Mosquito aquatic predator diversity and its abundance in Krabi Province, Thailand

Students (Grade 9): Nichapat Yothachai, Phongpanot Dolamphonphisuth, Artima Jamjang, Supichcha Tongboon, Jidapa Niamhom, Ashira Eiamarune, Supitcha Boonnak, Jarukan Tangkamonkasem, Kotchanun Charoenchinnaphat, Sirawit Saengchote, Teeraphat Kiatdumrong, Dhusaya Bangchompoo, Jirapat Baithongsiri
School: Samsenwittayalai School
Teacher: Mrs. Kornkamon Kumnerdkarn, Mrs. Suchada Sattamun
Scientists: Assoc.Prof.Dr.Krisanadej Jaorensutasinee, Assoc.Prof.Dr. Mullica Jaroensutasinee, Miss Pirarat Kettaphanthuwat, Miss Fatima Ninchuawong, and Miss Arisana Thongaram, Center of Excellence for Ecoinformatics, School of Science, Walailak University.
Email: rat.kornkamon@gmail.com

Abstract

This research examined mosquito control strategies in Krabi, Thailand, focusing on the negative environmental impacts of traditional pesticides. The study explored the role of aquatic predatory insects in controlling mosquito larvae populations and assessed the effect of distance from the dam on mosquito and predator diversity. The study area was divided into three sites: (1) Boon Siam Hotel, (2) Panurat Prachasan Temple, and (3) Kaew Korawaram Temple. Results revealed the presence of *Aedes albopictus* larvae at Boon Siam Hotel sites and *Culex* larvae in all sites, with the highest numbers found at Boon Siam Hotel. Seven types of water containers were identified: earthen jars, drainage, puddles, bromeliads, plant pots, fountains, and buckets. Pottery containers (jars, water tanks, etc.) exhibited the highest number of mosquito larvae. Five mosquito aquatic predators were identified: water striders, small water striders, fish, amphibians, gastropods, and bloodworms. A total of 107 containers were categorized based on material (0:25:26:56 metal: plastic: earthen: plant), presence of lids (2:105 with lids: without lids), container type (4:103 natural: artificial), and water levels (39:9:19:40 25:50:75:100%). Most mosquito aquatic predators were found in water with temperatures ranging from 29-32°C, pH levels of 7.0-8.2, and water salinity of 0.1-1.5. Mosquito larvae were found in water with temperatures ranging from 30-33°C, pH levels of 8.0-8.2, and water salinity of 0.4-2.5. These findings offer valuable insights into the distribution of breeding sites and water parameters near Boon Siam Hotel, highlighting potential areas for targeted vector control measures to mitigate mosquito-borne diseases.

Keywords: GLOBE Observer: MHM App, Mosquito Predator, Thailand

1. Introduction

The regulation of mosquito larvae in natural ecosystems hinges on a diverse array of predators. While much attention has been devoted to predatory aquatic insects in research (Knight et al., 2003; Tuno et al., 2005; Mogi, 2007; Quiroz-Martinez & Rodriguez-Castro, 2007; Shaalan et al., 2007; Forio et al., 2020), further exploration uncovers a broader spectrum of potential predators. Apart from insects, various other organisms control mosquito larvae across different habitats, including arachnids, crustaceans, amphibians, fish, birds, and even mammals.

Dengue presents a complex illness spectrum, encompassing dengue fever, hemorrhagic fever, and dengue shock syndrome/expanded dengue syndrome (WHO, 1997; 2011). Particularly prevalent in tropical and subtropical regions, especially Southeast Asia (WHO, 2009; 2012), dengue has maintained endemic status in Thailand for over six decades and is characterized by unpredictable outbreak patterns (Diseases Control Department, 2015). A retrospective analysis of dengue outbreaks spanning 2014 to 2018 revealed morbidity rates ranging from 63.25 to 222.58 cases per 100,000 inhabitants and mortality rates between 0.10% and 0.13% (Vector Borne Diseases Division, 2019).

Thailand is among several countries grappling with a persistent dengue fever challenge. The government has endured over 50 years of outbreaks, with morbidity rates surpassing the thirteen-year average from 1997 to 2009. Notably, the central region exhibits a higher incidence of dengue fever than other areas. In 2020, the central region reported the highest sickness rate at 18.06 per 100,000 individuals, with the Department of Disease Control recording 4,052 dengue cases and a case fatality rate of 0.10 percent (DDC, 2020). Epidemiological data from 2023 revealed a cumulative total of 79,475 cases of dengue fever, translating to an illness rate of 120.25 per 100,000 population, with 73 recorded deaths, equating to a death rate of 0.09 per 100,000.

