



THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Science (Environmental Science and Technology)

DEGREE

Environmental Science and Technology

FIELD

Division of Science

DEPARTMENT

TITLE: Potential for Trichoptera Communities as Biological Indicators of Water Quality in Mae Tao Watershed, Mae Sot District, Tak Province

NAME: Miss Pronthip Peumwarunyoo

THIS THESIS HAS BEEN ACCEPTED BY

THESIS ADVISOR

(Miss Taeng-On Prommi, Ph.D.)

HEAD OF DEPARTMENT

(Assistant Professor Thanawan Panich-pat, Ph.D.)

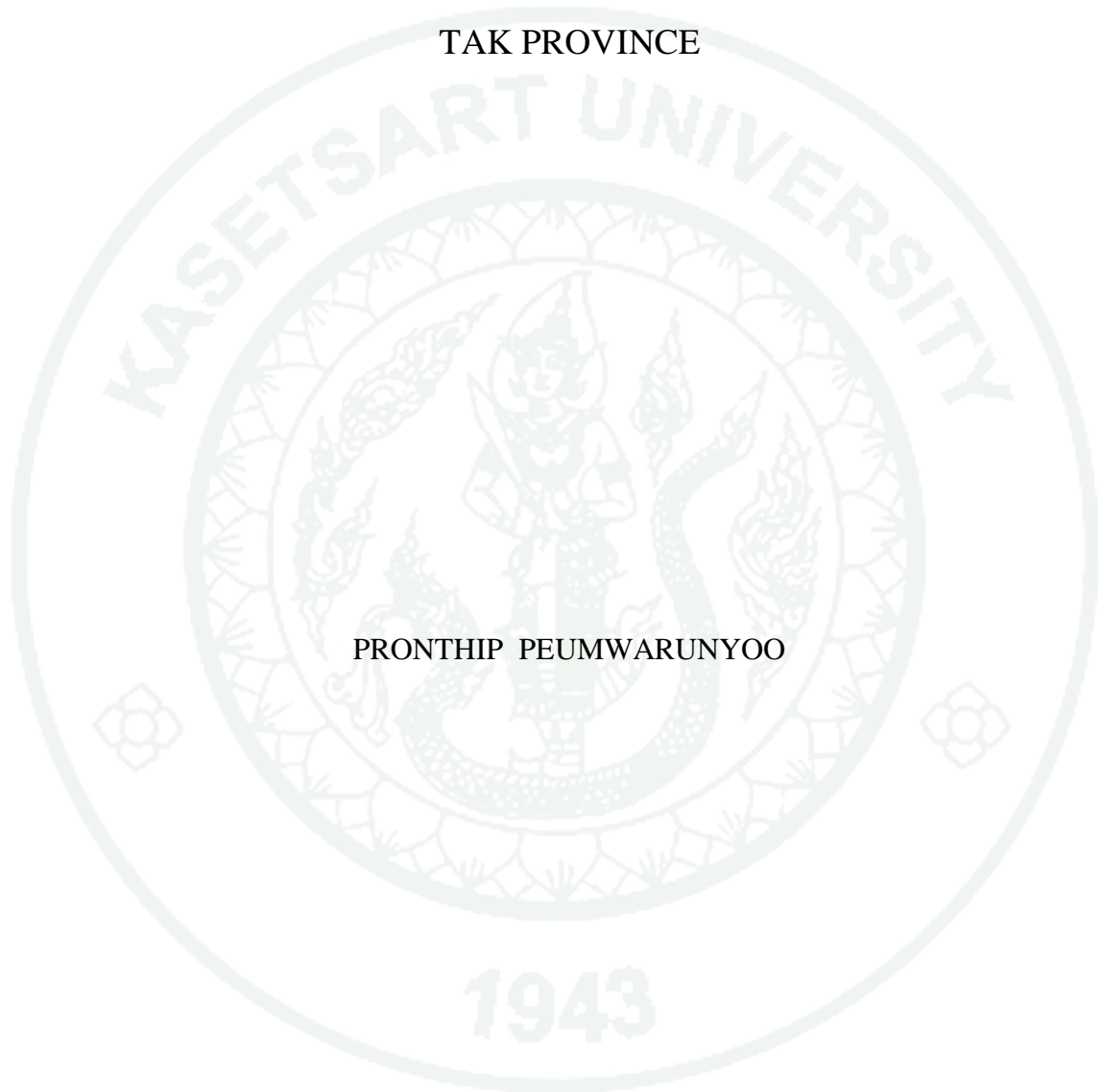
APPROVED BY THE GRADUATE SCHOOL ON _____

