Faith-based Communities Affecting Breeding Sites of Mosquito Larvae at Samui Island, Thailand Mosquito using Drone imagery and GLOBE Observer: Habitat Mapping App

Students: Switt Kitkumchonskul, Thanawin Khomwongthep, Warissara Kiattiyoscharoen, Chanakarn Limprasertsiri, Apicharee Wannasubphol, Ruksita Tinsiripattanakij, Tossapornprapa Sereeviriyakul, Nabhatara Tongsri, Jennittha Mitravijarn, Panassaya Boonwan, Yotsanon Punthongpaun, Krittithee Tuncharoen, Isariyarat Khaongam, Pichayapa Prasertwit, Sarisa Suwanmalee, Pattaravadee Sittiwong, Phatranit Grachangpho, Pimpajee Thalerngkul, Rinrada Meekaew, Thanet Chormune, Punyawee Laokum, Paramita Saenghao

School: Samsenwittayalai

Teacher: Mrs. Kornkamon Kumnerdkarn

Email: rat.kornkamon@gmail.com

Abstract

This study investigated (1) how faith-based communities (Buddhist and muslim communities) affect the key breeding sites of mosquito larvae at Samui Island, southern Thailand and (2) comparing the number of containers from drone imageries with conventional ground survey. We examined how the number of *Aedes aegypti*, *Ae. albopictus*, *Culex* and *Anopheles* larvae differed in various types of water containers. Water containers were categorised into the following groups: indoor/outdoor containers, artificial/natural containers, earthen/plastic containers, and containers with/without lids. Samples were collected from a total of 100 households from 50 buddhist and 50 muslim houses using GLOBE Observer: Mosquito Habitat Mapper App. Our results showed that *Aedes* larvae were found in 57 out of 197 water containers in buddhist and muslim houses. *Aedes* females laid eggs in different container types depending on faith based communities. *Aedes* larvae were found in highest numbers in plastic buckets in both communities. The number of positive containers was higher in outdoor containers than indoor containers, artificial containers than natural containers, plastic containers than earthen containers, container without lid than container with lid, and muslim community than Buddhist community. Our results showed that conventional ground survey using MHM App gave higher numbers of containers in both communities (Drone:Ground survey at Plailaem Buddhist community = 22:77; at Hua Thanon Muslim community = 37:80).

Keywords: Water containers, *Aedes* species**,** water qualities, mosquito larval index, drone image

Introduction

Dengue fever is caused by dengue viruses of the family Flaviviridae, transmitted principally by *Aedes aegypti*, and *Ae. albopictus*, in the tropical and subtropical regions of the world. WHO (2017) reported that 70% of dengue infected persons were from South East Asia and Western Pacific. Dengue becomes a global threat and spreads its authority in urban and semi urban areas with the tropical and the subtropical climates in many countries. Accurate mapping of the spatial distribution of mosquito breeding habitats is essential for cost-effective deployment of control practices. Geospatial mapping by using drone mapping offers the potential to identify larval habitats on a large area basis to a degree that is difficult or impossible using conventional ground survey (Fomace et al. 2014, Hardy et al. 2017). *Aede*s mosquitoes are the dominant disease vector and transmitter of the dengue fever, Zika, and Chikunkunya (Preechaporn et al., 2006; Chumsri et al., 2015, 2018). In southern Thailand, the primary vector species is *Ae. aegypti* (Preechaporn et al., 2006; Chumsri et al., 2015, 2018).

Mosquito control is a critical component of the arbovirus control programs, and one of the most effective ways to control a mosquito population is to reduce its breeding habitats. Classical survey techniques of larval habitats, achieve small spatial coverage, limiting research on *Aedes* breeding sites. Several studies have demonstrated the capability of satellite imagery to detect large mosquito breeding sites in several countries (Linthicum et al. 1987, Pope et al. 1992, Wood et al. 1992, Dale and Morris 1996, Thomson et al. 1996, Masuoka et al. 2003, Achee et al. 2006, de Castro et al. 2006; Vittor et al. 2009). However, these studies have not used drone mapping techniques. From an operational point of view, the map resolution from remote sensing is too coarse to implement local control strategies, is not specific to larval habitat, and is too costly. With the increasing status of this emerging arbovirus, a more accurate and finer grained mapping system is necessary to aid the dengue and Zika prevention program. Drone mapping is to be an excellent choice for studying the base imagery for larval habitat assessment.