This study investigates the diversity of mosquito larvae and predators at the Boon Siam Hotel, Panurat Prachasan Temple, and Kaew Korawaram Temple in Krabi Province, Southern Thailand. We conducted our mosquito larvae and predator survey at Boon Siam Hotel, Panurat Prachasan Temple, and Kaew Korawaram Temple to test this. We sampled all water containers to collect mosquito larvae and mosquito predators. We also consider the following factors: (1) natural/artificial containers, (2) metal/ plastic / earthen containers, (3) containers with lid / without lid, (4) water levels (0-25%, 26-50%, 51-75%, 76-100%), (5) water temperature, (6) water pH, (7) water salinity, (8) positive/negative containers, (9) mosquito species: *Aedes* (*Ae. albopictus, Ae. aegypti*), *Culex spp*., *Armigeres*, *Toxorhynchites* (10) predator species: *Arachnida*, *Crustacea*, *Odonata*, Heteroptera, Coleoptera, Diptera, fish, and Amphibia.

2. Materials and methods

2.1 Study site

A survey of mosquito larvae and aquatic insect predators was conducted at the Boon Siam Hotel, Panurat Prachasan Temple, and Kaew Korawaram Temple in Krabi Province, Thailand (8.1192° N, 99.1013° E) February-March 2024. Krabi Province has two seasons: summer (November to May and rainy (June to October).

			
(a)	(b)	(c)	(d)

Figure 1. (a) Krabi Map, (b) Boon Siam Hotel, (c) Panurat Prachasan Temple and (d) Kaew Korawaram Temple, Krabi Province

2.2 Sampling of mosquito larval predators and mosquito larvae.

In this study, we surveyed three areas with 30 houses per area and then collected samples of mosquito larvae and larval predators for classification. We collected all samples from every water container, both with and without water, and we measured pH, temperature, and salinity in containers with water. We recorded the water level of the container and whether or not it had a lid. We scooped up mosquito larvae and predators into plastic bags. We used the GLOBE Observer: MHM app to locate water container latitude and longitude coordinates, the number of mosquito larvae, and the mosquito species in the GLOBE database (Figure 2). The mosquito larvae and larval predators were classified up to the species level. The experimental design is shown in Figure 3.

