ORIGINAL ARTICLE

Effectiveness of ultraviolet (UV) insect light traps for mosquitoes control in coastal areas of Samut Songkhram province, Thailand

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Abstract This study aimed to investigate the effectiveness of ultraviolet (UV) insect light traps for mosquito control and to study the relationship between this effect and weather factors in coastal areas of Samut Songkhram province, Thailand. The study sites were divided into two areas, approximately 2and 4 km from the sea. The trap was placed less than one meter away from the house, where it could reach electrical plugs. The effectiveness of UV light trap was tested from September to October 2017between 6: 00p.m. and 6: 00a.m., for a total of 30days. A total of 2,605 adult mosquitoes within four species belonging to two genera were collected, including *Anopheles epiroticus* Linton & Harbach, *Culex quinquefasciatus* Say, *Cx. sitiens* Wiedmann and *Cx. gelidus* Theobald. The effectiveness of UV insect light traps in area 2 km from the sea trapped 45.96 ± 42.13 mosquitoes per night and area 4 km from the sea trapped 40.83 ± 33.61 mosquitoes per night. While, effectiveness comparison of the UV insect light traps 2 and 4 km from the sea of were shown to be statistically significantly different ($p < 0.05$). These results of this study are useful for planning and application of UV light traps to control mosquito populations in coastal areas of Samut Songkhram province, Thailand and other coastal areas.

Keywords: coastal areas, effectiveness, mosquito nocturnal, ultraviolet light traps,

Introduction

Mosquitoes are insects causing major vector-borne diseases in humans worldwide (Benelli et al 2016) including malaria, dengue fever, West Nile virus, chikungunya, yellow fever, filariasis, Japanese encephalitis (JE) and Zika virus (World Health Organization 2016; Chaiphongpachara 2017). According to the World Health Organization (2016) patients with vector-borne diseases make up 17% of all infectious disease patients worldwide (over a billion people in greater than 100 countries) and one million people die each year. These data have shown that insect-borne diseases continue to be a major international problem, particularly mosquito-borne infectious diseases (Norris and Coats 2017). Currently, there are more than 3,500 species of mosquitoes distributed all over the world (Norris and Coats 2017). More than half of mosquito-borne diseases are caused by mosquitoes active at night (Chaiphongpachara et al 2018). Each species of mosquito has a different disease carrier capacity (Diniz et al 2017).

In Thailand, there are 436 species of mosquitoes classified in 23 genera (Rattanarithikul et al 2005). There are three genera of nocturnal mosquitoes that carry important vector-borne diseases in Thailand, including *Anopheles* spp. as malaria vectors, *Culex* spp. as Japanese encephalitis and filariasis vectors and *Mansonia* spp. as filariasis vectors (Baxter et al 2017). A case report on nocturnal mosquitoes from the Bureau of Vector Borne Disease, Thailand in 2017 showed 5,273 malaria cases, 14 Japanese encephalitis cases and four filariasis cases which shows that these diseases are still a problem for Thailand.

Samut Songkhram is one of the central provinces in Thailand with abundant natural resources located on the Gulf of Thailand. This province is in a coastal area, which is different from other environments, including the species diversity of mosquito vectors (Chaiphongpachara and Sumruayphol 2017; Chaiphongpachara et al 2017; Chaiphongpachara et al 2018). Vector-borne diseases in this province are mostly nocturnal, mosquito-borne diseases, including malaria (Bureau of Vector Borne Disease, Thailand 2017). In addition, the JE virus has been reported in *Cx. quinquefasciatus* within the Samut Songkhram province (Nitatpattana et al 2005). There is little research on the control of mosquitoes in coastal areas of Thailand, which may be a major obstacle to controlling mosquito-borne disease. Thus, specific mosquito control methods should be employed to suit coastal areas.

Mosquito traps are a popular tool for vector control and are highly effective in reducing the number of nocturnal mosquitoes (Chaiphongpachara et al 2017; Chaiphongpachara et al 2018; Poulin et al 2017). An ultraviolet (UV) insect light trap is one type of mosquito trap that is quite effective in attracting mosquitoes and other insects (Sliney et al 2016).

