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Biodiversity of Adult Trichoptera and Water Quality Variables in Streams, Northern Thailand

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Abstract

The diversity of adult Trichoptera was surveyed at Mae Tao and Mae Ku watersheds, northern Thailand during July 2011 to May 2012. The aim of the study was to determine the relationship between physicochemical parameters of water quality and adult Trichoptera for monitoring of water quality. A total of 9,475 adult Trichoptera representing 14 families and 126 species were collected. The correlation between the biodiversity of adult Trichoptera and water quality showed that the *Ecnomus jojachin*, *Cheumatopsyche carmentis, C. chryseis, C. lucida, C. chrysothemis, C. dhanikari, Potamyia dryope, Leptocerus dirghachuka, L. trophonios, L. ganymedes, Oecetis scutulata, O. armadillo, O. raghava, O. asmada, O. tripunctata, Setodes flivialis, S. neptunus, S. endymion, S. okypete, Chimarra chiangmaiensis, Paduniella semarangensis, Lepidostoma doligung, Polyplectropus ahas, Psychomyia lak, Marilia sumatrana, Hydroptila thuna* and *Orthrotrichia typhoeus* depended on some physicochemical factors including air temperature, pH, electrical conductivity, turbidity, sulfate, nitrate-nitrogen, orthophosphate, ammonia-nitrogen and alkalinity in water.

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Keywords: Biodiversity, Trichoptera, water quality variables

1. Introduction

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Trichoptera, or caddisflies, one of the largest groups of aquatic insects, are holometabolous insects with aquatic larvae and pupae and terrestrial adults [1]. Trichoptera are potentially useful indicators of river and stream health [2-4]. They are relatively easy to identify to species level in the adult stage and show a diverse range of ecological, behavioral and functional feeding modes as larvae. Furthermore, they are good indicators of environmental perturbation, and because they are distributed along the stream continuum, they constitute one of the most interesting groups for studying the ecology of organisms in running water [5]

Previous studies on the use of adult caddisflies as a bioindicator of water quality in Thailand have been reported by Chiabu [6], Laudee [7], Cheunbarn [8] and Prommi and Thamsenanupap [9]. Caddisflies were chosen for this study because they are usually more diverse than other aquatic insect orders [10]. Adults have been studied widely because they are easily collected by light traps and can be used as a useful tool for bioassessment [11]. Chantaramongkol [2] recommends light trapping for assessing water quality in large rivers. Knowledge of the taxonomy and ecology of the species has proven valuable in biomonitoring programs because of differences in susceptibilities of the various species to pollutants and other types of environmental disturbances. Genus or species level identifications of adult caddisflies are possible and clearly produce more accurate results than family level identification, thereby giving better ability to assess the change of water quality. The aim of this paper is to investigate the diversity and distribution of adult Trichoptera from Mae Tao and Mae Ku watersheds. Water quality and some physicochemical factors were also measured to determine their effects, if any, on the diversity and distribution of adult Trichoptera.

2. Materials and Methods

2.1. Study site

The study was conducted at Mae Tao and Mae Ku watersheds. Five study sites were located along the Mae Tao stream. The stream is characterized by water flow throughout the year. The upstream part is rather narrow but widens downstream. The water velocity upstream is slower than downstream, resulting in stream bed deposits of debris. The substrate consists mainly of bedrock, gravel, sand, small stones, and some large boulders. The upstream originates in a forested area, also some human activity at the study site, resulting in minor inputs of waste water run-off. Two study sites were located in the Mae Ku stream. The water is fast flowing in monsoons so that debris is scarce in the streambed. The surrounding forest is very open. The upstream part is somewhat polluted by garbage from a village. The stream bed consists of bedrock, gravel, sand, small stones, and some large boulders. At each site, the sample was collected bi-monthly of the year of 2011 and 2012 (July, September, November, January, March and May).

2.2. Adult Trichoptera collection

At each study site, adults were collected using portable black-light traps (10-W fluorescent tube, 12-Volt DC battery) suspended across a white pan containing a detergent solution. Light traps started at various times between an hour before sunset and 1.5 hours after sunset near the stream margin. On each sampling occasion, the light trap was deployed for 5 h. Sampling was done on a night with a very clear sky when was no full moon to avoid light pollution to the trap. Insects attracted to the black light were collected in the detergent solution and transferred into 80% ethyl alcohol the next morning and transported to the laboratory. Specimens were sorted and examined under a dissecting stereomicroscope. For most caddisfly species, adult males primarily were used for making species determinations. The last two abdominal segments of adult male genitalia were removed and cleared by heating in 10% NaOH at 70 °C for 30 minutes. Specimen identification was carried out on the species level using Malicky [12]. For each species, specimen counts from

collections at each sampling station were summed.