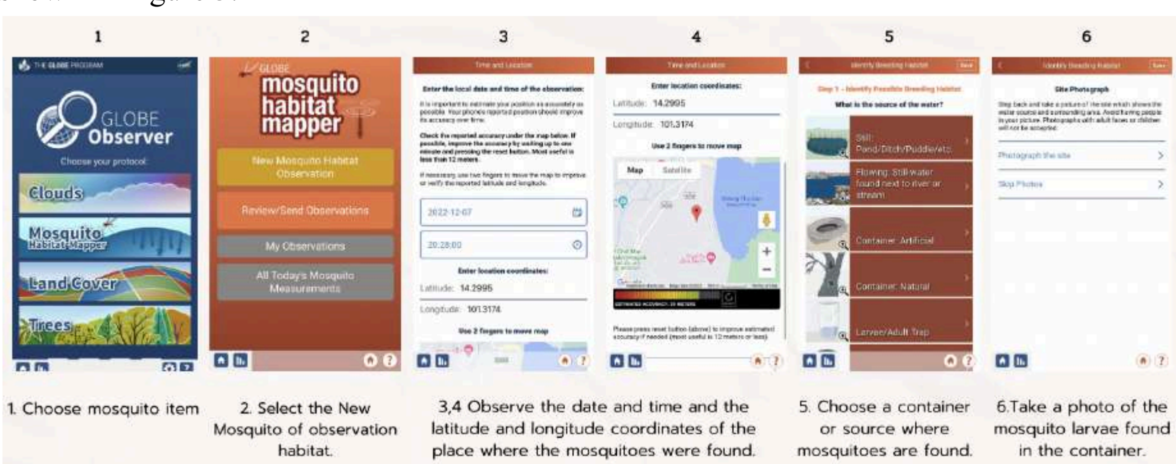


Figure 2. GLOBE Observer: MHM app

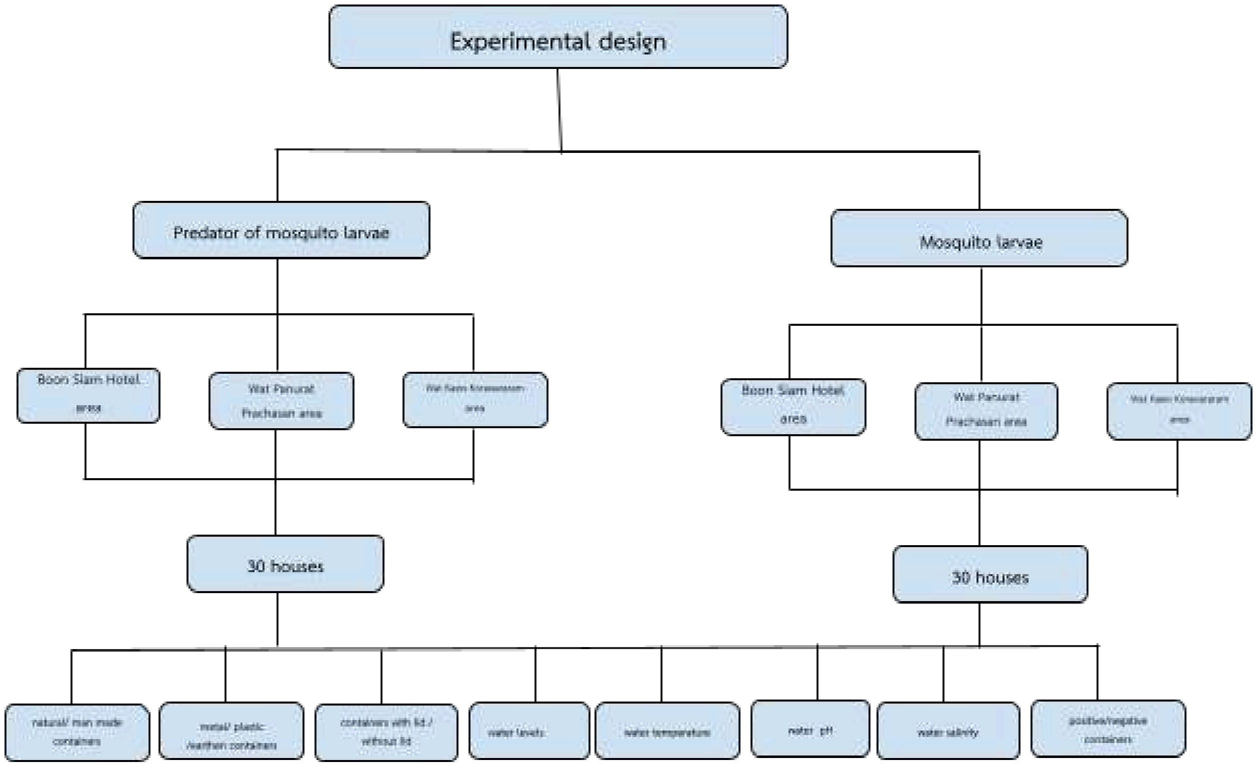


Figure 3. Experimental design in the study

2.3 Data collection

In this study, there were three sampling sites: (1) Boon Siam Hotel, (2) Panurat Prachasan Temple, and (3) Wat Kaew Korawararam. We sampled all water containers at each site to collect mosquito larvae and predators. All probable habitat types found at every site were recorded, classified, and inspected for the presence or absence of mosquito larvae and their predators. Each habitat was dipped 20 times using a standard mosquito dipper. We used a D-frame dip net of 0.3 m width attached to a long pole and a cone-shaped bag for capturing the mosquito larvae predators. We immediately preserved the captured mosquito larvae and predators in 90% ethanol for further identification. Water physico-chemical parameters (pH, temperature, conductivity, total dissolved solids (TDS), and salinity) were measured in situ using a hand-held multi-parameter- meter.

