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The Effect of the Blue and Black Light Trap on the Diversity of the Trichoptera (Caddisfly Adult) and Other Insects in Lotic and Lentic Area of Mae Tam Reservoir, Thailand

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Abstract

This study was conducted using two types of light traps to collect the insects at Mae Tam Reservoir from January to April 2018. The sampling area was divided into 4 points. Two points were located at the reservoir's bank, and the others were located at the reservoir's outlet. The study aimed to compare the efficiency of the fluorescent tube's blue and purple light, which had a different wavelength on insect's attraction. To compare the diversity of Trichoptera in the different stream habitats, Sørensen similarity index, Shannon-Wiener index, and Evenness index were used. The result showed that purple light could attract insects better than blue light. Hymenoptera was attracted by purple light. Coleoptera and Hemiptera were attracted by blue light. The study on the diversity of Trichoptera showed that there were 2,534 individuals of 9 families 48 species were collected. *Ecnomus puro* was the most abundant species (1,120 individuals). The highest Shannon-Wiener diversity index was sampling points 4 (2.10). The highest Evenness index was sampling points 4 (0.62). Sørensen similarity index showed that sampling points 3 and 4 had the highest value (67.92 %) because they were adapted from a natural creek to concrete where boulder, gravel, cobble, sand, and woody material were deposited at the stream bottom. These provided various microhabitats for insect larva to live and develop. The riparian had affected the distribution and colonization of mature insects.

Keywords: Trichoptera, Fluorescent tube, Light trap, Lentic ecosystem, Reservoir

Introduction

Light is an ecological factor that affected the biological process of insects. Flying and migration behavior depend on illuminance, photoperiod, wavelength, direction, and degree of polarization. Many insects fly to the light at night due to their inherited behavior which benefits movement, foraging, and mating. The light trap was invented for any purpose, such as investigating agricultural insects, trapping eatable insects, and some nocturnal insects [1]. The light trap was used widely in Thailand. Most of the insect responds to the wavelength between 253 - 700 nm. A different wavelength can attract more than 1,000 species of nocturnal insects. Moths and some insects were attracted by a short wavelength (> 400 nm.) that nearly with the ultraviolet wavelength (300 - 380 nm.) [2]. Then, blue fluorescent light and purple fluorescent light are widely sold and used for trapping insects but the study on their specification is not quite clear.

Taxonomy and diversity of Trichoptera in Thailand were studied for many decades, especially in Northern Thailand [3-28]. Most of the research on Trichopteran was conducted in the lotic ecosystem where it has more species than a lentic ecosystem [29]. Microhabitat (especially a variation on stream bottom) has affected the habit of caddisfly larvae. Early instars of caddisflies live in water; adults are found on the bank of a stream or river where larva live [30].

Materials and methods

Sampling location and sampling point selection

Mae Tam reservoir is located at Phayao province in the north of Thailand (**Figure 1**). This reservoir receives water from the Mae Tum watershed used for agriculture. The ridge length of the reservoir is approximately 1.8 km. Water storage is 37,000,000 m^3. The outlet transfers water to an irrigation channel in which the channel bottom was modified to a concrete bed. The spillway drains the excess water into the irrigation channel during the wet season. Some materials such as a boulder, cobble, gravel, sand and woody material that flow via water current, were stored in a channel. This condition is similar to lotic stream during the wet season and lentic stream in the dry season (Ecotone ecosystem). Four sampling points in the Mae Tum reservoir were chosen to place a light trap overnight. These sampling points include lentic and lotic habitat. Sampling points 1, 2 were located at the reservoir bank (represent as lentic habitat) and sampling points 3, 4 were located at the channel (represent as lotic habitat) (**Figure 2**). Each sampling point must not be disturbed by the other light sources. The coordinates and elevation of each sampling point are shown in **Table 1**.

