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Effect of the CDC light trap on control of nocturnal mosquitoes in coastal Samut Songkhram Province, Thailand

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Abstract. *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.* This study aimed to investigate the effect of CDC light trap on mosquito control and to study the relationship between this effect and weather factors in coastal areas (2 and 4 km from the sea) of Samut Songkhram Province, Thailand. We conducted a field test by trapping for 30 consecutive days from September to October 2017. The trap was hung at a height of 1.5 m and was 50 m away from a house. A total of 2963 adult female mosquitoes of 4 species belonging to 2 genera were trapped, including *Anopheles epiroticus* Linton & Harbach, *Culex quinquefasciatus* Say, *Cx. sitiens* Wiedmann and *Cx. gelidus* Theobald. The trapping rate of the CDC light trap set up 2 km from the sea was 85.70±73.81 adult mosquitoes per night. Meanwhile, at the location 4 km from the sea, the trap collected 13.07±11.40 adult mosquitoes per night. Comparing the numbers of mosquitoes captured by the CDC light trap between these two sites, there was a significant difference at $p < 0.05$. This study shows that the CDC light trap can be used for effective control of mosquitoes in coastal areas of Samut Songkhram Province, Thailand, especially *Cx. sitiens*, a filariasis vector.

Keywords: CDC light trap, coastal area, effect, nocturnal mosquitoes

INTRODUCTION

Mosquitoes are small insects with infectious effects on public health (Mint Mohamed Lemine et al. 2017; Chaiphongpachara et al. 2017). Currently, there are approximately 3500 species of mosquito around the world; each species of mosquito can carry different diseases (Diniz et al. 2017). According to a report from the World Health Organization (WHO), patients with mosquito-borne diseases make up 17% of all infectious disease patients worldwide (World Health Organization 2014). Therefore, the WHO has focused on the control of communicable diseases caused by mosquitoes, especially in tropical and subtropical countries (Mint Mohamed Lemine et al. 2017). Most mosquito-borne human diseases, such as malaria, Japanese encephalitis, and filariasis, are caused by nocturnal mosquitoes (Li et al. 2016).

At least 412 species of mosquitoes are found in Thailand (Pengsakul et al. 2017), including 3 genera that are medically important nocturnal vectors: *Anopheles*, a malaria vector; *Culex,* a Japanese encephalitis, and filariasis vector; and *Mansonia,* a filariasis vector (Baxter et al. 2017). In 2017, the Bureau of Epidemiology, Thailand reported 5273 malaria cases, 14 Japanese encephalitis cases and 4 filariasis cases (Ministry of Public Health 2017). Each species of mosquito has different behavior and breeding sites (Irish 2014). Different methods for the control of mosquito vectors are suitable for different areas depending on the mosquito species (Benelli et al. 2016).

Samut Songkhram is a province with abundant natural resources located on the Gulf of Thailand in central Thailand. In this province, there are coastal areas that differ from other provinces, with distinct plants and animals including species of mosquito. Coastal areas in Thailand are often inhabited by *Anopheles epiroticus* Linton & Harbach and *Culex sitiens* Weidemann because of their tolerance of saline areas (Chaiphongpachara and Sumruayphol 2017). There has been little research on control of mosquitoes in coastal areas of Thailand, which may be a major obstacle in controlling mosquito-borne disease in Samut Songkhram province.

The mosquito trap is a popular tool for vector control and is highly effective in reducing the number of nocturnal mosquitoes (Poulin et al. 2017). Currently, there are many traps available for use in catching mosquitoes, which can be used to break the mosquito life cycle by focusing on the adult mosquitoes (Beck-Johnson et al. 2017). The Centers for Disease Control and Prevention light trap, or CDC light trap, is one popular model of mosquito trap (Li et al. 2016). The operation of the CDC light trap is based on dry ice, which evaporates into carbon dioxide, an attractant for female mosquitoes and a fan sucks the attracted mosquitoes into a mesh bag (Aak et al. 2017). The advantages of the CDC light trap include its small size, portability, ease of use, and previous findings that it is highly effective at attracting mosquitos (Li et al. 2016). However, the effectiveness of the CDC light trap depends on the climate in the area. Weather conditions affect almost every organism in the environment. Mosquitoes can adapt their behavior during unfavorable weather conditions by

reducing activities such as aviation (Ramasamy and Surendran 2012).

