Diversity of Trichoptera Fauna and its Correlation with Water Quality Parameters at Pasak Cholasit reservoir, Central Thailand

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Abstract

The objectives of this study were to study the diversity of the Trichoptera fauna and the physicochemical parameters of water quality, as well as the correlation between physicochemical parameters and biodiversity of Trichoptera fauna for monitoring of water quality. The specimens were sampled monthly using portable black light traps from January to December 2010 at the inflow and outflow of Pasak Cholasit reservoir. A total of 20,380 adult caddis flies representing 7 families and 27 species were collected from the sampling sites in the present study. The family Hydropsychidae contained the greatest number of species (29%, 8 species), followed by Leptoceridae (26%, 7 species), Ecnomidae (19%, 5 species), Psychomyiidae (11%, 3 species), Philopotamidae (7%, 2 species), and Dipseudopsidae and Xiphocentronidae (4%, 1 species). Results of CCA ordination showed that eleven selected physicochemical water quality parameters (i.e., air and water temperature, pH of water, dissolved oxygen, total dissolved solids, electrical conductivity, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, sulfate and turbidity of water) were the important physicochemical factors to affect distribution of Trichoptera assemblages. Results revealed that the order Trichoptera, identified to species can be potentially used to assess environmental water quality status in freshwater ecosystems.

Keywords: water quality/ inflow/ outflow/ Dam/ Trichoptera/Pasak Cholasit dam

1.Introduction

The uses of immature aquatic insects in bio monitoring the health of aquatic ecosystems are severely limited, especially in Thailand. All aquatic habitats, for example, contain an abundance of microhabitats that are nearly impossible to sample; larval collecting techniques are also labor-intensive and difficult to standardize (Merritt et al., 1996; Barbour et al., 1999). These factors diminish the value of comparisons between different sampling sites. Furthermore, it is difficult to find rare species in aquatic habitat, and many larvae are not identifiable to the species level; both factors cause a loss of information (Dudgeon, 1999; Hawkins and Norris, 2000; Hawkins and Vinson, 2000; Hawkins et al. 2000).

Bio monitoring using adult insects will likely mitigate these concerns. Because adults have left the natal habitat, microhabitat representation is not an issue. It is easier to find rare species, and most adults are identifiable to the species level. Due to the disparate collecting techniques required for adults (e.g., Daly et al., 1998), however, it may be preferable to use only a single insect order for adult bio monitoring. The caddisflies (Trichoptera) are potentially ideal taxa for single-order adult bio monitoring due to their high species richness, ecological diversity, varying susceptibilities to different types of human disturbance, and abundance in virtually all types of freshwater ecosystems (Resh, 1992; Rosenberg and Resh, 1993; Barbour et al., 1999; de Moor, 1999; Dohet, 2002). They can also be sampled representatively without a great deal of effort. It is possible that bio monitoring using adult caddis flies may have greater value than bio monitoring with larvae of all aquatic taxa (Houghton et al, 2011).

Several collecting methods were developed to obtain large quantitative samples in order to study these functional roles of adult caddis flies. One of the best methods is light trapping. This trapping method has been extensively used by trichopterologists from temperate areas (e.g. Malicky, 1981; 1991; Waringer, 1989; Kovats et al., 1996), Mediterranean areas (e.g. Bonada et al., 2004; Diken and Boyaci, 2008) and from subtropical/tropical regions (e.g. Chan et al., 2007). In Thailand, many studies were conducted using adult caddis flies as a bio indicator of water quality (Prommi and Thamsenanupap, 2012). The aim of this study is to investigate the biodiversity of adult caddis flies at inflow and outflow of the Pasak Cholasit reservoir. Selected physicochemical parameters of water quality were also measured to determine their effects, if any, on the diversity of adult caddis flies.

2. Methodology

2.1 Study area

The Pasak Cholasit reservoir has been established according to the idea of His Majesty King Bumiboll in 1989 in order to control the water draining from Loei Province, which normally goes into the Chao Phraya River, and causes flooding in Bangkok and adjacent areas.

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The total area of the reservior is 21, 680 hectares. The reservoir also supplies water to the agricultural areas on the eastern side of the Chao Phraya River covering about 352,000 ha. In addition, the fish produced from this reservoir is an important food source of protein and income for local people.