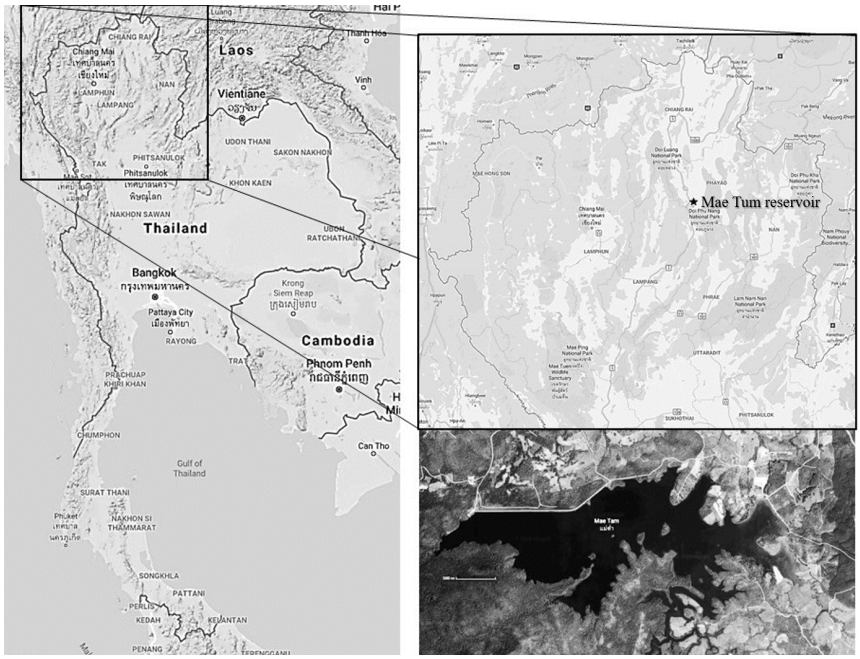

Figure 1 Mae Tum Reservoir, Phayao Province, Northern of Thailand.

Figure 2 Four sampling points at Mae Tum reservoir.

Table 1 Coordination and elevation of each sampling points.

Sampling point	Location / habitat	Coordinate	Elevation (m.asl.)
1	Reservoir bank / lentic	19°0′28′′ N, 99°57′27′′ E	470
2	Reservoir bank / lentic	19°0′22′′ N, 99°57′18′′ E	450
3	Channel / lotic	19°0′18′′ N, 99°56′33′′ E	440
4	Channel / lotic	19°0′24′′ N, 99°56′33′′ E	440

Light trap setting and insect collecting

The light trap set consists of 1) 18W blue and black light fluorescent tubes 2) battery DC 12V 11Ah 3) plastic tray with mixture of water and detergent. The blue and black light fluorescent tubes were measured as a wavelength using a direct spectroscope (**Figure 3**). Light traps were left overnight (from dusk until dawn) to collect the insects at each sampling point (**Figure 4**). Light traps were placed away from electric light. Each light trap had a distance of more than 200 meters to avoid light disturbance on insect attraction. On the morning of the next day, the material for insects was transferred into 80 % ethyl alcohol and transported to the laboratory. The sampling was conducted twice a week from January to April 2018.

Figure 3 Direct spectroscope.

Sorting and identification

Trichoptera were separated from another insect sample. Trichoptera (male) were sorted and examined under a dissecting stereomicroscope. The last 2 abdominal segments of adult male genitalia were separated and cleared by heating in 10 % NaOH at 70 °C for 30 - 45 min (depend on sample size). Species-level identification was done by using the atlas of southeast Asian Trichoptera [31] and Trichoptera world checklist [32]. Other insect groups were identified to order.

Figure 4 (a) - (b) Blue and black light traps at sampling point 1 and 2, (c) - (d) 3 and 4.