Thus, this study aims to investigate the effect of the CDC light trap and the relationship between this effect and weather factors in coastal areas)2 and 4 km from the sea(of Samut Songkhram Province, Thailand. The result of this research provides important guidance for the control and surveillance of mosquito vectors in coastal areas in Thailand.

MATERIALS AND METHODS

Study area

This research consisted of a field experiment to study the effect of the CDC light trap on nocturnal mosquito vectors in coastal areas of Samut Songkhram Province, Thailand. The coastal areas of this study consisted of 2 locations with different environments according to the distance from the sea, being 2 and 4 km. The coastal area 2 km from the sea (13° 25' 11.7" N, 100° 02' 21.0" E) is characterized by low population density. The surrounding area is a mangrove area, and there are saline water sources and salt ponds scattered in the area. Therefore, mosquitoes in this area are species with habitat in coastal areas. In contrast, the coastal area 4 km from the sea (13° 24' 33.6" N, 100° 00' 53.0" E) is characterized by high population density, semi-urban, with both saline water sources and wastewater sources (Figure. 1). Average weather conditions (climate) in our study area including coastal areas of Samut Songkhram province during September to October 2017 were 0.94 mm ± 2.05 of rainfall, 27.50°C ± 0.93 of temperature, 3.79 km/hr ± 1.62 of wind speed and 84.72% ± 5.81 of relative humidity.

Study on effect of CDC light trap on mosquito vectors in coastal areas

In this study, we used the Centers for Disease Control, and Prevention miniature light traps (CDC-LT) baited with CO_2)John W. Hock Co., Gainesville, Florida) with 1 trap per location to test the effect of the trap on reducing the number of mosquito vectors in the coastal areas. We conducted a field test by trapping from 6: 00 p.m. to 6: 00 a.m. for 30 consecutive days from September to October 2017. The trap was hung at a height of 1.5 m and 50 m away from the nearest houses. Every morning, we collected the trapped samples, recorded details and sent the samples to the laboratory at the College of Allied Health Sciences, Suan Sunandha Rajabhat University, Samut Songkhram Education Center. After that, the nocturnal mosquito samples were identified under a Nikon AZ 100 M stereo-microscope (Nikon Corp., Tokyo, Japan) with the aid of the Illustrated Keys to the Mosquitoes of Thailand (Rattanarithikul et al. 2010).

Study of the relationships among the effect of the CDC light trap, mosquito species and weather factors.

To study the relationship between the effect of the CDC light trap and weather factors, we received the weather information for Samut Songkhram province from September to October 2017 from the Samut Songkhram Provincial Meteorological Department, including rainfall data, temperature, wind speed and relative humidity. After receiving the data, we statistically analyzed the relationships between the total number of mosquitoes trapped and weather factors in both locations comprising of 2 km and 4 km.