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The advantages of this trap are its compact size, it is easy to use, easy to purchase, inexpensive and uses electricity from within a home, so that it can trap mosquitoes or other insects throughout the night. The principle of a UV insect light trap is the response of night-flying insects to UV light, which is highly effective in controlling insect vectors, including sand flies (Fernández et al 2015) and mosquitoes (Lee et al 2009). However, the effectiveness of the UV light trap depends on the climate (White et al 2016). Weather conditions affect almost every organism in the environment, including mosquitoes, which can adapt during unfavorable weather conditions, by reducing activities such as aviation (Ramasamy and Surendran 2012).

A study was conducted to investigate the effectiveness of UV or black light traps and to study the relationship between a black light trap's ability to trap mosquitoes and the climate factors in the coastal areas of Samut Songkhram province. The results of this research will be important in controlling mosquito vectors in coastal areas to reduce cases of mosquito-borne diseases.

Materials and Methods

Study areas

A field experiment was conducted in the coastal area of Samut Songkhram province, Thailand. The study sites were divided into two areas, approximately 2 and 4 km from the sea. The coastal area 2 km from the sea (13° 25' 11.7" N and 100° 02' 21.0" E) was characterized by low population density, with mangrove trees, saline water sources and salt ponds scattered throughout. The coastal area 4 km from the sea (13° 24' 33.6" N and 100° 00' 53.0" E) was characterized with high population density, semi-urban settlements, with both saline water sources and waste water sources (Figure 1).