Data analysis and statistical analysis

Trichoptera species and other insect orders were count and summarized. Sørensen similarity index [33] was used to compare a Trichoptera species in each sampling point.

$$C_s = [2j/(a+b)]\times 100 \quad (1)$$

where C_s = Percentage of Sørensen index (Sørensen's similarity coefficient)
j = Number of species found in both sites
a = Number of species in site A
b = Number of species in site B

Shannon – Wiener diversity index and Species evenness [30] were chosen to describe species diversity in each sampling point.

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad (2)$$

where H' = Shannon – Wiener diversity index
s = Total of species
pi = Proportion of each species per total of species
i = species 1, 2, 3, …, N

$$J' = H'/\ln S \quad (3)$$

where J' = Species evenness index
H' = Shannon – Wiener diversity index
S = Total of species in each sampling point

Independent-Sample t-test was used to compare species number of caddisfly species and other insect orders.

Result and discussion

By using a spectroscope**,** it was found that the blue light fluorescence had a wavelength of 405, 438, 548, 580, 625 and 630 nm, respectively, while the black light fluorescence had a wavelength of 375 nm (**Table 2**). The blue light fluorescence tubes gave more spectrum than the black light fluorescence tubes. A differentiation of the light came from a chemical substance inside a fluorescence tube. The blue light fluorescence tube contained magnesium tungstate which gave a white-blue light.The blacklight fluorescence contained cadmium borate and calcium tungstate (pink and blue light) that gave a purple light [34,35].

Table 2 The wavelength and the spectrum of the blue light fluorescence tube and the purple light fluorescence tube.

Blue light fluorescence tube *(n = 5)*		**Black light fluorescence tube *(n = 5)***	
Wavelength (nm)	**Spectrum**	**Wavelength (nm)**	**Spectrum**
405	violet	375	Violet
438	purple	-	-
548	green	-	-
580	yellow	-	-
625	orange	-	-
630	red	-	-

Forty-seven species of Trichoptera were collected. There were 12 species were found in lentic habitat and 18 species were found in lotic habitat. The others were found in both habitats (**Table 3**). *Cheumatopsyche lucida* (Hydropsychidae) and *Ecnomus puro* (Ecnomidae) were dominant species in the Mae Tum reservoir as they were found both in lentic and lotic habitats. According to Prommi *et al.* [36], these two species were also found in the Mae Ku stream at Tak province. These larvae had a good adaptation to live in various streams bottom.*Cheumatopsyche copia*, *Potamyia alleni*, *Cheumatopsyche schwendingeri*, *Potamyia euadne*, *P. phaidra*, *Ecnomus alkaios*, *Oecetis bengalica*, *O. meghadouta*, *O. kodros*, *Setodes argentiguttatus*, *S. sarapis*, *Setodes tejasvin*, *S. okyrrhoe*, *Leptocerus posticus*, *Psychomyia kalais*, *P. lak*, *Abaria guatila*, *Hydroptila sabit*, *Oxyethira bogambara*, *Ugandatrichia honga*, *Marilia sumatrana*, *Chimarra toga*, *C. chiangmaiensis*, *C. terramater* and *C. monorum* were very rare in this area. Luadee and Prommi [37] found these species in Tapee river, Surathanee province, and Mae Ku stream, Tak province. It can be concluded that these species were widespread in Thailand. However, their status and their species were rare.

Table 3 Species of Trichoptera and individual number in Mae Tum reservoir during January to April 2018.