2.2 Adult Trichoptera collection and identification

Adults Trichoptera were sampled each month during January to December 2010 with portable black-light trap. A trap consisted of an 10-watt black-light tube placed over a white pan filled with detergent solution. A trap was placed near the stream margin at dusk and left over night. Two samples were collected at each of the inflow and outflow of reservoir. 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 caddis fly 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 the taxonomic key by Malicky (2010). 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 inflow and outflow of the reservoir were recorded directly at sampling site and included the pH, measured by a pH-meter, water temperature and air temperature 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 were determined in accordance with the standard method procedures (APHA, AWWA, WPCF, 1992).

2.4 Data analysis

Canonical correspondence analysis (CCA) of PC-ord version 4.0 (McCune and Mefford, 1999) was investigated the contribution of the environmental stressors on the distribution and abundance of transformed caddis flies species data (log(x+1)). The Monte-Carlo test was applied to test the significance of the produced canonical axes with 998 permutations at $P < 0.05$. The biplot ordination diagram was produced using CanoDraw for Windows 10. In the CCA, taxa constituting more than 0.1% of the total abundance were selected, and in totals, 21 taxa were used in the analyses.

3. Results and discussion

3.1 Adult caddisflies survey

Seven families and 27 species of caddis flies were caught by light trapping in the sampling sites in the present study (Table 1).

The family Hydropsychidae contained the greatest number of species (29%, 8 species) inventoried, followed by Leptoceridae (26%, 7 species), Ecnomidae (19%, 5 species), Psychomyiidae (11%, 3 species), Philopotamidae (7%, 2 species), and Dipseudopsidae and Xiphocentronidae (4 %, 1 species). Taxonomic composition, richness, and abundance varied greatly between different months. In general, higher richness and abundance were recorded in the dry months (January to June), and the rainy season of July to November yielded lower richness and abundance values. The flight period for many species was year-long (e.g., *Chimarra chiangmaiensis*, *Paduniella sampati*, *Psychomyia samanaka, Dipseudopsis robustior, Ecnomus mammus, E, volovicus*, *Cheumatopsyche lucida, Macrostemum indistinctum, Amphipsyche meridiana* and *Cereclea hypsipyle*).

Net spinning caddis flies, particularly hydropsychids, commonly occur in high densities at lake outlets (Barnard, 1984; Harding, 1997). Their abundance has been associated with the presence of high food quality (Peterson, 1987; Harding, 1997), stable water flow and stable substrata common in these habitats (Georgian and Thorp, 1992). As in this study, the numerous numbers of adult hydropsychids, *A. meridiana*, *C. lucida*, and *M. indistinctum*, were generally found in fast-flowing rivers on a stony substrate and below reservoir outflow, less numbers were found at inflow of reservoir because of fewer habitats (Harding, 1992).

Table 1: List of adult Trichoptera collected by light traps at Pasak Cholasit Reservoir during January to December 2010. M&C = Malicky and Chantaramongkol, C&M = Chantaramongkol and Malicky.