Mosquitoes utilise a wide variety of larval habitat types. Artificial containers are a major source of breeding habitats for mosquitoes worldwide. These artificial containers include tyres, plastic bottles, metal boxes, and cans (Wongkoon et al., 2005; Lester & Pike, 2003, Preechaporn et al., 2006). There are several examples of how each mosquito species prefers different breeding sites. *Ae. aegypti* breeds in a wide assortment of domestic containers, whereas *Ae. albopictus* tends to be found in natural containers, such as bamboo stumps and coconut shells, or in artificial containers outside the houses such as tyres, opened cans and plastic bottles (Wongkoon et al., 2005; Lester & Pike, 2003, Preechaporn et al., 2006).

Samui Island is one of the most tourist attraction places in Thailand where mosquito breeding sites could be affected by tourism. The objectives of this study are to investigate (1) how religious beliefs (i.e. Buddhist and Muslim) affecting water container types, mosquito species, and their numbers, (2) relationship between mosquito numbers and water pH and temperature, and (3) how can drone photo can be used to detect water containers comparing with conventional ground survey.

Materials and methods

Study sites

The study was conducted at Samui Island in Surat Thani province, Southern Thailand (9°29'43.70" N, 100° 0'13.14"E) (Figure 1) from 17-19 February, 2020.

Figure1 Map of Thailand and study site at Samui Island, Surat Thani province, Thailand.

(a) Plailaem buddhist community and (b) Hua Thanon muslim community

Data Collection

Mosquito larval survey was conducted in Samui Island, southern Thailand located at 9°29'43.70" N latitude and 100° 0'13.14" longitude in February 2020. We studied two faith-based communities: (Plailaem buddhist community and Hua Thanon muslim community, Figure 1a,b). Fifty household samples were collected in each faith-based community randomly.

Entomological Studies

We collected all mosquito larvae from both indoor and outdoor containers using GLOBE Observer: Mosquito Habitat Mapper App (GO MHM). We collected water pH and water temperature of each water container using the GLOBE Hydrosphere protocol. We collected mosquito larvae from each outside and outside (natural and artificial) water container by using fishnets with 0.55 mm mesh size nets. All mosquito larvae from each water container were placed in a plastic bag and tied the bag with a rubber band (Chumsri et al., 2015). We preserved mosquito larvae in 70% alcohol and identified them up to genus level using Rattanarithikul and Panthusiri's keys (Rattanarithikul et al., 1994).

Data Analysis

All variables were tested for normality using the Kromogorov-Smirnov test. The equality of variances was evaluated using Levene's test. Descriptive statistics of the data were analysed. Independent sample-t tests were used to test the differences in numbers of water containers, container types, numbers of *Aedes* larvae between buddhist and muslim communities. Correlation was used to find some association between water pH and water temperature and the number of *Aedes* larvae.

Results

Water temperature and pH

Water temperature in containers at Plailaem Buddhist community was higher than at Hua Thanon Muslim community (Table 1) but water pH did not differ between these two communities.

Numbers of Mosquito larvae

There were only *Ae. aegypti* and *Ae. albopictus* larvae found at Plailaem Buddhist community but *Ae. aegypti*, *Ae. albopictus*, *Culex* and *Anopheles* larvae were found at Hua Thanon Muslim community (Table 2). The number of *Ae. aegypti* and *Ae. albopictus* larvae were significantly higher at Plailaem Buddhist than at Hua Thanon Muslim community (Table 2).

Containers types

Containers types and numbers differed significantly among the sites. Muslim community had the highest number of containers, those were mostly bucket. On the other hand, Buddhist community had the lowest number of containers (Table 1).