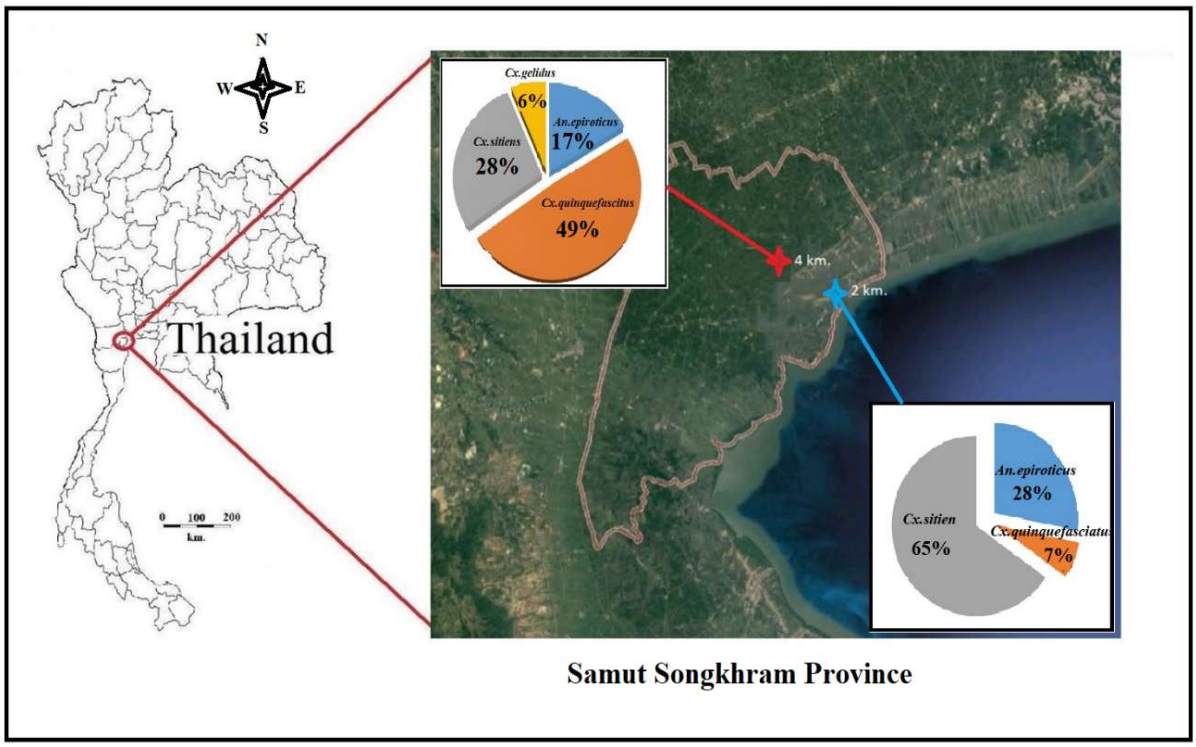

Figure 1 Study areas and species of mosquito caught in both areas.

Effectiveness of UV light trap on mosquito vectors in coastal areas and the relationship to weather factors

The UV insect light traps (IS-003, P.M.C industrial company, Thailand) used caught mosquitoes in both areas, using one trap per area. The trap was placed less than one meter away from the house, where it could reach electrical plugs. The effectiveness of UV light trap was tested from September to October 2017 between 6: 00p.m. and 6: 00a.m., for a total of 30 days and no mosquito trapping occurred on rainy days. Every mornings, the trapped mosquitos and other insects were collected from the traps. Details of the samples were recorded and sent to the laboratory at the College of Allied Health Sciences, Suan Sunandha Rajabhat University, Samut Songkhram Provincial Education Center. The nocturnal mosquito species were then identified under a Nikon AZ 100 M stereo-microscope (Nikon Corp., Tokyo, Japan) using the Illustrated Keys to the Mosquitoes of Thailand (Rattanarithikul 2016).

To study the relationship between the number of mosquito and weather factors, weather information of Samut Songkhram province was received from the Samut Songkhram Provincial Meteorological Department. The data included rainfall, temperature, wind speed and relative

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humidity. The data were analyzed for relationships between the number of mosquitoes and the weather using statistical tests.

Data analysis

The mean and standard deviation (SD) of mosquitoes caught using UV insect light traps in both areas (2 and 4 km from the sea) were compared using the t-test. The data were analyzed for relationships between numbers of mosquito and weather factors in each areas using Pearson's correlation. The level of statistical significance was determined at $P = 0.05$.

Results

Effectiveness of UV light traps on mosquito vectors in coastal areas

In this study, 2,605 adult mosquitoes within four species belonging to two genera (Table 1) were collected, including *Anopheles epiroticus* Linton & Harbach, *Culex quinquefasciatus* Say, *Cx. sitiens* Wiedmann and *Cx. gelidus* Theobald (Figure 2). The area 2 km from the sea trapped 45.96 ± 42.13 mosquitoes per night, of which the largest number were *Cx. sitiens* with 30 ± 20.23 mosquitoes and the lowest were *Cx. quinquefasciatus* with 3.03 ± 3.01 mosquitoes. While the area 4 km from the sea trapped 40.83 ± 33.61 mosquitoes per night, of which the largest number were *Cx. quinquefasciatus* with 20±13.08 mosquitoes and the lowest were *Cx. gelidus* with 2.63 ± 3.53 mosquitoes (Table1).

The effectiveness comparison of the UV insect light traps 2 and 4 km from the sea of were shown to be statistically significantly different ($p < 0.05$); see Table1. In addition, the UV insect light trap also captured other insects; at 2 km from the sea it caught 5,519 adult insects and at 4 km from the sea it caught 4,746 adult insects.

The relationship between number of mosquitoes in each area and weather factor

The analysis of the relationship between the numbers of mosquito vectors caught in the area 2 km from the sea was not statistically significant, though 4 km from the sea it was significantly correlated with temperature (Table 2).