2.4 Entomological studies

All water containers were sampled for mosquito larvae and predators. Tiny water containers were emptied through the containers. Larger water containers were sampled by dipping the net in the water, starting at the top of the container and continuing to the bottom in a swirling motion that sampled all edges of the container. All live mosquito larvae were collected in plastic bags, taken to the laboratory, preserved, and identified up to species level using Rattanarithikul and Panthusiri's keys. This study discarded the first-second instars and pupae because immature mosquitoes could not be identified at these stages. There were a total of 129 container categories in this study. Plastic water containers were divided into two categories: large plastic containers used for water storage (>100 L) and plastic bottles (i.e., 0.5–2.0 L water bottles). Earthen jars were classified into two categories: small earthen jars with a volume of ≤100 L and large earthen jars with a volume of >100 L.

Water containers that were found at each house were classified as (1) natural/artificial containers, (2) metal/ plastic / earthen containers, (3) containers with lid / without lid, (4) water levels (0-25%, 26-50%, 51-75%, 76-100%), (5) water temperature, (6) water pH, (7) water salinity, (8) positive/negative containers. The mosquito larvae were identified as *Aedes (Ae. albopictus, Ae. aegypti), Culex spp.,and Armigeres*. Predator species were identified as Arachnida, crustacea, Odonata, heteroptera, Coleoptera, Diptera, fish, and amphibia.

2.5 Statistical analysis

Three larval indices (i.e., house index (HI), container index (CI), and Breteau index (BI)) were worked out as per standard WHO guidelines. There were three larval indices calculated as per standard WHO guidelines: House Index (HI), Container Index (CI), and Breteau Index (BI). House index (HI) was calculated by the number of cheerful houses divided by the total number of houses inspected timed 100. The container index (CI) was calculated by the number of positive containers divided by the total number of containers inspected timed 100. Breteau index (BI) was calculated by the number of positive containers divided by the total number of houses inspected timed 100.

3. Results

Table 1. The number of households (X ± SD) that had indoor/outdoor water containers in three sampling sites: (1) Boon Siam Hotel, (2) Panurat Prachasan Temple, and (3) Kaew Korawaram Temple, Krabi Province, Thailand

Container types	The number of water containers			
	Boon Siam Hotel	Panurat Prachasan Temple	Kaew Korawaram Temple	Number of mosquito larvae
Metal	0	0	0	0
Plastic	13	0	12	19
Earthen	17	5	4	66
Other containers	9	3	44	31

***Ae. aegypti* and *Ae. albopictus* larvae**

We found forty-five lotus basins, two drain containers, and one bromeliad in other containers. In Krabi Province, we found 25 plastic containers and 26 earthen containers. From all four types of water containers, we found the highest number of mosquito larvae in earthen containers (66 larvae), followed by other containers (31 larvae), and lowest in metal containers (0 larvae) (Table 1).

Location and Mosquito larvae

Only two mosquito larval species were found at these three sites: *Aedes* and *Culex* larvae (Figure 2a). Boon Siam Hotel had the highest number of *Aedes* and *Culex* larvae, followed by Kaew Korawaram Temple and Panurat Prachasan Temple (Figure 2a). In Boon Siam Hotel, we found 34 *Aedes* and 40 *Culex* larvae (Figure 2a). In Kaew Korawaram Temple, we found 12 *Aedes* and 25 *Culex* larvae (Figure 2a). In Panurat Temple, there are no *Culex* larvae (Figure 2a).

Predator species: Amphibia, Annelida, Arachnida, Arthropoda, Fish, Heteroptera, Monnusca, Odonata.

Six mosquito predator groups were found at these three sites: water striders, small water striders, fish, amphibians (tadpoles), shellfish, and blood worms (Figure 2b). We found most water striders and small water striders at Boon Siam Hotel, followed by Kaew Korawaram Temple and Panurat Prachasan Temple (Figure 2b). For fish, we found most at Panurat Prachasan Temple, followed by Boon Siam Hotel and Kaew Korawaram Temple (Figure 2b). For amphibians (tadpoles), we only found them at Boon Siam Hotel (Figure 2b). For shellfish, we found most at Kaew Korawaram Temple, followed by Boon Siam Hotel and Panurat Prachasan Temple (Figure 2b). For water and blood worms, we only found them at Kaew Korawaram Temple (Figure 2b).

Positive Containers / Mosquito Larval Predators

When we looked at the number of water containers with mosquito larvae (called positive containers), Boon Siam Hotel had the highest number of positive containers (18 positive containers out of 39). Kaew Temple had two positive containers out of 60 containers. Panurat Temple had only one container out of 8 (Figure 2c). When we looked at the number of water containers with mosquito larval predators (called positive containers), we found that Kaew Temple had the highest number of positive predator containers (37 positive containers out of 60). Boon Siam Hotel had 13 positive containers out of 39. Panurat Temple had seven containers out of 8 (Figure 2c). This strongly indicates that mosquito larval predators are an effective way to control mosquito larval population.