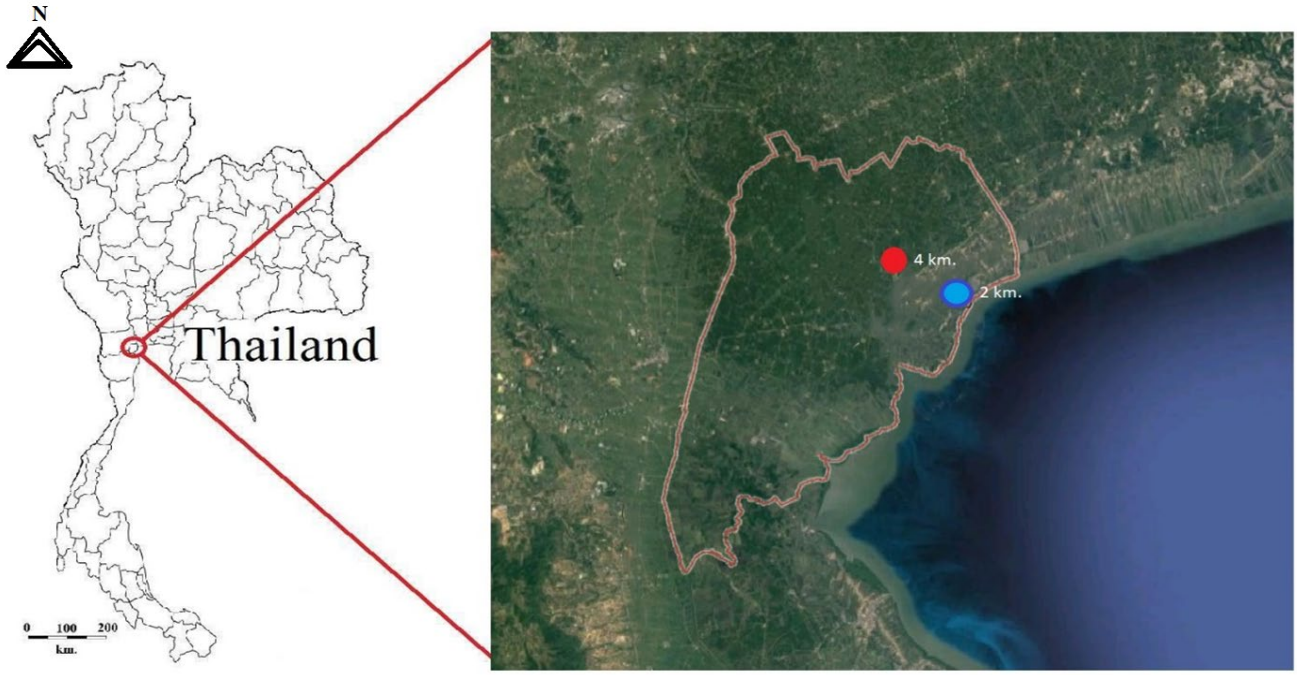

Figure 1. Study areas in coastal areas of Samut Songkhram Province, Thailand. Blue color = area 2 km from the sea, and red color = area 4 km from the sea.

Data analysis

The results of the field testing of the CDC light trap in both coastal locations (2 and 4 km from the sea) are presented as mean values with standard deviations. A t-test was used to compare the effects of the CDC light trap between the two locations. Meanwhile, the relationships between the number of collected mosquitoes, species of vectors in each area and weather factors were analyzed by Pearson correlation.

RESULTS AND DISCUSSION

Effect of CDC light trap on mosquito vectors in coastal areas

Mosquito trapping for 30 consecutive days resulted in a total 2963 trapped adult female mosquitoes within 4 species belonging to 2 genera, including *Anopheles epiroticus* Linton & Harbach, *Culex quinquefasciatus* Say, *Cx. sitiens* Wiedmann and *Cx. gelidus* Theobald (Table 1). The CDC light trap in the location 2 km from the sea captured 2571 adult mosquitoes (85.70 ± 73.81 per night), of which the largest proportion was *Cx. sitiens* with 2499 mosquitoes (83.3 ± 73.96 per night) and the lowest was *Cx. quinquefasciatus* with 6 mosquitoes (0.2 ± 0.41 per night). At the location 4 km from the sea, 392 adult mosquitoes were collected (13.07 ± 11.40 per night). *Cx. sitien*s again represented the highest proportion, with 259 mosquitoes (8.63 ± 10.08 mosquitoes per night), and the lowest was *Cx. gelidus* with 22 mosquitoes (0.73 ± 3.37 mosquitoes per night). Comparing the number of mosquitoes captured by the CDC light trap between the two locations, there was a significant difference at $p < 0.05$ (Table 1).

Relationship between effect of CDC light trap, mosquito species and weather factors

The analysis of the relationship between the total number of mosquitoes trapped and weather factors in the location 2 km from the sea was significantly correlated with temperature (negative correlation) ($p < 0.05$). In contrast, for the site 4 km from the sea, the effect of the CDC light trap was significantly correlated with rain and relative humidity (positive correlation) ($p < 0.05$) (Table 2).