Family	**Species**	**Sampling point**			
		1	**2**	**3**	**4**
Hydropsychidae	*Cheumatopsyche lucida*	256	9	505	37
	Amphipsyche meridiana	32	-	-	1
	Cheumatopsyche dhanikari$^{(Lotic)}$	-	-	5	3
	Cheumatopsyche copia$^{(Lentic)}$	-	-	1	-
	Cheumatopsyche globosa	-	1	6	2
	Potamyia alleni$^{(Lentic)}$	1	-	-	-
	Cheumatopsyche schwendingeri$^{(Lentic)}$	1	-	-	-
	Potamyia euadne$^{(Lentic)}$	1	-	-	-
	Potamyia phaidra$^{(Lotic)}$	-	-	1	-
Ecnomidae	*Ecnomus puro*	366	462	207	85
	Ecnomus obtusus	4	38	2	1
	Ecnomus mammus	30	13	4	-
	Ecnomus atevalus$^{(Lentic)}$	4	-	-	-
	Ecnomus alkmene	12	3	5	8
	Ecnomus alkaios$^{(Lentic)}$	-	1	-	
	Ecnomus cincibilus	-	1	16	6
	Ecnomus jojachin$^{(Lotic)}$	-	-	1	11
	Ecnomus singkarakensis$^{(Lotic)}$	-	-	5	-
Leptoceridae	*Oecetis tripunctata*	1	1	8	1
	Oecetis scutulata	6	1	-	4

Family	Species	Sampling point			
		1	**2**	**3**	**4**
	Oecetis biramosa	35	38	5	1
	Oecetis empusa$^{(Lotic)}$	-	-	1	3
	Oecetis bengalica$^{(Lentic)}$	-	2	-	-
	Oecetis meghadouta$^{(Lentic)}$	1	-	-	-
	Oecetis kodros$^{(Lentic)}$	2	-	-	-
	Setodes argentiguttatus$^{(Lentic)}$	2	-	-	-
	Setodes sarapis$^{(Lotic)}$	-	-	1	-
	Setodes tejasvin$^{(Lotic)}$	-	-	1	-
	Setodes okyrrhoe$^{(Lentic)}$	1	-	-	-
	Leptocerus dirghachuka$^{(Lotic)}$	-	-	6	-
	Leptocerus posticus$^{(Lotic)}$	-	-	2	-
Psychomyiidae	*Psychomyia kalais*$^{(Lotic)}$	-	-	-	1
	Psychomyia lak$^{(Lotic)}$	-	-	-	1
	Paduniella sampati	13	25	24	21
Xiphocentronidae	*Abaria guatila*$^{(Lotic)}$	-	-	-	1
Hydroptilidae	*Hydroptila thuna*	2	-	14	2
	Hydroptila sabit$^{(Lentic)}$	1	-	-	-
	Hydroptila gaya$^{(Lotic)}$	-	-	7	3
	Orthotrichia indica	27	19	69	7
	Oxyethira bogambara$^{(Lotic)}$	-	-	-	1
	Ugandatrichia honga$^{(Lotic)}$	-	-	1	-
Odontoceridae	*Marilia sumatrana*$^{(Lentic)}$	-	2	1	-
Philopotamidae	*Chimarra toga*$^{(Lentic)}$	1	-	-	-
	Chimarra chiangmaiensis$^{(Lotic)}$	-	-	1	2
	Chimarra akkaorum$^{(Lotic)}$	-	-	7	5
	Chimarra terramater$^{(Lotic)}$	-	-	1	-
	Chimarra monorum$^{(Lentic)}$	1	-	-	-
	Individual Number	800	616	911	207

Sørensen similarity index

The sampling points 3 and 4 had the highest similarity of species (67.91 %), while the lowest similarity was sampling points 1 and 3 (41.51 %) (**Figure 4**). The homogeneity of sampling point affects species abundance. The channel units of sampling point 3 were similar to run (smooth fast water) which was good to transport fine particulate organic matter (FPOM) during the wet season and store benthic particulate organic matter (BPOM) during the dry season [38]. The channel bed of sampling 4 had boulders, rocks, cobbles, gravel, and depositional pool which provide various habitats and food resources for the larva stage [39,40].

■	Similarity > 70 %
●	Similarity = 70 - 50 %
	Similarity < 50 %

Sampling point	**1**	**2**	**3**	**4**
1		52.63	41.51	49.83
2	●		53.33	57.89
3		●		67.92
4		●	●	

Figure 4 Sørensen similarity index of Trichoptera species between 4 sampling points.