Lid / Without Lid Containers

There were no containers found with lids. There were 38 no-lid containers at Boon Siam Hotel, 57 at Kaew Temple, and eight at Panurat Temple (Figure 2d).

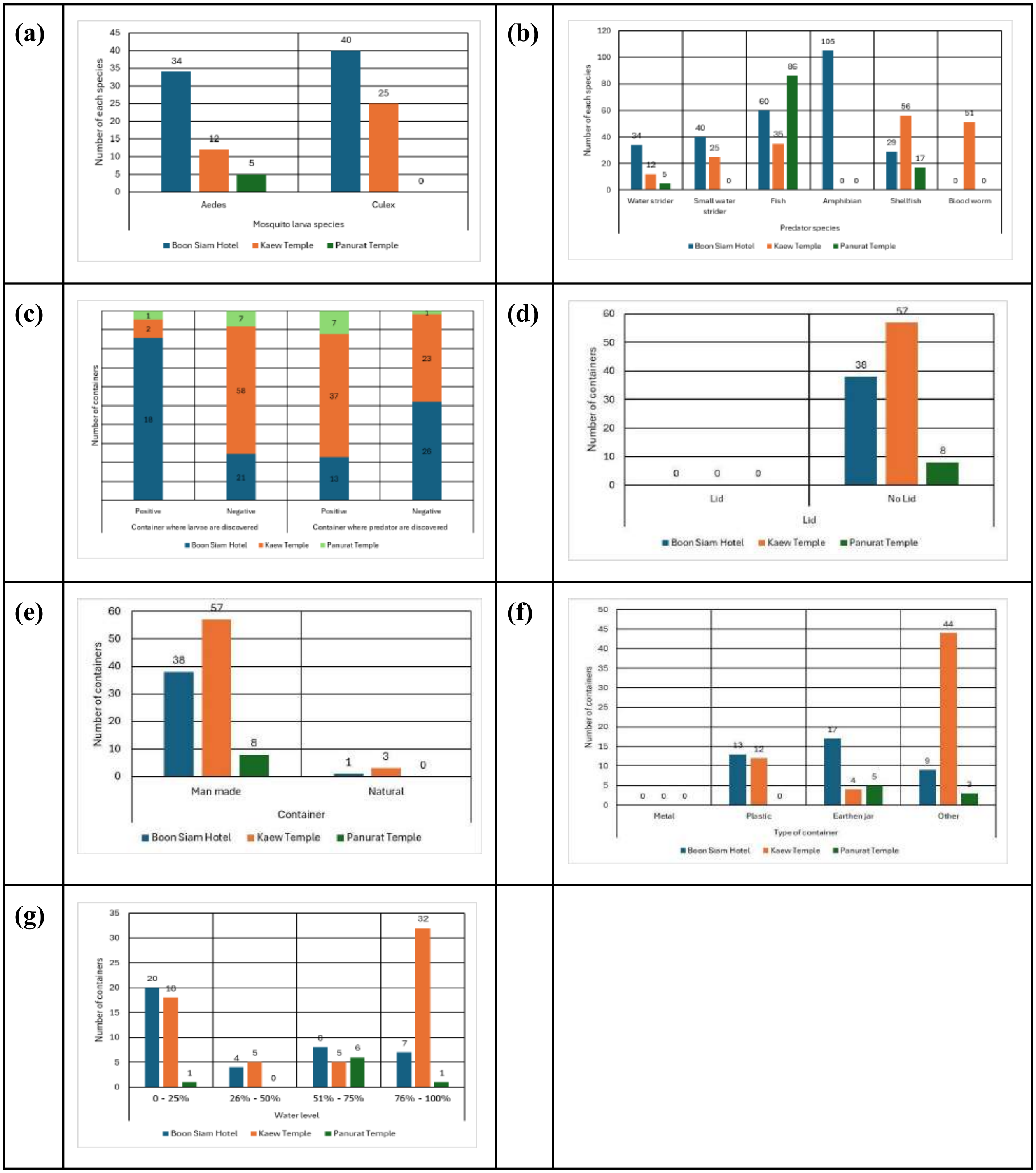


Figure 2. Water containers predators and mosquito larvae. (a) *Ae. aegypti*, *Ae. albopictus*, *Culex* spp., *Armigers* spp. and *Toxorhynchites* spp., (b) Predator species: Amphibia, Annelida, Arachnida, Arthropoda, Fish, Heteroptera, Monnusca, Odonata, (c) containers: breeding sites, (d) lid/without lid, (e) natural/artificial container, (f) metal/ plastic /earthen /other containers, (g) water levels (0-25%, 26-50%, 51-75%, 76-100%), (h) water temperature, (i) water salinity and (j) water pH

Natural /Artificial Containers

There were more artificial than natural containers in all three sites (Figure 2e). Kaew Korawaram Temple had 57 artificial and three natural containers. Boon Siam Hotel had 38 artificial and one natural container. Panurat Prachasan Temple had eight artificial and no natural containers (Figure 2e).

Metal/ Plastic /Earthen /Other Containers