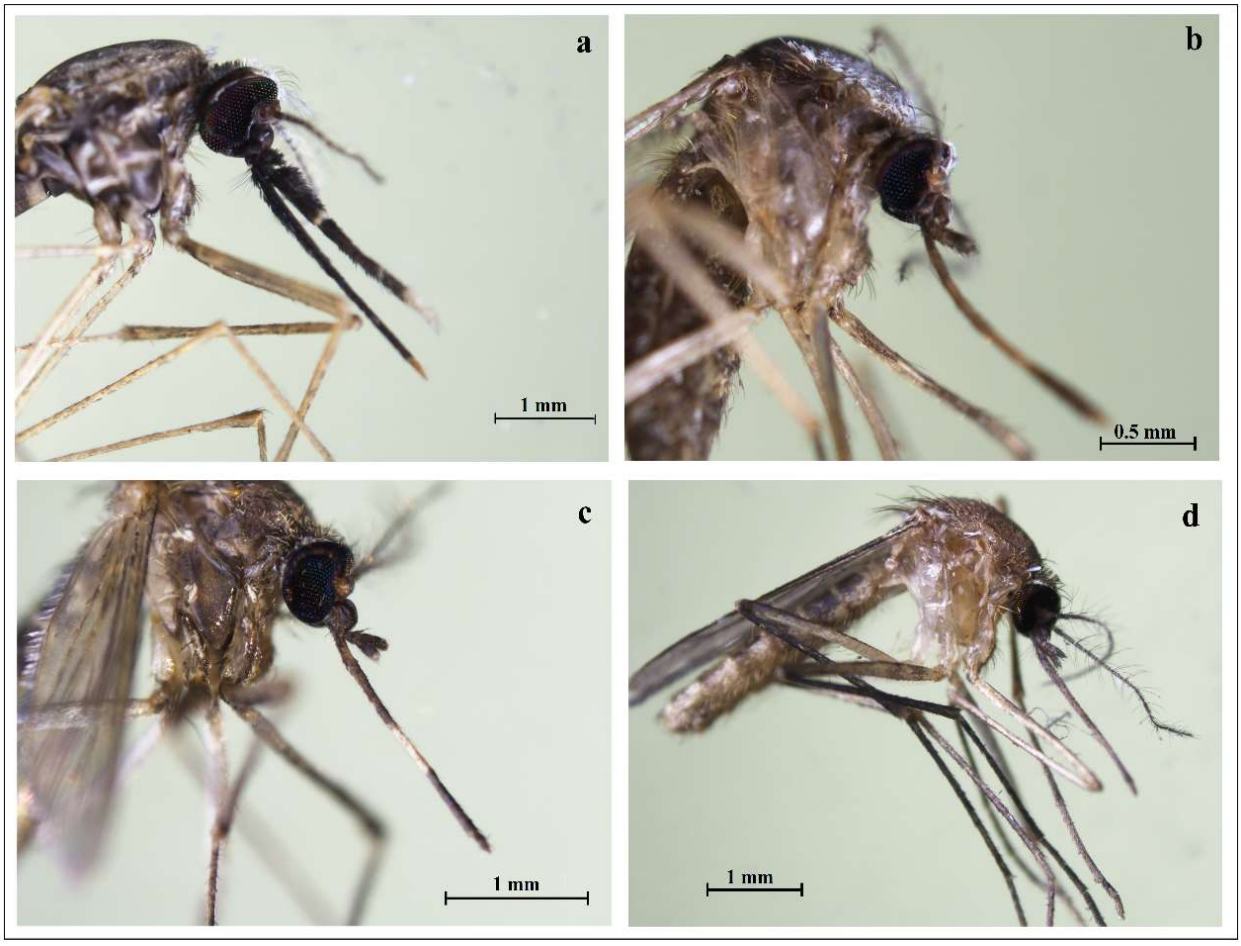

Figure 2 Lateral views of mosquitoes caught by UV insect light trap in this study.

(a = *An. epiroticus,* b = *Cx. gelidus*, c = *Cx. sitiens* and d = *Cx. quinquefasciatus*).

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Table 1 Effectiveness of UV insect light traps in coastal area of Samut Songkhram province.