Shannon-wiener diversity index

The sampling point 4 had the highest value (2.10), while the sampling point 1, 3 and 2 were 1.57, 1.54 and 1.06, respectively. Although the sampling point 3 was lotic habitat as in sampling point 4, the channel bed was sand and concrete. Furthermore, sampling point 4 had mixed materials. Sampling points 1 and 3 had a similar value because they were "ecotone" where a lentic and lotic habitat closed together. Trichoptera adults can share a micro habitat for foraging, mating, and lay eggs between these 2 habitats. *Cheumatopsyche lucida*, *Ecnomus puro*, *Ecnomus obtusus*, *Ecnomus alkmene*, *Oecetis tripunctata*, *Oecetis biramosa*, *Paduniella sampati* and *Orthotrichia indica* were species in this study that reflected this evidence.

Species evenness

Sampling point 4 had the highest species evenness (0.67). Sampling point 2 had the lowest species evenness (0.39), while sampling points 1 and 3 were 0.50 and 0.45. A low value reflects that species in sampling tended to have more changes on species composition if their habitat was disturbed. *Cheumatopsyche copia, Potamyia phaidra, Ecnomus alkaios*, *Ecnomus singkarakensis, Oecetis bengalica*, *Oecetis bengalica, Leptocerus dirghachuka*, *Leptocerus posticus*, *Ugandatrichia honga, Marilia sumatrana,* and *Chimarra terramater*, these species were reservoir-habitat sensitive. The reason was that they were rarely found only at sampling points 2 and 3.

Ephemeroptera and Diptera had the highest individual number in sampling points 1 and 2 (lenthic habitat), while Diptera and Trichoptera had the highest individual number in sampling points 3 and 4 (lotic habitat). Odonata, Orthoptera, Hemiptera, Collembola, and Isoptera were very few in this reservoir. Coleoptera and Hemiptera were attracted by blue light trap better than the black light trap. Trichoptera, Ephemeroptera, Odonata, Orthoptera, Diptera, Lepidoptera, Hymenoptera, Homoptera, Isoptera, and Collembola were attracted by the black light trap better than the blue light trap (**Table 4**). By using independent-samples t-test, there is no significant difference between these light traps on the individual number of insects ($p < 0.05$).

Ephemeroptera, Orthoptera, Coleoptera, Hymenoptera, and Isoptera were collected in lentic habitat (sampling point 1, 2) more than in lotic habitat (sampling point 3, 4). Trichoptera, Diptera, Hemiptera, Lepidoptera, Homoptera, and Collembola were collected in lotic habitat more than in lotic habitat. By using independent-samples t-test, there is no significant difference between the lentic and lotic habitats on an individual number of insects that were caught ($p < 0.05$). Considering the total of individual insect number (44,175), sampling point 3 had the highest catch (15,886) which consisted of Diptera (543 individuals from the blue light and 5,576 individuals from the black light), Trichoptera (1,356 individuals from the blue light and 3,675 individuals from the black light) and Ephemeroptera (352 individuals from the blue light and 2,131 individuals from the black light). The lowest catch was found in sampling point 4 which consisted of Diptera (2,101 individuals from the blue light and 1,313 individuals from the black light), Trichoptera (1,207 individuals from the blue light and 430 individuals from the black light) and Coleoptera (440 individuals from the blue light and 415 individuals from the black light). By using statistical analysis (One-way ANOVA), only Trichoptera had a significant difference between the sampling points ($p < 0.05$)

Table 4 The insects were collected using the blue and black light traps in sampling points 1-4 from January. to April 2018.