Total mosquito larvae, container types in buddhist and muslim communities: The number of *Aedes aegypti*, *Aedes albopictus*, *Culex* spp and *Anopheles* spp larvae was higher at muslim community than at buddhist community. The number of *Aedes aegypti*, *Aedes albopictus*, *Culex* spp and *Anopheles* spp larvae differed among container type (Table 3).

Breeding sites mosquito larvae using Drone imagery and GLOBE Observer: Habitat Mapping App in buddhist and muslim communities: Containers number observed from drone image had the lowest number containers from GLOBE Observer App (Table 4).

Discussion

Amoung difference sites at Plaileam buddhist community and Hua Thanon muslim community. Chumsri et al. (2018) found that container types and their numbers were difference among subdistricts in Nakhon Si Thammarat province. Furthermore, we observed that mosquito larvae numbers increased with increasing of container numbers in all sub-districts. To our knowledge, no study has shown the direct relationship between container numbers and mosquito larvae numbers. Snow & Medlock (2006) suggested that increasing numbers of water butts (containers used to collect rainwater) might increase the numbers of mosquitoes that breed in them. The results of our study show that number of containers also has an effect on the number of mosquito larvae, along with container types and seasons.

We also observed that *Ae. aegypti* preferred to breed both in outdoor water containers, but *Ae. albopictus* preferred to breed mostly in outdoor containers. Previous studies found similar results, Chareonviriyaphap et al. (2003) and Wongkoon et al. (2007) found *Ae. aegypti* larvae both in indoor and outdoor containers but *Ae. albopictus* larvae mostly in outdoor containers. However, our results showed higher numbers of *Ae. aegypti* and *Ae. albopictus* larvae in mangrove forest area than the previous study (Wongkoon et al., 2007). The possible reason could be because we collected our samples in Thasala district but Wongkoon et al., (2007) collected their sample from Pakpanang and Huasai districts. *Ae. aegypti* larvae mostly prefer to breed in drums, jars, concrete tanks and discarded objects (Phong and Nam, 1999), *Ae. albopictus* prefer to breed outside in open spaces with shaded vegetation (Wongkoon et al., 2007; Saleeza et al., 2011). This study use drone images to observe breeding sites mosquito larvae and use Globe observer. Drone images can be used to detect water containers comparing with ground trothing, through ground trothing best to observe container number than drone image.

In this study *Culex* spp. and *Anopheles* spp. were found only in outdoor containers. Previous studies also observed that, *Culex* spp. larvae were mostly found in outside containers (Preechaporn et al., 2007) such as in plant plates, used pots, plastic cement mixer tubes, and used bowls (Chumsri et al., 2015), those were situated outside of the households.

Through this study, we have been informed that which containers are used as breeding sites for *Aedes* spp. *Ae. aegypti*, *Ae. albopictus*, *Culex* spp. and *Anopheles* spp. the most important mosquito vectors of dengue fever viruses (Knudsen, 1995; Mousson et al., 2005). If we can suggest to the fishery households to destroy those *Aedes* spp. holding containers, may be it is possible to control dengue fever, as destruction of breeding habitats is an important strategy to reduce the *Aedes* mosquito population; as well to reduce the larval development and adult mosquito population growth (Li et al., 2014).

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Table 1 (Mean ± SE) of parameter, mosquito larvae and storage containers at Plailaem buddhist community and Hua Thanon muslim community; '**' indicates P < 0.001 and '*' P < 0.05.

Parameters	Plailaem Buddhist Community	Hua Thanon Muslim community	t-test
1.Water temperature (°c)	31.51 ± 1.47	29.75 ± 1.13	t_{155} = 8.443**
2. pH	7.56 ± 0.89	7.43 ± 0.89	t_{155} = 0.908
3. *Aedes aegypti* larvae	0.04 ± 0.19	0.95 ± 2.60	t_{155} = -3.067**
4. *Aedes albopictus* larvae	0.17 ± 0.83	1.16 ± 3.94	t_{155} = -2.166*
5. *Culex* spp. larvae	0.00 ± 0.00	0.11 ± 0.53	t_{155} = -1.871
6. *Anopheles* spp. larvae	0.00 ± 0.00	0.01 ± 0.11	t_{155} = -0.981
7. containers with lid/ without lid	7:70	7:73	
8. Indoor/ Outdoor container	5:72	3:77	
9. Natural/Manmade containers	11:66	2:78	
10. Earthern jar: cement tank : plastic container: metal container: pond	16:12:35:3:11	12:5:60:1:2	