DEAN

(Associate Professor Gunjana Theeragool, D.Agr.)

THESIS

POTENTIAL FOR TRICHOPTERA COMMUNITIES AS
BIOLOGICAL INDICATORS OF WATER QUALITY IN
MAE TAO WATERSHED, MAE SOT DISTRICT,
TAK PROVINCE



PRONTHIP PEUMWARUNYOO

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science (Environmental Science and Technology)
Graduate School, Kasetsart University
2012

Pronthip Peumwarunyoo 2012: Potential for Trichoptera Communities as Biological Indicators of Water Quality in Mae Tao Watershed, Mae Sot District, Tak Province. Master of Science (Environmental Science and Technology), Major Field: Environmental Science and Technology, Division of Science. Thesis Advisor: Miss Taeng-On Prommi, Ph.D. 107 pages.

The potential of using Trichoptera communities as biological indicators of water quality was studied in Mae Tao and Mae Ku watershed during February to December 2011. Seven sampling sites (MT1-MT5, MK2, MK8) were selected. A total of 3,442 individual of trichopteran larvae belonging to 10 family and 18 genera were found. The larvae of family Hydropsychidae were the most abundance, followed by Philopotamidae, Odontoceridae, and Leptoceridae, respectively. The genus *Cheumatopsyche*, *Hydropsyche*, and *Chimarra* were the most abundance genera in this study. For the trichopteran adult, a total of 8,376 male individuals, belonging to 14 families, 35 genera and 122 species were recorded. The most species rich were *Hydroptila thuna*, *Chimarra akkaorum*, *Oecetis scutulata* and *Setodes okypete*. The species diversity index (H') of Trichoptera larvae was highest in MT1 (0.842) and lowest (0.352) in MK8, whereas the highest diversity of Trichoptera adult was found in MT2 (1.168) and the lowest (0.535) was at MT5. Results of ordination analysis indicated that the species group, *Potamyia flavata* were correlated negatively with dissolved oxygen and the species *Oecetis asmada* and *O. scutulata* were correlated positively with water turbidity, electric conductivity and total dissolved solids, whereas increased abundance of *Hydroptila* sp. was the best bioindicator of agriculturally impacted sites. Physico-chemical parameters revealed that mostly the surface water quality in Mae Tao and Mae Ku watersheds were not exceed standard within the Type III of The Surface Water Standard for Agriculture and Water Quality for Protection of Aquatic Resources. Changes in the caddisfly fauna may indicate changes in physico-chemical factors owing to agricultural

Student's signature

Thesis Advisor's signature

ACKNOWLEDGEMENTS

This thesis would not have been possible without the assistance and encouragement of many people. Primarily, my major advisor, Dr. Taeng-On Prommi, for taking me on as her student and for her time, effort, and patient guidance in helping me pursue this project.

The member of my examination committee: Dr. Penkhae Thamsenanupap of Maharakham University and Assist. Prof. Dr. Thitiya Pung of Kasetsart University are to be thanked for their criticisms.

Thanks are also to the member of Zoology Unit, Miss Pharawee Mansukphol and Miss Panomwan Youprom and other colleges not mentioned here.

Without the love and constant encouragement from my parents, I would not have been able to complete this project. To them I will always be deeply grateful.

Financial support for this study was given through a scholarship and grants of the Graduate School, Kasetsart University.

