36.5%) prefer plastic (Table 4).

Chi-Square Test Results for Larvae Counts Across Thai and Chinese Temples

		Sites			Total
			Temple 1	Temple 2	
Genus		7	0	0	7
	Ae. aegypti	0	1	1	2
	Ae. albopictus	0	1	1	2
	Culex spp.	0	1	1	2
	Masonic spp.	0	1	1	2
Total		7	4	4	15

Chi-Square Tests				
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	15.000[a]	8	.059	.028
Likelihood Ratio	20.728	8	.008	.003
Fisher's Exact Test	15.390			.001
N of Valid Cases	15			

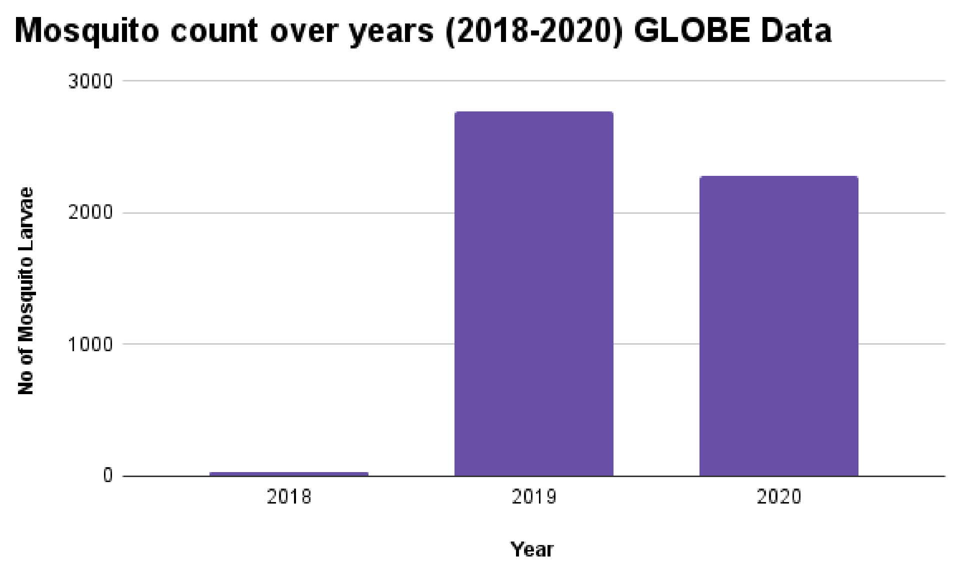
A Chi-Square Test of Independence was conducted to examine the association between mosquito genus and temple locations (Thai vs. Chinese temple). The Pearson Chi-Square test ($\chi 2(8)=15.00$, $p=0.028 \chi 2(8)=15.00$, $p=0.028$) and the Likelihood Ratio test ($\chi 2(8)=20.728$, $p=0.003 \chi 2(8)=20.728$, $p=0.003$) indicate a statistically significant association between mosquito genus distribution and temple locations. Additionally, Fisher's Exact Test ($p=0.001p=0.001$) further confirms this significant association, suggesting that certain mosquito species are more prevalent in one temple compared to the other. Given the small sample size, Fisher's Exact Test provides the most reliable result, supporting the conclusion that mosquito genus distribution differs significantly between the Thai and Chinese temples. Further research with a larger dataset is recommended for validation.

The crosstabulation results showed that *Ae. aegypti* was only found in the Chinese temple, while *Culex spp.* and *Masonic spp.* were exclusive to the Thai temple. *Ae. albopictus* was present in both temples but with differing counts. The findings suggest that certain mosquito species may have habitat preferences linked to temple characteristics or environmental factors.

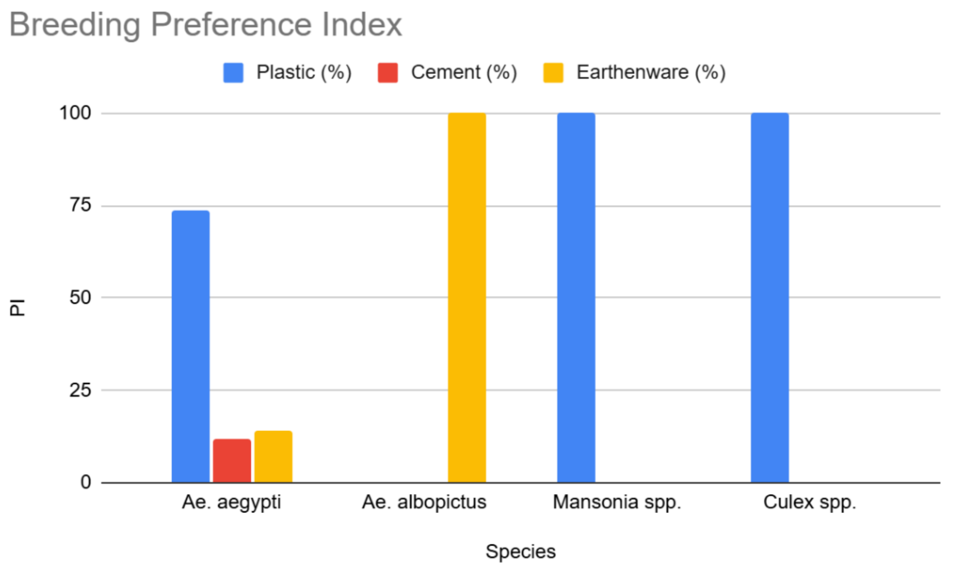
Overall, the analysis reveals a significant difference in mosquito genus distribution between the Thai and Chinese temples. Due to the small sample size, further research with a larger dataset is recommended to confirm these findings and explore potential