Areas	Species of mosquito	n	Mean± SD (Mosquitoes/Night)
2 km from the sea	*An. epiroticus*	388	12.93 ± 18.89
	Cx. quinquefasciatus	91	3.03 ± 3.01
	Cx. sitiens	900	30 ± 20.23
	Total	1,379	45.96 ± 42.13[a]
4 km from the sea	*An. epiroticus*	202	6.7 ± 5.69
	Cx. quinquefasciatus	*600*	20 ± 13.08
	Cx. sitiens	345	11.5 ± 11.31
	Cx. gelidus	79	2.63 ± 3.53
	Total	1,226	40.83 ± 33.61[b]

*Comparison of the effectiveness of the UV insect light trap (2vs. 4km from the sea): different letters indicate that the difference was statistically significant at $p < 0.05$.

Table 2 Relationships between numbers of mosquito and weather factors.

Areas		Rain	Temperature	Wind speed	Relative humidity
2 km from the sea	r	.078	.141	.0.29	-.190
	p	.682	.485	.877	.316
4 km from the sea	r	.139	-.449*	-.173	.250
	p	.464	.013	.360	.183

*Correlation is significant at the 0.05 level (2-tailed).

Discussion

This study found that UV insect light traps can control mosquito vectors in areas both 2 and 4 km from the sea. A total of 2,605 mosquito vectors from four species in two genera were caught, including *An. epiroticus,* which is a secondary malaria vector in Thailand (Sumruayphol et al 2010) *Cx. sitiens* , which is Japanese encephalitis and filariasis vector (Rattanarithikul et al 2005), *Cx. quinquefasciatus,* which is a Japanese encephalitis (Nitatpattana et al 2005) and filariasis vector (Sabatinelli et al 1994) and *Cx. gelidus*, which is a Japanese encephalitis vector (Ramesh et al 2015). These results were consistent with the research of Chaiphongpachara and Sumruayphol (2017) which reported the presence of these four species of mosquito in coastal areas of Samut Songkhram province, Thailand. The effectiveness of this mosquito trap in the area 2 km from the sea was 45.96 ± 42.13 mosquitoes per night, which consisted of three species of mosquito: *An. epiroticus*, *Cx. sitiens* and *Cx. quinquefasciatus*. The effectiveness of the trap in the area 2 km from the sea was 40.83 ± 33.61 mosquitoes per night, which consists of four species of mosquitoes: *An. epiroticus*, *Cx. sitiens*, *Cx. quinquefasciatus* and *Cx. gelidus*. These results reveal the ability of UV light traps to capture nocturnal mosquitoes in a coastal area. Previous research has reported the ability of this trap having high potential for trapping mosquitoes in the Republic of Korea (Kim et al 2017; Lee et al 2009). However, the ability of a UV light trap to collect vectors depends on the species and the density of the mosquito population in each area. The results of the investigation into its effectiveness in Samut Songkhram province were consistent with the research of Chaiphongpachara and Sumruayphol (2017) which found that the UV light trap in an area 2and 4km from the sea can collect the most *Cx. sitiens* and *Cx. quinquefasciatus*, respectively.

In addition, the UV insect light trap can also catch other insects quite well (Li et al 2015). In this study, UV light collected more than 4,500 other insects in both coastal areas (2 km caught 5,519 other insects and 4 km caught 4,746 other insect) . This indicates that the UV light trap is not specific to only mosquito vector control. This is consistent with the research of Nielsen et al (2013) which studied UV light traps to monitor the abundance, spread and behavior of *Halyomorpha halys*.

The UV insect light trap in the area 2 km from the sea trapped mosquitoes more effectively than 4 km from the sea at statistical significance ($p < 0.05$). This was due to the different environments in both areas. In the area 2 km away from the sea, there were saline and brackish water sources, which are suitable habitats for coastal mosquitoes, including *An. epiroticus* and *Cx. sitiens* (Chaiphongpachara and Sumruayphol 2017; Prummongkol et al 2012). The number of mosquito caught were correlated with temperature. Normally, the blood feeding of female mosquitoes is associated with weather (Chuang et al 2011). Previous studies have reported that temperature and relative humidity affect the flight behavior of female mosquitoes (Rowley and Graham 1968). The results of this study are useful for planning and

application of UV insect light traps to control mosquito populations in coastal areas of Samut Songkhram province, Thailand and other coastal areas. Finally, the goal of this research is to reduce the number of patients with mosquito-borne diseases and contribute to eliminating these diseases altogether.