2.3. Physicochemical analysis

Physicochemical parameters of the water quality in the river were recorded directly at sampling site and included the pH, measured by a pH-meter, water temperature (WT) and air temperature (AT) were measured by a hand thermometer and dissolved oxygen (DO), which was measured by a HACH® Model sensION 6 DO meter, total dissolved solid (TDS) and electrical conductivity (EC) were measured by a EURECH CyberScan CON110 conductivity/TDS meter. Water samples from each collecting period were stored in polyethylene bottles (500 mL). The ammonia-nitrogen (NH_4-N), sulfate (SO_4^{2-}), nitrate-nitrogen (NO_3-N), orthophosphate (PO_4^{3-}) and turbidity (TUB) were determined in accordance with the standard method procedures [13]. Alkalinity (ALK) was measured by titration [13].

2.4. Data analysis

Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physicochemical parameters of the seven sampling sites. Correlations between all variables for water quality parameters and Trichoptera species were tested by Pearson product-moment correlation coefficient using SPSS v. 13.0 (http://www.spss.com/).

3. Results and Discussion

3.1. Physicochemical variables

The result of the physicochemical variables of Mae Tao and Mae Ku watersheds are presented in Table 1. The spatial trend in the pattern of each physicochemical characteristic was similar along the stream. The dissolved oxygen, turbidity, orthophosphate and ammonia-nitrogen were not significantly difference (P>0.05) during the period of study. The water and air temperatures, pH of water, electrical conductivity, total dissolved solids, sulfate, nitrate-nitrogen and alkalinity among the seven sampling sites varied significantly difference (P<0.05) (Table 1).

Table 1. Mean ± S.D. physicochemical water quality parameters in Mae Tao and Mae Ku watersheds during July 2011 to May 2012.

Parameter/sites	MT1	MT2	MT3	MT4	MT5	MK2	MK8
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
AT (ºC)	30.98±2.38^{c}	29.68±3.96^{bc}	31.01±2.69^{c}	26.23±2.67^{ab}	28.20±2.13^{abc}	25.49±3.27^{a}	31.28±2.83^{c}
WT (ºC)	26.46±2.46^{a}	25.41±1.84^{a}	25.48±2.16^{a}	24.96±2.53^{a}	25.65±2.47^{a}	24.31±1.91^{a}	27.25±2.68^{a}
DO (mg L^{-1})	4.13±0.90^{a}	5.03±0.95^{a}	5.09±0.71^{a}	4.83±0.96^{a}	3.93±1.63^{a}	5.02±0.85^{a}	4.84±0.73^{a}
pH	8.03±0.18^{a}	8.56±0.11b^{cd}	8.64±0.13^{cd}	8.58±0.17^{cd}	8.37±0.24^{b}	8.75±0.08^{d}	8.50±0.09^{bc}
EC (µS cm^{-1})	297.05±85.51^{a}	506.83±119.26^{b}	500.92±114.48^{b}	440.44±111.63^{ab}	513.52±132.41^{b}	550.86±127.39^{b}	587.71±207.77^{b}
TDS (mg L^{-1})	163.30±31.62^{a}	235.87±18.57^{b}	237.66±51.47^{b}	216.05±53.23^{ab}	251.66±50.61^{bc}	272.16±64.43^{bc}	315.10±101.03^{c}
TUB (mg L^{-1})	14.00±7.48^{a}	19.33±27.23^{a}	13.50±18.23^{a}	157.33±369.74^{a}	14.33±23.65^{a}	18.00±22.05^{a}	37.17±55.90^{a}
SO_4^{2-} (mg L^{-1})	15.33±2.07^{a}	24.67±6.89^{b}	34.33±5.16^{cd}	35.50±5.54^{cd}	38.17±6.67^{c}	23.00±5.90^{ab}	27.00±12.43^{bc}
NO_3-N (mg L^{-1})	1.80±0.61^{a}	1.87±0.46^{a}	2.00±0.49^{a}	2.57±1.31^{ab}	2.10±0.74^{ab}	2.98±0.35^{b}	2.98±0.68^{b}
PO_4^{3-} (mg L^{-1})	0.89±1.26^{a}	0.27±0.31^{a}	0.19±0.18^{a}	0.22±0.12^{a}	0.68±0.79^{a}	0.29±0.11^{a}	0.60±0.64^{a}
NH_4-N (mg L^{-1})	0.24±0.15^{a}	0.23±0.16^{a}	0.23±0.15^{a}	0.28±0.20^{a}	0.30±0.16^{a}	0.24±0.18^{a}	0.23±0.15^{a}
ALK (mg L^{-1})	51.17±11.57^{a}	70.83±13.42^{ab}	82.73±29.28^{ab}	68.10±11.63^{ab}	69.50±9.03^{ab}	71.50±22.57^{ab}	81.00±22.16^{b}