At the species level, nine significant relationships between the number of individuals captured and weather conditions were identified. At the location 2 km from the sea, capture of *An. epiroticus* was related to individuals captured with rain (negative correlation), wind speed (positive correlation) and relative humidity (negative correlation). *Cx. sitiens* were also positively related to individuals captured with temperature. While at the other location 4 km from the sea, we found that capture rates for *An. epiroticus* and *Cx. sitiens* were also related to weather factors, with *An. epiroticus* capture was associated with rain (negative correlation), wind speed (positive correlation) and relative humidity (negative correlation) and *Cx. sitiens* capture was associated with humidity (positive correlation) and rain (positive correlation) ($p < 0.05$) (Table 3).

Table 1. Effect of CDC light trap in coastal areas

Location	Species of mosquito	n	Mean ± S.D.) mosquitoes/night (
2 km from the sea	*An. epiroticus*	66	2.20 ± 2.44
	Cx. quinquefasciatus	6	0.20 ± 0.41
	Cx. sitiens	2499	83.30 ± 73.96
	Total	2571	85.70 ± 73.81[a]
4 km from the sea	*An. epiroticus*	30	1.00 ± 2.35
	Cx. quinquefasciatus	81	2.70 ± 1.90
	Cx. sitiens	259	8.63 ± 10.08
	Cx. gelidus	22	0.73 ± 3.37
	Total	392	13.07 ± 11.40[b]

Note: * Comparison of the effects of CDC light trap (2 vs. 4 km from the sea(: Different letters indicate significantly different at $p < 0.05$ by t-test.

Table 2. Relationship between effect of CDC light traps and weather factors

Locations		Rain	Temperature	Wind speed	Relative humidity
2 km from the sea	r	.306	-4.20*	-213	.306
	p	.100	.021	.257	.100
4 km from the sea.	r	.385*	-.256	-.200	.385*
	p	.036	.172	.290	.036

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

Table 3. Relationship between mosquito species and weather factors

Locations	Species of mosquito		Rain	Temp.	Wind speed	Relative humidity
2 km from the sea	*An. epiroticus*	r	-.421*	.308	.362*	-.421*
		p	.0.20	.079	.049	.020
	Cx.quinquefasciatus	r	.273	-.216	-.324	.273
		p	.144	.164	.081	.144
	Cx. sitiens	r	.280	.357*	-.213	-.280
		p	135	.041	.285	.135
4 km from the sea	*An. epiroticus*	r	-.372*	.256	.635**	-.372*
		p	.043	.172	.000	.043
	Cx.quinquefasciatus	r	.188	-.349	-.239	.188
		p	.319	.059	.203	.319
	Cx. sitiens	r	.473**	-.311	-.342	.473**
		p	.008	.095	.064	.008
	Cx. gelidus	r	.133	-.323	-.159	.133
		p	.482	.082	.403	.482

Note: **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Discussion

Effect of CDC light trap on mosquito vectors

The mosquito species included in Table 3 are all disease vectors: *An. epiroticus* is a secondary malaria vector, *Cx. sitiens* is a filariasis vector, *Cx. quinquefasciatus* is a Japanese encephalitis and filariasis vector, and *Cx. gelidus* is a Japanese encephalitis vector. *An. epiroticus* and *Cx.*

sitiens is brackish mosquito. In Rayong province, Thailand, there have been some reports of malaria parasite infections detected in *An. epiroticus* (Sumruayphol et al. 2010). While, *Cx. gelidus* is found in flooding areas, fresh water, and fertile areas and the number of the mosquitoes was high during hot and wet, and hot and dry seasons (Ramesh et al. 2015).

In the area of 2 km from the sea, 3 species of mosquito were found: *An. epiroticus*, *Cx. sitiens* and *Cx. quinquefasciatus*. At the location 4 km from the sea, we found another species called *Cx. gelidus.* We did not see this species of mosquito in the area of 2 km from the sea because the water is mostly brackish and sea water throughout the area. The area is different from the area 4 km from the sea which is mostly fresh water. For *Cx. quinquefasciatus*, we found the lowest number of this *Culex* species in 2 km from the sea and the low number in 4 km from the sea because the species were found in households and their breeding habitat is wastewater from households. In addition, these species were rare in our study area (Pennington, Prager, Walton, & Trumble, 2016). These results indicate that the different environments between the two locations affect the species diversity and density of mosquitoes in each area. This is consistent with the research of Chaiphongpachara and Sumruayphol (2017), which was conducted in the coastal areas of Samut Songkram province and found 3 species of mosquito vector in the area of 2 km from the sea and 4 species in the area of 4 km from the sea. However, it is possible that the CDC light trap is specific to *Cx. sitiens* mosquito because previous research used black light traps in this area and showed that the number of *Cx. quinquefasciatus* was higher than that of *Cx. sitiens* (Chaiphongpachara and Sumruayphol 2017).