After examining the four container types (i.e., metal, plastic, earthen, and other containers) across all three areas, we found no metal containers (Figure 2f). Boon Siam Hotel had the highest number of plastic and earthen containers, and Kaew Temple had the highest number of other containers (i.e., bromeliad, lotus basin, and drainage) (Figure 2f).

Other Containers

Bromeliad

Lotus Basin

Drainage

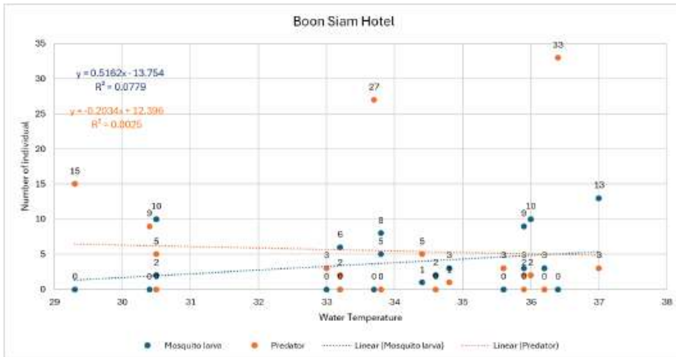
Water Levels (0%, 25%, 50%, 75%, 100%)

Based on the survey findings, containers had different water levels among sites. Kaew Korawaram Temple contains the most frequent water level of 76-100% (Figure 2g). Panurat Prachasan Temple had containers with the most frequent water level of 51-75% (Figure 2g). Boon Siam Hotel had containers with the most frequent water level of 0-25% (Figure 2g).

Water Temperature

Water temperature in containers varied among sites: Boon Siam Hotels (35.5-36.5°C), Panurat Prachasan Temple (31.6-32.2°C) and Kaew Korawaram Temple. There was no relationship between water temperature, the number of mosquito larvae, and predators at Boon Siam Hotel (Figure 5a) and Kaew Temple (Figure 5c). On the other hand, at Panurat Prachasan Temple, as the water temperature in containers increased, the number of mosquito larvae decreased, and predators increased (Figure 5b).

(a)



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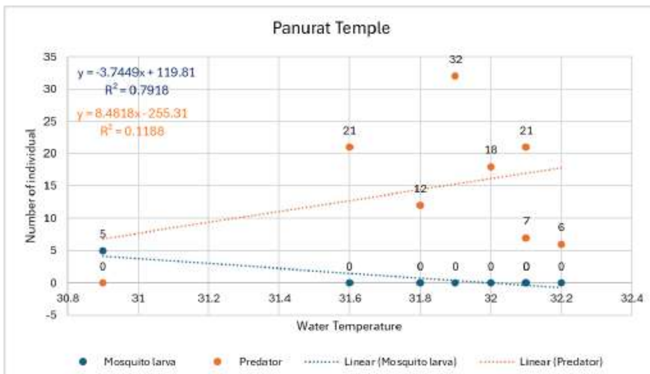