*: Indicates significant difference (P<0.05), ANOVA.

3.2. Adult caddisflies survey

A total of 9,475 adult Trichoptera representing 14 families and 126 species were collected (Fig. 1). Leptoceridae showed the greatest number of species (37 species) found, followed by Hydroptilidae (26 species), Hydropsychidae (21 species), Psychomyiidae (10 species), Ecnomidae (9 species), Philopotamidae (7 species), Polycentropodidae (7 species), Lepidostomatidae (2 species), Goeridae (2 species), and Dipseudopsidae, Odontoceridae, Calamoceratidae, Glossosomatidae and Xiphocentronidae (each family 1 species). From these results *Chimarra akkaorum, C. chiangmaiensis*, *Lype atnia, Cheumatopsyche dharikani, C. globosa, Potamyia flavata, Setodes scutulata* and *S. okypete* were most commonly and widely distributed in all sampling sites. Net spinning caddisflies, particularly hydropsychids, commonly occur in high densities at all sampling sites [14]. Their abundance has been associated with the presence of high food quality [14, 15], stable water flow and stable substrata common in these habitats [16]. As in this study, the numerous numbers of adult hydropsychids, *Cheumatopsyche lucida*, *C. globasa* and *Potamyia flavata*, are generally found in fast-flowing rivers on a stony substrate. Generally, substrate diversity indirectly affects the distribution of aquatic insects as it offers shelter for them to lay eggs continue reproduction [17].

3.3. The correlation between Trichoptera species and physicochemical variables

Pearson's correlation coefficient (r) relationship between Trichoptera species and physicochemical variables are shown in Table 2. *Ecnomus jojachin*, *Cheumatopsyche carmentis*, *Cheumatopsyche chrysies*, *Potamyia dryope*, *Leptocerus dirghachuka*, *Leptocerus trophonios*, *Oecetis scutulata*, and *Setodes fluvialis* were negatively correlated with air temperature ($P<0.01$, $P<0.05$), Higher air temperatures at these streams may also favor increased production of some species as found for several hydropsychids [18]. Also, Hirabayashi et al. [19] suggests that mean air temperature and summer floods impacted the seasonal abundance of adult Trichoptera at Shinano River. *Setodes endymion* and *Marilia sumatrana* were negatively correlated with sulfate ($P<0.05$). The pH, electrical conductivity, turbidity nitrate-nitrogen, orthophosphate, ammonia-nitrogen, and alkalinity were positively correlated with many Trichoptera species (Table 2). The present study shows that most of the caddisfly species that were found in this area are indicator species that are always present in the river and therefore have potential as water quality bioindicators for this river and its watershed [6, 8]. The results of this study will be valuable baseline information for monitoring environmental change in the area in the future and the study will be continued at a later date.