Globe Data Analysis (Trang) (2018-2020)

(a)(i)

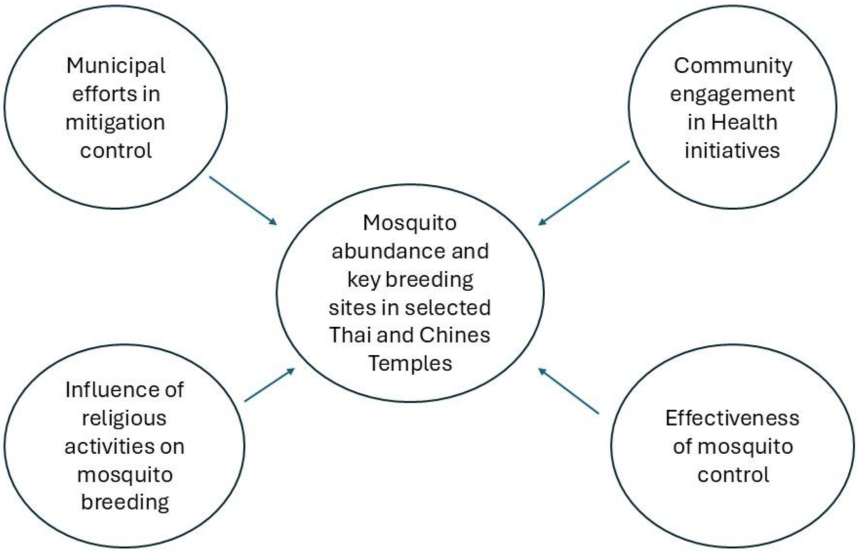


(b)(ii)



The GLOBE data from 2018 to 2020 shows a significant rise in mosquito larvae counts, the hike in 2019 before the decrease in 2020. The Breeding Preference Index indicates that different mosquito species prefer distinct breeding materials. *Ae. aegypti* shows a less preference for plastic, while *Ae. albopictus* primarily breeds in cement containers. *Mansonia spp*. and *Culex spp*. exhibit a strong preference for plastic, highlighting the role of different materials in mosquito breeding patterns. These findings emphasize the importance of material selection in mosquito control strategies.

The impact of mosquito control and mitigation practices on mosquito abundance and key breeding sites



The thematic analysis revealed key themes on mosquito control efforts, community involvement, and effectiveness.

1. **Municipal Efforts in Mitigation Control**: Municipal programs like fumigation and larvicide treatments were identified as vital in reducing mosquito populations.
2. **Community Engagement in Health Initiatives**: Community participation was found to be crucial in mosquito control. When residents actively engage in clean-up campaigns and are educated on controlling breeding sites, mosquito abundance decreases. This collaboration between the community and authorities ensures more sustainable outcomes.
3. **Effectiveness of Mosquito Control**: While mosquito control efforts such as insecticide spraying and larval management showed some success, their impact was often temporary. A combination of methods and long-term solutions is necessary to address seasonal or persistent breeding sites.
4. **No Influence of Religious Activities on Mosquito Breeding**: Surprisingly, the analysis found no significant impact of religious activities on mosquito populations. Mosquito breeding was primarily influenced by environmental factors, such as stagnant water, rather than cultural or religious practices.

Effective mosquito control requires integrated efforts from both municipalities and communities. Long-term, comprehensive strategies should be prioritized, with an emphasis on environmental factors over misconceptions about cultural practices.

4. Discussion

Distinct Mosquito Patterns in Chinese and Thai Temples

Our findings show a notable contrast in mosquito species distribution between Chinese and Thai temples in Trang. The presence of only *Aedes aegypti* and *Aedes albopictus* in Chinese temples indicates a breeding environment influenced by specific architectural and environmental factors. In comparison, Thai temples supported a broader variety of species, such as *Culex spp.* and *Mansonia spp.*, likely due to differences in water storage methods, vegetation, and building structures. This aligns with previous research highlighting how temple landscapes influence mosquito breeding preferences (Githeko et al., 1996; Kittayapong et al., 2006).