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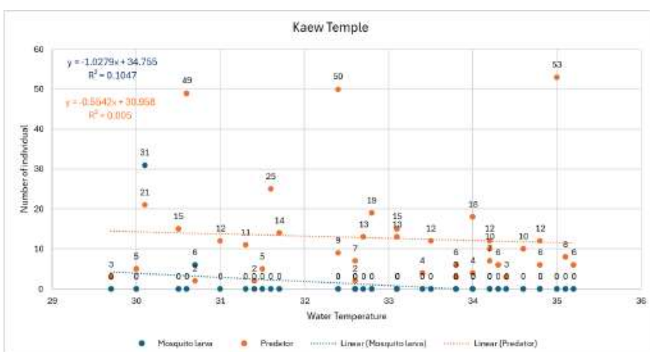


Figure 5. Relationship between water temperature, mosquito larvae, and predators. (a) Boon Siam Hotel, (b) Panurat Prachasan Temple, and (c) Kaew Korawaram Temple

Water salinity and pH

Water Salinity in containers varied among sites: Boon Siam Hotels (0.5 ppt, pH 9.0), Panurat Prachasan Temple (1 ppt, pH 8.5) and Kaew Korawaram Temple (0.7 ppt, pH 8.5). There was no relationship between water salinity and pH, the number of mosquito larvae, and predators at Boon Siam Hotel (Figure 6a, b), Panurat Prachasan Temple (Figure 6c, d), and Kaew Temple (Figure 6e, f).

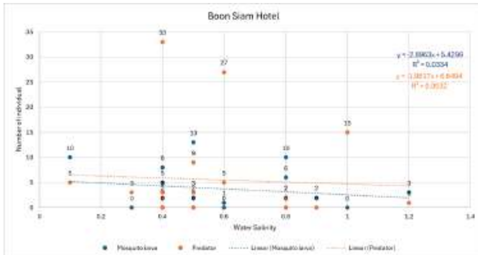
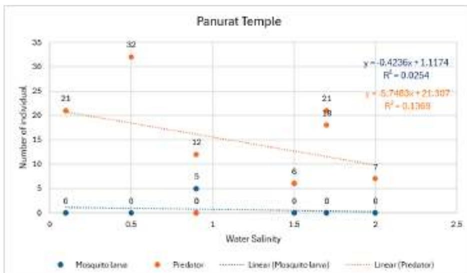
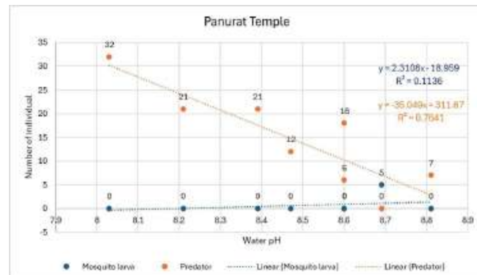
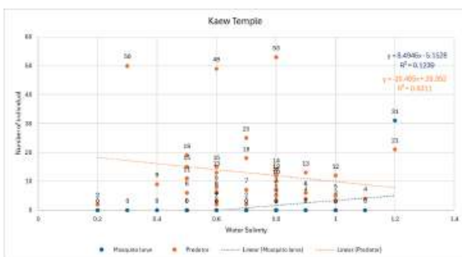
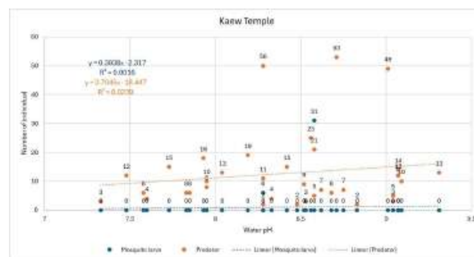
	Water Salinity		Water pH
(a)		(b)	
(c)		(d)	
(e)		**(f)**	

Figure 6. Relationship between water salinity and pH, mosquito larvae, and predators. (a, b) Boon Siam Hotel, (c, d) Panurat Prachasan Temple, and (e, f) Kaew Korawaram Temple

Mosquito Larval Indices

Boon Siam Hotel had the highest larval indices in all three indices (i.e., HI, CI, and BI) (Table 2). The National Institute of Communicable Diseases defined a high risk of dengue hemorrhagic fever transmission when BI was > 50, HI >10, and a low risk of transmission when BI was < 5 and HI was <1. Boon Siam Hotel had BI > 50 and HI >10, which indicated a high risk of dengue hemorrhagic fever transmission area.

Table 2: The number of household containers and larvae indices in the Boon Siam Hotel area, Panurat Prachasan Temple area, and Kaew Korawaram Temple area.