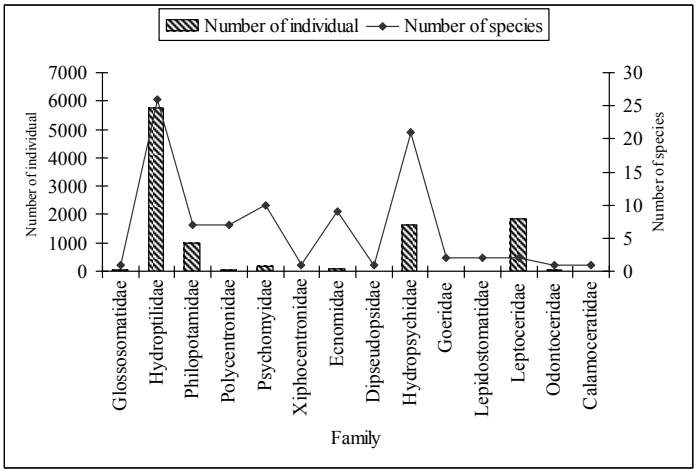

Fig. 1. Overall number of individual and caddisflies species collected in Mae Tao and Mae Ku watersheds during July 2011 to May 2012.

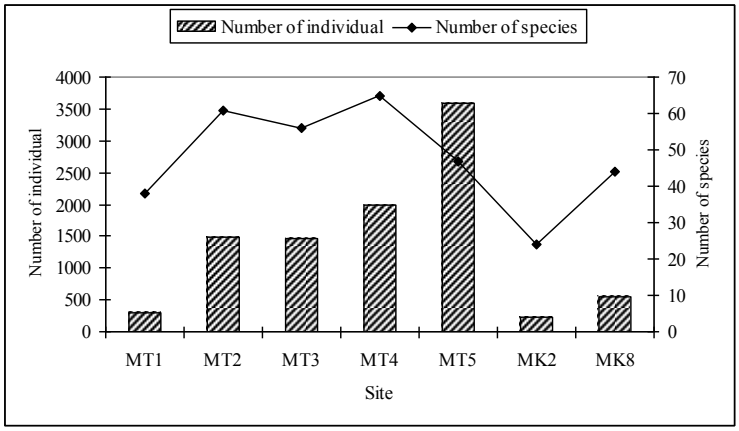

Fig. 2. The total number of species and individuals caught at the two sampling sites in Mae Tao and Mae Ku watersheds.

Table 2. Pearson's correlation between the physicochemical parameters of water quality and Trichoptera species encountered during the sampling period at Mae Tao and Mae Ku watersheds.

Taxa/parameters	AT	pH	EC	TUR	SO_4^{2-}	NO_3-N	PO_4^{3-}	NH_4-N	ALK
Ecnomus jojachin	-.884*					.901*		.999**	
Cheumatopsyche carmentis	-.964**			.908*		.968**			
Cheumatopsyche chryseis	-.934*								
Potamyia dryope	-.891*					.880*			
Leptocerus dirghachuka	-.972**			.889*		.984**		.929*	
Leptocerus trophonios	-.910*			.918*		.973**		.938*	
Oecetis scutulata	-.929*								
Setodes fluvialis	-.899*					.939*		.970**	
Chimarra chiangmaiensis		.880*							
Paduniella semarangensis			.906*						.948*
Cheumatopsyche lucida				.995**		.966**			
Leptocerus ganymedes				.936*		.891*			
Oecetis armadillo						.891*			
Oecetis raghava				.988**		.925*			
Oecetis asmada				.992*		.965**			
Setodes neptunus				.975**		.925*			
Lepidostoma doligung				.952*		.905*			
Polyplectropus ahas				.999**		.916*			
Psychomyia lak				.990**		.939*			
Setodes endymion					-.905*				
Marilia sumatrana					-.952*				
Oecetis tripunctata						.916*		.949*	
Cheumatopsyche dhanikari							.887*		
Hydroptila thuna							.880*		
Cheumatopsyche chrysothemis									.914*
Orthrotrichia typhoeus									.925*
Setodes okypete									.896*

*: Indicates significant difference (P<0.05), **: Indicates significant difference (P<0.01).

4. Conclusions

Baseline organism biodiversity research is necessary for an understanding of ecosystem, ecology and

organism conservation. The conservation aspect is becoming increasingly important due to a measured decline in worldwide organism biodiversity and a concern over the potential ecological implications of this decline. The aim of this paper is to investigate the diversity and distribution of adult Trichoptera from Mae Tao and Mae Ku watersheds. Water quality and some physicochemical factors were also measured to determine their effects, if any, on the diversity and distribution of adult Trichoptera. Although the primary value is to add to the knowledge of the Trichoptera fauna of northern Thailand itself, this research has further value of helping to fill gaps in our knowledge of Trichoptera distribution in Thailand.

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