Taxa/months	Species Code	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	%Abundance
Philopotamidae														
Chimarra akkaorum C&M 1989	Chiakk	7	5	11	15	8	7	0	0	0	0	0	0	0.26
Chimarra chiangmaiensis C&M 1989	Chichi	45	31	27	43	36	41	12	63	45	96	112	102	3.2
Psychomyiidae														
Paduniella sampati M&C 1993	Padsam	18	24	19	35	18	19	7	12	11	12	22	18	1.05
Psychomyia kaiya M&C 1993	Psykai	1	1	0	3	0	3	3	0	2	5	1	3	0.11
Psychomyia samanaka M&C 1993	Psysam	11	26	5	17	17	18	21	11	6	2	7	9	0.73
Dipseudopsidae														
Dipseudopsis robustior Ulmer 1929	Diprob	34	55	41	66	38	38	20	18	15	29	12	32	1.95
Ecnomidae														
Ecnomus atevalus M&C 1993	Ecnate	41	66	48	73	48	62	4	5	7	0	1	5	1.76
Ecnomus mammus M&C 1993	Ecnmam	39	40	42	53	46	35	15	15	15	42	5	23	1.81
Ecnomus puro M&C 1993	Ecnpur	9	4	5	2	0	4	2	0	2	0	4	0	0.15
Ecnomus volovicus M&C 1993	Ecnvol	63	91	42	98	50	62	5	8	11	18	39	5	2.41
Ecnomus votticius M&C 1993	Ecnvot	2	1	62	5	6	0	1	5	0	8	1	2	0.45
Xiphocentronidae														
Abaria guatila M&C 1992	Abagua	3	4	0	5	0	2	2	0	3	0	4	2	0.12
Hydropsychidae														
Cheumatopsyche banksi Mosely 1942	Cheban	0	0	0	0	0	0	2	0	0	0	7	3	0.05
Cheumatopsyc charites M&C 1997	Checha	56	73	45	53	48	29	8	11	0	0	0	0	1.58
Cheumatopsyche lucida Ulmer 1907	Checog	64	57	82	96	91	69	85	103	169	128	121	113	5.78
Cheumatopsyche niasensis Malicky 1997	Chenia	0	1	0	1	0	0	0	0	0	0	0	0	0
Cheumatopsyche naumanni Malicky 1986	Chenau	12	36	18	29	12	14	18	0	6	13	36	0	0.95
Macrostemum indistinctum Banks 1911	Macind	96	129	86	136	96	98	86	16	96	45	129	112	5.52
Potamyia flavata Banks 1934	Potfla	0	1	0	1	1	0	0	0	0	0	0	0	0.01
Amphipsyche meridiana Ulmer 1909	Ampmer	109	102	145	2643	1569	562	1033	859	563	2522	3783	605	71.1
Leptoceridae														
Ceraclea hypsipyle Malicky 2005	Cerhyp	9	8	7	6	5	5	3	1	3	5	2	3	0.27
Leptocerus dienli Malicky 1991	Lepdie	0	0	1	0	0	0	0	0	0	0	0	0	0.01
Oecetis biramosa Martynov 1936	Oecbir	11	16	12	15	4	13	0	0	0	0	0	0	0.34
Oecetis empusa Malicky&Chaibu 2000	Oecemp	5	3	2	5	2	6	0	0	0	0	0	0	0.11
Oecetis laodike M&C 2005	Oeclao	0	0	0	0	0	0	0	0	1	0	1	0	0.01
Oecetis meghadouta Schmid 1958	Oecmeg	0	1	0	1	0	2	0	0	0	0	0	0	0.01
Triaenodes narkissos Malicky 2005	Trinar	3	5	1	2	0	7	3	1	0	0	5	7	0.13
Total number of species		**21**	**24**	**20**	**24**	**18**	**21**	**19**	**14**	**16**	**13**	**19**	**16**	

3.2 Physicochemical survey

Variations, of environmental variables in each month show some differences. Air and water temperature varied from 26.03°C to 33.32°C and 25.67°C to 34.00°C. The values of pH ranged between 7.33 to 8.50. The DO values ranged between 4.39 mgL^{-1} to 6.40 mgL^{-1}. The conductivity/total dissolved solids ranged between 267.7 μScm^{-1} to 583.33 μScm^{-1} and 140.67 mgL^{-1} to 269 mgL^{-1}.

The turbidity ranged between 1.67 FTU to 98.67 FTU. The mean nitrate-nitrogen concentrations varied from 1.57 mgL^{-1} to 2.73 mgL^{-1}.The mean ammonia-nitrogen concentrations varied from 0.07 mgL^{-1} to 0.47 mgL^{-1}. The mean orthrophosphate value concentration varied from 0.07 mgL^{-1} to 0.53 mg L^{-1}. The mean sulfate value concentration varied from 18.00 mgL^{-1} to 26.33 mg L^{-1}. The average values of physicochemical parameter of water quality are shown in Table 2.

Table 2: Summary of mean water quality parameters of the Pasak Cholasit reservoir during a period from January to December 2010.

Parameters /month	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
AT	26.03	29.3	33.23	31.6	31.17	30.9	27.3	27.3	27.43	28.17	28.17	27.17
WT	25.67	30.4	34	32.13	32.23	32.9	29.8	31	30.67	27.43	27.43	26.7
pH	8.5	7.33	8.47	7.43	7.6	7.8	7.48	7.48	7.56	7.36	7.36	8.05
EC	430.33	442	419	538.33	480.67	419	267.7	294.67	436.67	282.67	284	357.67
TDS	216	221.33	209.67	269	240.67	210	146.7	141.33	217.33	140.67	140.67	180.67
DO	5.6	5	4.39	4.6	4.64	4.6	5.53	6.4	5.53	6.4	6.4	6
NO_3-N	2.73	2.57	1.73	2.63	2.3	1.73	2.27	2.27	2.27	1.57	1.57	2.17
NH_4-N	0.25	0.23	0.06	0.17	0.24	0.07	0.47	0.47	0.47	0.29	0.29	0.27
PO_4^{3-}	0.14	0.07	0.34	0.17	0.26	0.34	0.53	0.53	0.53	0.25	0.28	0.22
SO_4^{2-}	25.33	21.33	20.67	20.33	20.33	20.67	26.33	26.33	26.33	23.33	18	23
Turbidity	10.67	9	3.33	1.67	2.67	3.33	54.33	98.67	91.33	10	10	10