	Boon Siam Hotel	Panurat Prachasan Temple	Kaew Korawaram Temple
No. of households	30	30	30
No. of positive households	12	1	3
No. of containers	39	8	60
No. of positive containers	18	1	3
Larval index			
HI (%)	40	3.33	10
CI (%)	46.15	12.5	5
BI	60	3.33	10

4. Discussion

The research conducted in Krabi, Thailand, delved into mosquito control strategies with a focus on mitigating the environmental repercussions of traditional pesticides. The study centered on the efficacy of aquatic predatory insects in regulating mosquito larvae populations and evaluated the impact of proximity to a dam on mosquito and predator diversity. Divided into three sites, namely Boon Siam Hotel, Panurat Prachasan Temple, and Kaew Korawaram Temple, the study uncovered significant findings pertinent to vector control measures.

The presence of Aedes albopictus larvae was noted primarily at Boon Siam Hotel sites, while Culex larvae were prevalent across all sites, with Boon Siam Hotel exhibiting the highest numbers. The study identified various types of water containers acting as breeding grounds for mosquitoes, with pottery containers harboring the highest number of mosquito larvae. Moreover, five mosquito aquatic predators were identified, highlighting the diverse ecosystem present in these habitats.

Sampling efforts involved meticulous collection of mosquito larvae and larval predators from water containers across the study sites. Parameters such as pH, temperature, and salinity were measured to assess the environmental conditions conducive to mosquito breeding. The classification of containers based on material, presence of lids, container type, and water levels provided insights into the distribution of breeding sites.

Entomological studies further elucidated the prevalence of mosquito larvae species and their predators across the sites. The statistical analysis yielded larval indices crucial for assessing the risk of mosquito-borne diseases transmission, with Boon Siam Hotel presenting the highest risk due to elevated indices.

The findings underscore the significance of employing integrated vector management approaches, leveraging the natural predators of mosquitoes to curb their populations. The abundance of mosquito larvae and predators varied across sites, suggesting the need for site-specific interventions. Moreover, the absence of lids on water containers highlights a potential area for intervention to reduce mosquito breeding habitats.

The study's comprehensive approach, combining field sampling, entomological studies, and statistical analysis, provides valuable insights into the dynamics of mosquito populations and their predators in Krabi, Thailand. These insights can inform targeted vector control measures aimed at mitigating the risk of mosquito-borne diseases transmission in the region.

5. Conclusion

The study elucidates the relationship between container types and mosquito larvae abundance, underscoring the role of materials and container characteristics in influencing breeding. The spatial distribution of containers across surveyed areas revealed varying preferences, with earthen containers dominating the Boon Siam Hotel area and Panurat Prachasan Temple area. Other containers gaining significance in the Kaew Korawaram Temple area. The consistent prevalence of containers without lids in all areas raises concerns about increased mosquito breeding, emphasizing the importance of lid promotion or alternative strategies. The study examined environmental factors and found variations in water temperature, pH, and salinity across different areas, potentially impacting mosquito breeding and predator presence. Calculated larval indices indicated a higher risk of dengue transmission in the Boon Siam Hotel area, providing crucial information for public health planning and mosquito control prioritization. The discussion references previous studies, highlighting the significance of predator-prey relationships in mosquito population control and reinforcing the current findings. Practical implications are emphasized, suggesting community-based interventions for mosquito control based on the study's insights. Recommendations include promoting specific container types, advocating lid usage, and integrating environmental factors into mosquito control strategies. Acknowledging study limitations, such as the regional focus and exclusion of certain larval stages, the discussion calls for future research to expand the study to different regions and include additional ecological variables. This comprehensive discussion contributes valuable insights to understanding and mitigating mosquito-borne diseases.

I would like to claim IVSS badges

1.I make an impact.

The report clearly describes how a local issue led to the research questions or makes connections between local and global effects. The students must clearly explain or show how the research positively impacted their community by making recommendations or taking action based on findings. The study of mosquito larvae ecology can give information on preserving and reducing the infection of the disease via the animal vector by reducing or changing the materials of the container.

2. I am a STEM professional.

The report clearly describes the collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results. Data were analyzed using independent-sampled t-tests to compare the numbers of mosquito larvae in different types of containers.

3. I am a data scientist.

The report includes an in-depth analysis of students' data and other data sources. Students discuss the limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases. The latitude and longitude of the area where mosquito larvae are available were recorded using a GLOBE observer and an MHM application.

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