Conclusions

The results of this study shows that UV insect light traps can be used to control mosquito vectors with high efficiency for *Culex* spp., but especially for *Cx.sitiens* in the areas 2 km from the sea and *Cx. quinquefasciatus* in the areas 4 km from the sea. The disadvantage of UV light trap is that it is not specific to any one insect. This traps is an alternative trap that can be used to effectively control mosquitoes in coastal areas of Samut Songkhram, Thailand.

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References

Bureau of Vector Borne Disease, Thailand (2017) Annual report. http://thaivbd.org/n/home. Accessed on: Dec,15 2017.

Baxter RHG, Contet A, Krueger K (2017) Arthropod innate immune systems and vector-borne diseases. Biochemistry 56:907–918.

Benelli G, Jeffries CL, Walker T (2016) Biological control of mosquito vectors: past, present, and future. Insects. doi:10.3390/insects7040052.

Chaiphongpachara T, Bunyuen P, Chansukh KK (2018). Development of a more effective mosquito trapping box for vector control. The Scientific World Journal. doi.org/10.1155/2018/6241703

Chaiphongpachara T, Padidpoo O, Chansukh KK, Sumruayphol S (2018) Efficacies of five edible mushroom extracts as odor baits for resting boxes to attract mosquito vectors: A field study in Samut Songkhram Province, Thailand. Tropical Biomedicine 35:653–663.

Chaiphongpachara T, Pimsuka S, Saisanan Na Ayudhaya W, Wassanasompon W (2017) The application of geographic information system in dengue haemorrhagic fever risk assessment in Samut Songkhram province, Thailand. International Journal of GEOMATE 12:53–60.

Chaiphongpachara T, Laojun S, Kunphichayadecha C (2018) Effect of the CDC light trap on control of nocturnal mosquitoes in coastal Samut Songkhram Province, Thailand. Biodiversitas 19:1750–1754.

Chaiphongpachara T, Sumruayphol S (2017) Species diversity and distribution of mosquito vectors in coastal habitats of Samut Songkhram province, Thailand. Tropical Biomedicine 34:524–532.

Chuang TW, Hildreth MB, Vanroekel DL, Wimberly MC (2011) Weather and land cover influences on mosquito populations in Sioux Falls, South Dakota. Journal of Medical Entomology. 48:669–679.

Diniz DFA, De Albuquerque CMR, Oliva LO, De Melo-Santos MAV, Ayres CFJ (2017) Diapause and quiescence: Dormancy mechanisms that contribute to the geographical expansion of mosquitoes and their evolutionary success. Parasites and Vectors. doi:10.1186/s13071-017-2235-0.

Fernández MS, Martínez MF, Pérez AA, Santini MS, Gould IT, Salomón OD (2015) Performance of light-emitting diode traps for collecting sand flies in entomological surveys in Argentina. Journal of Vector Ecology 40:373–378.

Kim HC, Kim MS, Choi KS, Hwang DU, Johnson JL, Klein TA (2017) Comparison of adult mosquito black-light and light-emitting diode traps at three cowsheds located in malaria-endemic areas of the Republic of Korea. Journal of Medical Entomology 54:221–228.

Lee HIl, Seo BY, Shin EH, Burkett DA, Lee JK, Shin YH (2009). Efficiency evaluation of Nozawa-style black light trap for control of anopheline mosquitoes. Korean Journal of Parasitology 47:159–165

Li CX, Smith ML, Fulcher A, Kaufman PE, Zhao TY, Xue RD (2015) Field evaluation of three new mosquito light traps against two standard light traps to collect mosquitoes (Diptera: Culicidae) and non-target insects in Northeast Florida. Florida Entomologist 98:114–117.