Breeding Hotspots: Container Index Analysis

The findings from the Container Index (CI) highlight the elevated risk of mosquito breeding in Chinese temples, as every surveyed water-holding container was found to harbor larvae (CI = 100%). This observation implies that conventional practices of water storage or ceremonial offerings may foster optimal breeding conditions. Conversely, the comparatively lower CI in Thai temples (57.89%) and the average from the GLOBE dataset (46.71%) suggest a spectrum of risks across diverse environments. Empirical studies have demonstrated that the proficient management of water containers is instrumental in mitigating mosquito populations. (Chareonviriyaphap et al., 2003).

Further examination of reproductive inclinations indicated that *Aedes aegypti* predominantly preferred cement receptacles within Chinese temples, whereas *Aedes albopictus* exhibited a preference for earthenware vessels. In the context of Thai temples, both *Aedes aegypti* and *Aedes albopictu*s demonstrated a predilection for earthenware, in contrast to Mansonia spp. and Culex spp., which flourished in plastic containers. These findings are consistent with existing research that elucidates species-specific oviposition preferences contingent upon the type of container material and the quality of water. (Vezzani & Albicócco, 2009).

Statistical Confirmation: Chi-Square Test Insights

The Chi-Square test confirmed a statistically significant association between mosquito species and temple locations ($p = 0.028$). The exclusive presence of *Ae. aegypti* in Chinese temples, along with *Culex spp.* and *Mansonia spp.* in Thai temples, suggests environmental conditions unique to each temple type shape mosquito populations. Additionally, Fisher's Exact Test further validated these findings, emphasizing the need for further research with larger datasets to strengthen statistical reliability.

Temporal Trends: Insights from GLOBE Data (2018-2020)

An analysis of the GLOBE dataset (2018-2020) revealed a peak in mosquito larvae counts in 2019, followed by a decline in 2020. This variation may be influenced by environmental conditions, seasonal changes, or vector control measures. The Breeding Preference Index reinforced species-specific container preferences: *Ae. aegypti* in cement, *Ae.*

albopictus in earthenware, and *Mansonia spp.* and *Culex spp.* in plastic. Understanding these trends is crucial for designing targeted mosquito control interventions (Morrison et al., 2004).

Effective Mosquito Control: Municipal vs. Community Approaches

Municipal Efforts and Their Limitations

While municipal interventions such as fumigation and larvicide treatments remain vital, their effects are often temporary, necessitating ongoing efforts. Studies indicate that integrated vector management—combining chemical, biological, and environmental control—is more effective than standalone chemical treatments (Rozendaal, 1997).

Power of Community Engagement

Community-oriented initiatives are instrumental in the advancement of sustainable mosquito management. Educational outreach campaigns, organized sanitation activities, and proactive involvement in the eradication of breeding sites markedly reduce mosquito populations. Empirical studies have demonstrated that community-driven interventions are pivotal to achieving enduring success in vector control (WHO, 2017). Promoting resident engagement in mosquito surveillance and habitat remediation improves the comprehensive efficacy of control measures.

Long-Term Control Strategies

While insecticide spraying and larval management have shown effectiveness, their impact is short-lived. Sustainable strategies, such as environmental modifications and biological control methods, offer longer-term solutions. Studies have demonstrated that combining multiple approaches yields superior results compared to relying solely on chemical treatments (Gubler, 2002).

Religious Practices: No Direct Influence on Mosquito Breeding

Contrary to assumptions, religious activities were found to have no significant impact on mosquito breeding patterns. Instead, environmental factors, particularly stagnant water availability, were the primary determinants of mosquito populations. These findings are consistent with previous research on mosquito ecology in cultural and religious sites (Rohani et al., 2011).

Conclusion and Recommendations

This study highlights significant differences in mosquito species distribution between Chinese and Thai temples in Trang, influenced by environmental and structural factors. The high Container Index in Chinese temples emphasizes the need for targeted interventions. Sustainable mosquito control efforts should prioritize community engagement, environmental management, and integrated control strategies over short-term chemical treatments. Future research with larger datasets is recommended to refine and enhance control measures.

I would like to claim IVSS badges

I make an impact

The document explicitly outlines the link between a community concern and the research inquiries, establishing connections between local and global repercussions. The students must depict how their research has positively influenced their community by providing recommendations or implementing actions derived from their findings. Exploring the ecology of mosquito larvae offers insights that can be utilized to safeguard the community against disease transmission via animal vectors, achieved by modifying or minimizing the use of specific container materials.

I am a STEM professional.

The report distinctly outlines the collaboration with a STEM professional, which bolstered the research methods, enhanced precision, and facilitated more advanced analyses and interpretations of the results. The data underwent analysis through independent-samples t-tests to compare the quantities of mosquito larvae in various container types.

I am a data scientist.

The report thoroughly examines the students' proprietary data and additional data sources. Students critically evaluate the limitations of this data, draw inferences about historical, current, or future events, and leverage the data to address questions or resolve issues within the depicted system. This may involve incorporating data from other educational institutions or utilizing information from external databases. The latitude and longitude of the locations where mosquito larvae were observed were recorded using the GLOBE Observer: MHM App.

Acknowledgments

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