3.3 The correlation between caddis fly species and physicochemical parameters

Canonical Correspondence Analysis (CCA) was utilized to investigate the effect of the environmental parameters on the diversity of adult caddis flies. The CCA biplot is shown in Figure 1. The first axis explained 37.8% and the second axis 27.2% of the variances and the Monte Carlo permutation test (998 permutations) was significant at $P < 0.05$. The air and water temperature, pH of water, total dissolved solids and electrical conductivity showed the highest positive correlation with axis 1. Axis 1 was interpreted as an environmental gradient of increasing the air and water temperature, pH of water, total dissolved solids and electrical conductivity. Taxa with high positive scores on the first CCA axis included *Chimarra akkaorum, E. atevalus, E. votticius, C. charites*, *O. biramosa* and *O. empusa*, and therefore proposed as taxa increasing when the air and water temperature, pH of water, total dissolved solids and electrical conductivity are increased. Taxa with high negative scores on axis 1 included *C. chiangmaiensis, Psychomyia kaiya, Abaria guatila, C. lucida, M. indistinctum* and *A. meridiana*, and proposed as taxa decreasing when the air and water temperature, pH of water, total dissolved solids and electrical conductivity are decreased (Figure 1).

Axis 2 explained 27.2% of the variance in taxa–environment relations. The dissolved oxygen, ammonia-nitrogen,nitrate-nitrogen, orthrophosphate, sulfate and turbidity of water were negatively correlated with axis 2, so this axis was interpreted as a gradient of decreasing the dissolved oxygen, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, sulfate and turbidity of water. Taxa with high negative scores on axis 2 included *E. atevalus, E. puro, E. volovicus, Abaria guatila, C. charites, O. biramosa, O. empusa* and *Triaenodes narkissos,* and proposed as taxa tolerant to the dissolved oxygen, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, sulfate and turbidity of water. Many taxa, such as *C. chiangmaiensis, Psychomyia kaiya, E. votticius*, *C. lucida* and *A. meridiana* and *C. hypsipyle* had high positive scores with axis 2, and proposed as taxa intolerant the to dissolved oxygen, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, sulfate and turbidity of water (Figure 1).

In this reservoir, the air and water temperature, pH of water, total dissolved solids, electrical conductivity, dissolved oxygen, ammonia-nitrogen,nitrate-nitrogen, throphosphate, sulfate and turbidity of water are considered as the important factors which affects the adult caddis fly faunas.