Nielsen AL, Holmstrom K, Hamilton GC, Cambridge J, Ingerson-Mahar J (2013) Use of black light traps to monitor the abundance, spread, and flight behavior of *Halyomorpha halys* (Hemiptera: Pentatomidae). Journal of Economic Entomology 106:1495–1502.

Nitatpattana N, Apiwathnasorn C, Barbazan P, Leemingsawat S, Yoksan S, Gonzalez J P (2005) First isolation of Japanese encephalitis from *Culex quinquefasciatus* in Thailand. Southeast Asian Journal of Tropical Medicine and Public Health 36:875–878.

Norris EJ, Coats JR (2017) Current and future repellent technologies: The potential of spatial repellents and their place in mosquito-borne disease control. International Journal of Environmental Research and Public Health. doi:10.3390/ijerph14020124.

Poulin B, Lefebvre G, Muranyi-Kovacs C, Hilaire S. (2017) Mosquito traps: an innovative, environmentally friendly technique to control mosquitoes. International Journal of Environmental Research and Public Health. doi:10.3390/ijerph14030313.

Prummongkol S, Panasoponkul C, Apiwathnasorn C, Lek-Uthai U. (2012) Biology of *Culex sitiens*, a predominant mosquito in Phang Nga, Thailand after a tsunami. Journal of Insect Science (Online) 12:1–8.

Ramasamy R, Surendran SN (2012) Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones. Frontiers in Physiology. doi:10.3389/fphys.2012.00198.

Ramesh D, Muniaraj M, Philip Samuel P, Thenmozhi V, Venkatesh A, Nagaraj J, Tyagi BK (2015) Seasonal abundance & role of predominant japanese encephalitis vectors *Culex tritaeniorhynchus & Cx. gelidus* Theobald in Cuddalore district, Tamil Nadu. Indian Journal of Medical Research 142:23–29.

Rattanarithikul R, Harrison BA, Panthusiri P, Coleman RE (2016) Illustrated keys to the mosquitoes of Thailand. The Southeast Asian Journal of Tropical Medicine and Public Health 41 Suppl 1:1–225.

Rattanarithikul R, Harrison BA, Panthusiri P, Coleman RE (2005) Illustrated keys to the mosquitoes of Thailand. I. Background; geographic distribution; lists of genera, subgenera, and species; and a key to the genera. Southeast Asian Journal of Tropical Medicine and Public Health 36:1–80.

Rowley WA, Graham CL (1968) The effect of temperature and relative humidity on the flight performance of female *Aedes aegypti*. Journal of Insect Physiology 14:1251–1257.

Sabatinelli G, Ranieri E, Gianzi FP, Papakay M, Cancrini G (1994) Role of *Culex quinquefasciatus* in the transmission of bancroftian filariasis in the Federal Islamic Republic of Comoros (Indian Ocean). Parasite 1:71–76.

Sliney DH, Gilbert DW, Lyon T (2016). Ultraviolet safety assessments of insect light traps. Journal of Occupational and Environmental Hygiene 13:413–424.

Sumruayphol S, Apiwathnasorn C, Komalamisra N, Ruangsittichai J, Samung Y, Chavalitshewinkoon-Petmitr P (2010). Bionomic status of *Anopheles epiroticus* Linton & Harbach, a coastal malaria vector, in Rayong province, Thailand. Southeast Asian Journal of Tropical Medicine and Public Health, 41:541–547.

Chaiphongpachara T, Moolrat L (2017) Insecticide resistance of temephos on *Aedes aegypti* as dengue vector in Samut Songkhram, Thailand. Annals of Tropical Medicine and Public Health, 10:1439–1442.

White PJT, Glover K, Stewart J, Rice A (2016). The technical and performance characteristics of a low-cost, simply constructed, black light moth trap. Journal of Insect Science. doi:10.1093/jisesa/iew011.

World Health Organization (2016) Mosquito born diseases. Retrieved from http://www.who.int/neglected_diseases/vector_ ecology/mosquito-borne diseases /en/ Accessed on: Dec,15 2017.