Sampling point	Light trap	Individual number of insect order											
		Trichoptera	Ephemeroptera	Odonata	Orthoptera	Diptera	Coleoptera	Hemiptera	Lepidoptera	Hymenoptera	Homoptera	Collembola	Isoptera
1	Blue	1,145	1,982	-	21	2,223	664	7	154	4	20	4	-
	Black	1,703	1,592	-	10	1,280	372	8	58	10	58	-	1
2	Blue	828	2,453	1	6	1,813	610	4	109	5	76	7	-
	Black	551	1,830	2	51	1,629	1,025	8	154	6	38	15	-
3	Blue	1,356	352	1	2	549	759	10	129	4	127	-	-
	Black	3,675	2,131	1	7	5,576	597	6	163	13	422	-	6
4	Blue	1,207	360	-	8	2,101	440	16	108	-	231	-	3
	Black	430	115	1	4	1,313	415	5	183	4	66	-	-

Conclusions

The blue light fluorescence tube had a wavelength from 405 to 630 nm, giving many spectrums compared with the black light fluorescence tube with a wavelength of 630 nm, which gave only a purple light. The black light trap was able to trap insects more than the blue light trap. However, when compared to insect order, purple light is suited to collect Hymenoptera while blue light is suited for Coleoptera and Hemiptera, following Henda *et al*. 1999 [41]. Lepidoptera does not have a specific light due to its responses to wavelength 340 - 460 nm, a wavelength of blue and black light fluorescence tube [42].

Sampling point 3 had the highest species abundance and diversity of Trichoptera, especially on Hydropsychidae. Hydropsychid larva was a filter feeder. High turbulence flow and stable substrate suited them, while sampling point 2 had the lowest abundance and diversity. This sampling point was an open area that directly receives wind, which is not good for Trichoptera that cannot fly well. So, species abundance and diversity depend on their life cycle, habitat, and environment [43]. *Cheumatopsyche schwendingeri*, *Potamyia euadne*, *Ecnomus obtusus*, *Ecnomus mammus*, *Ecnomus singkarakensis*, *Ecnomus alkmene*, *Ecnomus alkaios*, *Oecetis kodros*, *Setodes tejasvin*, *Setodes okyrrhoe*, *Psychomyia kalais*, *Paduniella sampati*, *Hydroptila gaya*, *Chimarra terramater* were a dominant species in this reservoir while *Cheumatopsyche copia*, *Potamyia alleni*, *Cheumatopsyche schwendingeri*, *Potamyia euadne*, *Potamyia phaidra*, *Ecnomus alkaios*, *Oecetis bengalica*, *Oecetis meghadouta*, *Oecetis kodros*, *Setodes argentiguttatus*, *S. sarapis*, *S. tejasvin*, *S. okyrrhoe*, *Leptocerus posticus*, *Psychomyia kalais*, *P. lak*, *Abaria guatila*, *Hydroptila sabit*, *Oxyethira bogambara*, *Ugandatrichia honga*, *Marilia sumatrana*, *Chimarra toga*, *C. chiangmaiensis*, *C. terramater* and *C. monorum* were rare species.

An Individual number of insect's orders between lentic and lotic habitat did not significantly differ while it differed between the sampling point. In the lentic habitat, the reservoir bottom was fine sediment that suits a burrower insect. Sampling point 1 was near a forest, but sampling point 2 was an open area. It made sampling point 1 collected insect more than sampling point 2. In the lotic habitat, the channel bottom of sampling point 3 had various materials near the reservoir's spillway. It suits Trichoptera and Ephemeroptera, which their larva requires high dissolved oxygen. At the same time, Diptera was abundant in sampling point 2 because there is a high deposit of debris, providing a perfect micro habitat for dipterans larva [44,45].

Diversity indices showed that habitat type was more affected by insect abundance and diversity than light traps. Some insect orders such as Collembola and Isoptera and many species of Trichoptera were rather specific to microhabitat. Changing running water to standing water or standing water to running water may affect the existence of these insects. The seasonal study is necessary to answer which species

can be used to indicate an environmental change in this reservoir and to understand the role of these insects in the ecosystem [46].

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