Table 2 Total mosquito larvae with storage containers at Plailaem buddhist community and Hua Thanon muslim community

Water storage	*Aedes aegypti*		*Aedes albopictus*		*Culex* spp.		*Anopheles* spp.	
	Buddhist community	Muslim community	Buddhist community	Muslim community	Buddhist community	Muslim community	Buddhist community	Muslim community
1. Earthern jar	1 (11)	17 (9)	1 (11)	6 (9)	0 (11)	1 (9)	0 (11)	0 (9)
2. Bucket	1 (31)	39 (58)	9 (31)	53 (58)	0 (31)	3 (58)	0 (58)	0 (58)
3. Pan	0 (2)	0 (0)	0 (2)	0 (0)	0 (2)	0 (0)	0 (2)	0 (0)
4. Pond	0 (11)	0 (2)	2 (11)	0 (2)	0 (11)	0 (2)	0 (11)	0 (2)
5. Drainage	0 (2)	18 (2)	0 (2)	34 (2)	0 (2)	5 (2)	0 (2)	1 (2)
6. Fish tank	0 (11)	0 (3)	0 (11)	0 (3)	0 (11)	0 (3)	0 (11)	0 (3)
7. Animal pan	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
8. Plant pot	1 (2)	1 (2)	1 (2)	0 (2)	0 (2)	0 (2)	0 (2)	0 (2)
9. Plant saucer	1 (1)	1 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)

Table 3 Pearson Correlation. Mosquito larvae; water temperature and pH at Plailaem buddhist community and Hua Thanon muslim community; '**' indicates P < 0.001 and '*' P < 0.05.

Mosquito genus/species	Water temperature (°c)	Water pH
Aedes aegypti	r_{157} = -0.205**	r_{157} = 0.023
Aedes albopictus	r_{157} = -0.177*	r_{157} = 0.019
Culex spp.	r_{157} = -0.181*	r_{157} = 0.028
Anopheles spp.	r_{157} = -0.118	r_{157} = 0.019

Tabel 4 Breeding sites mosquito larvae using Drone imagery and GLOBE Observer: Habitat Mapping App at Plailaem buddhist community and Hua Thanon muslim community.

Community	Drone imagery	Habitat Mapping App
Plailaem Buddhist community	22	77
Hua Thanon muslim community	37	80

References

Achee NL, Grieco JP, Masuoka P, Andre RG, Roberts DR, Thomas J, et al. 2006. Use of remote sensing and geographic information systems to predict locations of *Anopheles darlingi*-positive breeding sites within the Sibun River in Belize, Central America. J Med Entomol. 43(2):382–92.

Belkin, J. N. 1968. Mosquito studies (Diptera: Culicidae) VII, the Culicidae of New Zealand. Contributions of the AEI. 3, 1-182.

Chumsri, A., F. W. Tina, M. Jaroensutasinee, K. Jaroensutasinee, and Y. Sririsathikul. 2015. *Aedes, Culex* and *Mansonia* spp. Mosquito Larval Prevalences in Nakhon Si Thammarat, Thailand. The 41st Congress on Science and Technology of Thailand, Nakhonratchasima, Thailand. 6th-8th November 2015, pp. 447-455.

Chumsri, A., Tina, F. W., Jaroensutasinee, M. and Jaroensutasinee, K. (2018). Seasons and socio-cultural practices affecting *Aedes* mosquito larvae in southern Thailand. *Tropical Biomedicine* 35(1): 1-15 (2018).