In this study, we found that the CDC light trap is effective at trapping *Culex* spp, especially *Cx. sitiens,* at both coastal locations, with 83.3 ± 73.96 mosquitoes trapped per night at the site 2 km from the sea and 8.63 ± 10.08 at the site 4 km from the sea. This is consistent with the study of Sriwichai et al. (2015) on the effectiveness of the CDC light trap at the Thai-Burmese border and found that this trap can catch most *Culex* mosquitoes, representing 46.39 percent of the total number of mosquitoes trapped. The effect of the CDC light trap varied between the 2 studied areas of Samut Songkhram province; the trap at the site 2 km from the sea captured significantly more mosquitoes than the trap 4 km from the sea)$p < 0.05$(. The CDC light trap is highly effective in the area of 2 km from the sea, because this area is filled with saline water sources and salt ponds scattered throughout, which results in a high density of *Cx. sitiens* populations (Chaiphongpachara and Sumruayphol 2017). This is consistent with previous studies that CO_2, the attractant used in the CDC light trap, can effectively attract the species. CO_2 comes from exhalation of human and animals and can attract targets of female mosquitoes to take blood of the targets. Currently, there are many traps that CO_2 is used as bait which an excellent and environmentally friendly odor for controlling mosquito vectors and other insects (McMeniman et al. 2014).

Relationship between CDC light trap and weather factors.

In this analysis, we found a significant positive correlation between total number of mosquitoes trapped and relative humidity and rain in the area of 4 km from the sea ($p < 0.05$). High humidity, especially rain, could increase the mosquito survival (Chuang et al. 2011). The relationship may come from oviposition behavior of female mosquitoes. In fact, previous research has reported the positive relationship between *Cx. nigripalpus* and high relative humidity in Indian River County, Florida (Day et al. 1990).

After analyzing the relationship at the species level, we found that both areas including 2 and 4 km from the sea were very similar. *An. epiroticus* captures were associated with rain (negative correlation(, wind speed (positive correlation(and relative humidity (negative correlation(. Rain is a major factor in the flight of mosquitoes, so the negative relationship that was found is not surprising. Previous research has reported that the slow flight-speed of mosquitoes is associated with rain (Dickerson et al. 2012). However, it is surprising that wind speed is positively correlated with the number of *An. epiroticus* because wind speed affects host-seeking activities and flight direction of mosquito (Chuang et al. 2011). The reason for this positive correlation may be associated with trap placement. In this study, to avoid damaging the trap, we installed traps under a house's roof. Meanwhile, the result of negative correlation of relative humidity was consistent with Bashar and Tuno)2014) which showed strong negative correlation between relative humidity and abundance of *An. karwari*, *An. minimus* s.l., *An. annularis*, and *An. jeyporiensis* in Bangladesh.

Cx. sitiens captures in 2 km from the sea were associated with temperature (positive correlation(and in the captures, in the area, 4 km from the sea were associated with rain (positive correlation(and relative humidity (positive correlation(. Previous studies have reported that rain, wind speed and relative humidity affect the flight behavior of female mosquitoes (Rowley and Graham 1968; Tran et al. 2013). Normally, blood feeding of female mosquitoes is associated with weather (Chuang et al. 2011). However, these results have revealed a positive correlation with the rain effect including rainfall, temperature and relative humidity on *Cx. sitiens*, which may be the specific stimulus on this species of mosquito. Another possible reason is the oviposition behavior of female mosquito, which such a relationship has been reported.

In conclusion, this study showed that the CDC light trap can be an effective tool to control mosquitoes, especially *Cx. sitiens* as a filariasis vector, in coastal areas of Samut Songkhram Province, Thailand. The mosquito is predominant species in coastal areas. Therefore, the use of this trap to control the vectors, especially near the sea which is *Cx. sitiens* habitat, is appropriate.

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