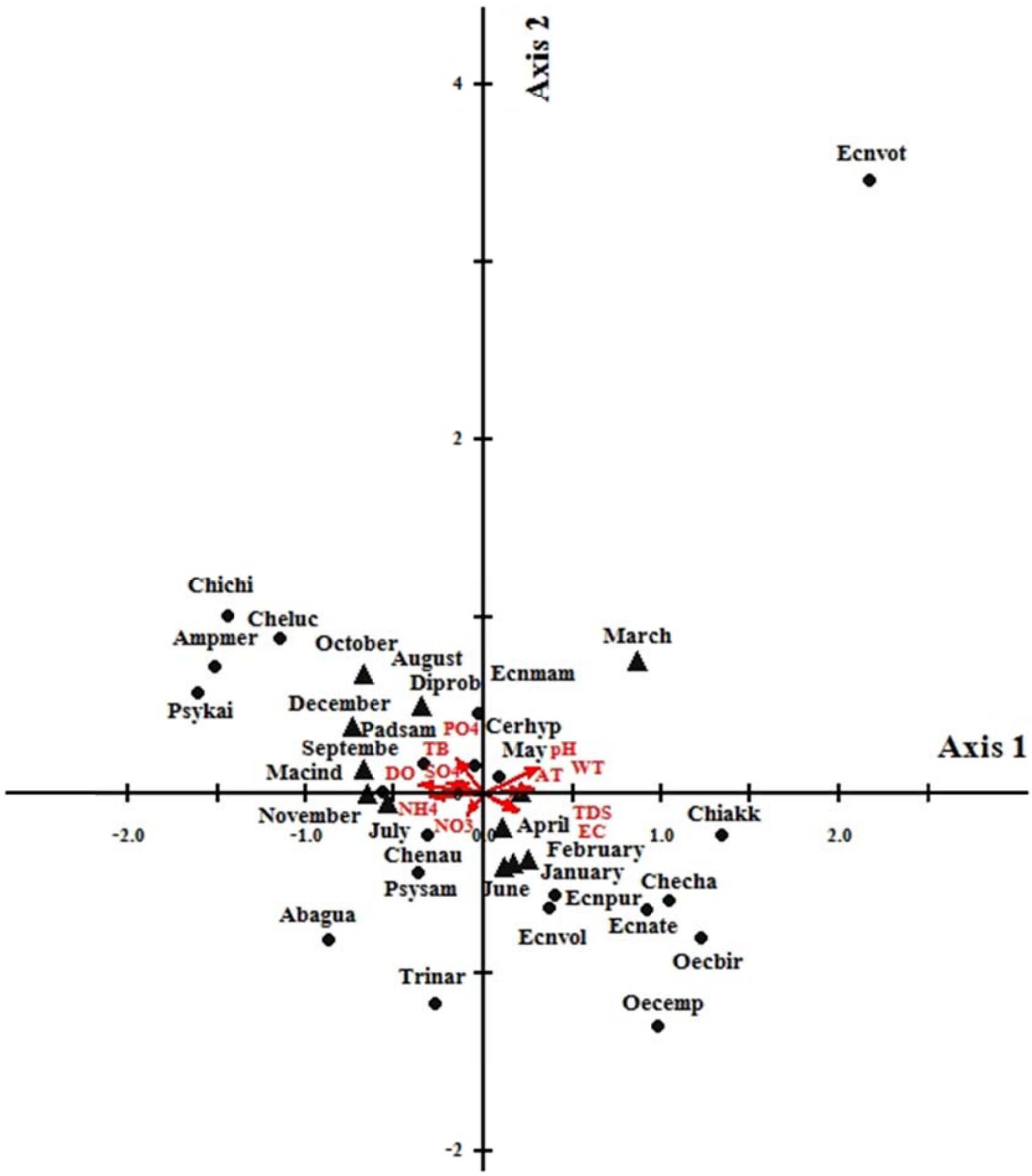

Figure 1. CCA showing correlation between caddis fly species and physicochemical variables. Monte Carlo test; p= 0.002, eigenvalue axis1 = 0.22, eigenvalue axis1 = 0.18, Pearson correlation: $r^2 = 1.00$). Solid circles represent species, solid triangles represent month, and arrows represent physicochemical variables. Month, species and lines in same quadrate show positive correlations whereas a negative correlation is indicated where in an opposite quadrate. Abbreviations of taxonomic names are shown in Table 1

4. Conclusion

From our results throughout the study period, there are total of 20,380 adult caddis flies representing 7 families and 27 species that were collected in the inflow and outflow of the Pasak Cholasit reservoir from January to December 2010. The caddis fly, *Chimarra akkaorum, E. atevalus, E. votticius, C. charites*, *O. biramosa* and *O. empusa* are increased when the air and water temperature, pH of water, total dissolved solids and electrical conductivity are increased, whereas, *C. chiangmaiensis, Psychomyia kaiya, Abaria guatila, C. lucida, M. indistinctum* and *A. meridiana*, are decreased when the air and water temperature, pH of water, total dissolved solids and electrical conductivity are decreased.

The caddis fly, *E. atevalus, E. puro, E. volovicus, Abaria guatila, C. charites, O. biramosa, O. empusa* and *Triaenodes narkissos,* are tolerant to the dissolved oxygen, ammonia-nitrogen, nitrate-nitrogen, orthrophosphate, sulfate and turbidity of water, whereas, *C. chiangmaiensis, Psychomyia kaiya, E. votticius, C. lucida* and *A. meridiana* and *C. hypsipyle* are intolerant the to dissolved oxygen, ammonia-nitrogen, nitrate-nitrogen, orthrophosphate, sulfate and turbidity of water.

Based on our results CCA is a very useful examining tool, since it is able to extract all variables important in structuring adult trichoptera data sets and relates physiochemical variables to changes in taxa composition (taxa counts) at the same time.

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