Dale, P. E., and C. D. Morris. 1996. *Culex annulirostris* breeding sites in urban areas: using remote sensing and digital image analysis to develop a rapid predictor of potential breeding areas. J. Am. Mosq. Control Assoc. 12: 316-320.

de Castro MC, Monte-Mor RL, Sawyer DO, Singer BH. 2006. Malaria risk on the Amazon frontier. Proc Natl Acad Sci U S A. 103(7):2452–7. Epub 2006/02/08. https://doi.org/10.1073/pnas.0510576103

Fornace KM, Drakeley CJ, William T, Espino F, Cox J. Mapping infectious disease landscapes: unmanned aerial vehicles and epidemiology. Trends Parasitol. 2014; 30(11):514-519.

Graham, D. H. 1939a. Mosquitoes of the Auckland district. Trans. Proc. NZ. Inst. 60, 205-244.

Graham, D. H. 1939b. Mosquito life in the Auckland district. Report of the Auckland mosquito research committee on an investigation. Tran. Proc. Royal Soc. NZ. 69, 210-44.

Hardy A, Makame M, Cross D, Majambere S, Msellem M. Using low-cost drones to map malaria vector habitats. Parasit Vectors. 2017; 10(1): 29.

Laird, M. 1990. New Zealand's north mosquito survey. J. Am. Mosq. Contr. Assoc.; 6, 287-99.

Laird, M. 1995. Background and finding of the 1993-94 New Zealand mosquito survey. NZ Entomologist. 18, 77-90.

Lester, J. P. and Pike, A. J. 2003. Container surface area and water depth influence the population dynamics of the mosquito *Culex pervigilans* (Diptera: Culicidae) and its associated predators in New Zealand. J. Vector Ecol. 28, 267-74.

Linthicum, K. J., C. L. Bailey, F. G. Davies, and C. J. Tucker. 1987. Detection of Rift Valley fever viral activity in Kenya by satellite remote sensing imagery. Science (Wash., DC) 235: 1656-1659.

Masuoka, P. M., D. M. Claborn, R. G. Andre, J. Nigro, S. W. Gordon, T. A. Klein, and H. Kim. 2003. Use of IKONOS and Landsat for malaria control in the Republic of Korea. Remote Sensing Environ. 88: 187-194.

Pope, K. O., E. J. Sheffner, K. J. Linthicum, C. L. Bailey, T. M. Logan, E. S. Kasischke, K. Birney, A. R. Njogu, and C. R. Roberts. 1992. Identification of central Kenyan Rift Valley Fever virus vector habitats with Landsat TM and evaluation of their flooding status with airborne imaging radar. Remote Sensing Environ. 40: 185-196.

Preechaporn, W. Jaroensutasinee, M. and Jaroensutasinee, K. 2006. The larval ecology of *Aedes aegypti* and *Ae. albopictus* in three topographical areas of Southern Thailand. Dengue Bull. 30, 204-213.

Preechaporn, W., M. Jaroensutasinee and K. Jaroensutasinee. 2006. The Larval Ecology of *Aedes aegypti* and *Aedes albopictus* in Three Topographical Areas of Southern Thailand. *Dengue Bull.*, **30**, 204-213.

Thomson, M. C., S. J. Connor, P.J.M. Milligan, and S. P. Flasse. 1996. The ecology of malaria - as seen from Earth-observation satellites. Ann. Trop. Med. Parasitol. 90: 243-264.

Vittor AY, Pan W, Gilman RH, Tielsch J, Glass G, Shields T, et al. 2009. Linking deforestation to malaria in the Amazon: characterization of the breeding habitat of the principal malaria vector, *Anopheles darlingi*. Am J Trop Med Hyg. 81(1):5–12. Epub 2009/06/27.

WHO. 2017. What is dengue and how is it treated? (2017). Retrieved August 02, 2017 from http://www.who.int/features/qa/54/en/

Wongkoon, S., Jaroensutasinee, M. and Jaroensutasinee, K. 2005. Larval infestation of *Aedes aegypti* and *Ae. albopictus* in Nakhon Si Thammarat, Thailand. Dengue Bull. 29, 169-75.

Wood, B. L., L. R. Beck, R. K. Washino, K. Hibbard, and J. S. Salute. 1992. Estimating high mosquito-producing rice fields using spectral and spatial data. Int. J. Remote Sensing 13: 2813-2826.