Pronthip Peumwarunyoo

April 2012

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	v
INTRODUCTION	1
OBJECTIVES	4
LITERATURE REVIEW	5
MATERIALS AND METHODS	11
RESULTS AND DISCUSSION	20
Results	20
Discussions	56
CONCLUSION AND RECOMMENDATIONS	62
Conclusion	62
Recommendations	64
LITERATURE CITED	65
APPENDICES	71
Appendix A The number larvae and adult of Trichoptera species found at seven sampling sites of the Mae Tao and Mae Ku watersheds during February to December 2011	72
Appendix B The Physico-chemical water quality parameters of the seven sampling sites of the Mae Tao and Mae Ku watersheds during February to December 2011	99
CURRICULUM VITAE	107

LIST OF TABLES

Table	Page	
1	Details of each sampling site.	15
2	List of caddisflies larvae collected in Mae Tao and Mae Ku watersheds during February to December 2011	21
3	List of adult trichopteran species collected in Mae Tao and Mae Ku watersheds during February to December 2011.	25
4	Average physico-chemical water quality parameters and cadmium measured at all the sampling sites in Mae Tao and Mae Ku watersheds (mean value \pm S.D.) during February to December 2011.	39
5	Summary statistics of the PCA for study sites based on larvae and adults of Trichoptera at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province during February to December 2011.	50
6	Canonical coefficients for significant environmental variables at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province during February to December 2011.	51
Appendix Table		
A1	Abundance of Trichoptera species at MT1, Mae Sot District, Tak Province recorded during February to December 2011.	73
A2	Abundance of Trichoptera species at MT2, Mae Sot District, Tak Province recorded during February to December 2011.	74
A3	Abundance of Trichoptera species at MT3, Mae Sot District, Tak Province recorded during February to December 2011.	75

LIST OF TABLES (Continued)

Appendix Table	Page
A4 Abundance of Trichoptera species at MT4, Mae Sot District, Tak Province recorded during February to December 2011.	76
A5 Abundance of Trichoptera species at MT5, Mae Sot District, Tak Province recorded during February to December 2011.	77
A6 Abundance of Trichoptera species at MK2, Mae Sot District, Tak Province recorded during February to December 2011	78
A7 Abundance of Trichoptera species at MK8, Mae Sot District, Tak Province recorded during February to December 2011.	79
A8 Abundance of adult Trichoptera species at MT1, Mae Sot District, Tak Province recorded during February to December 2011.	80
A9 Abundance of adult Trichoptera species at MT2, Mae Sot District, Tak Province recorded during February to December 2011.	82
A10 Abundance of adult Trichoptera species at MT3, Mae Sot District, Tak Province recorded during February to December 2011.	86
A11 Abundance of adult Trichoptera species at MT4, Mae Sot District, Tak Province recorded during February to December 2011.	89
A12 Abundance of adult Trichoptera species at MT5, Mae Sot District, Tak Province recorded during February to December 2011.	92
A13 Abundance of adult Trichoptera species at MK2, Mae Sot District, Tak Province recorded during February to December 2011.	95
A14 Abundance of adult Trichoptera species at MK8, Mae Sot District, Tak Province recorded during February to December 2011.	97
B1 Physico-chemical water quality parameters at MT1, Mae Sot District, Tak Province recorded during February to December 2011.	100
B2 Physico-chemical water quality parameters at MT2, Mae Sot District, Tak Province recorded during February to December 2011.	101

LIST OF TABLES (Continued)

Appendix Table	Page
B3 Physico-chemical water quality parameters at MT3, Mae Sot District, Tak Province recorded during February to December 2011.	102
B4 Physico-chemical water quality parameters at MT4, Mae Sot District, Tak Province recorded during February to December 2011.	103
B5 Physico-chemical water quality parameters at MT5, Mae Sot District, Tak Province recorded during February to December 2011.	104
B6 Physico-chemical water quality parameters at MK2, Mae Sot District, Tak Province recorded during February to December 2011.	105
B7 Physico-chemical water quality parameters at MK8, Mae Sot District, Tak Province recorded during February to December 2011.	106

LIST OF FIGURES

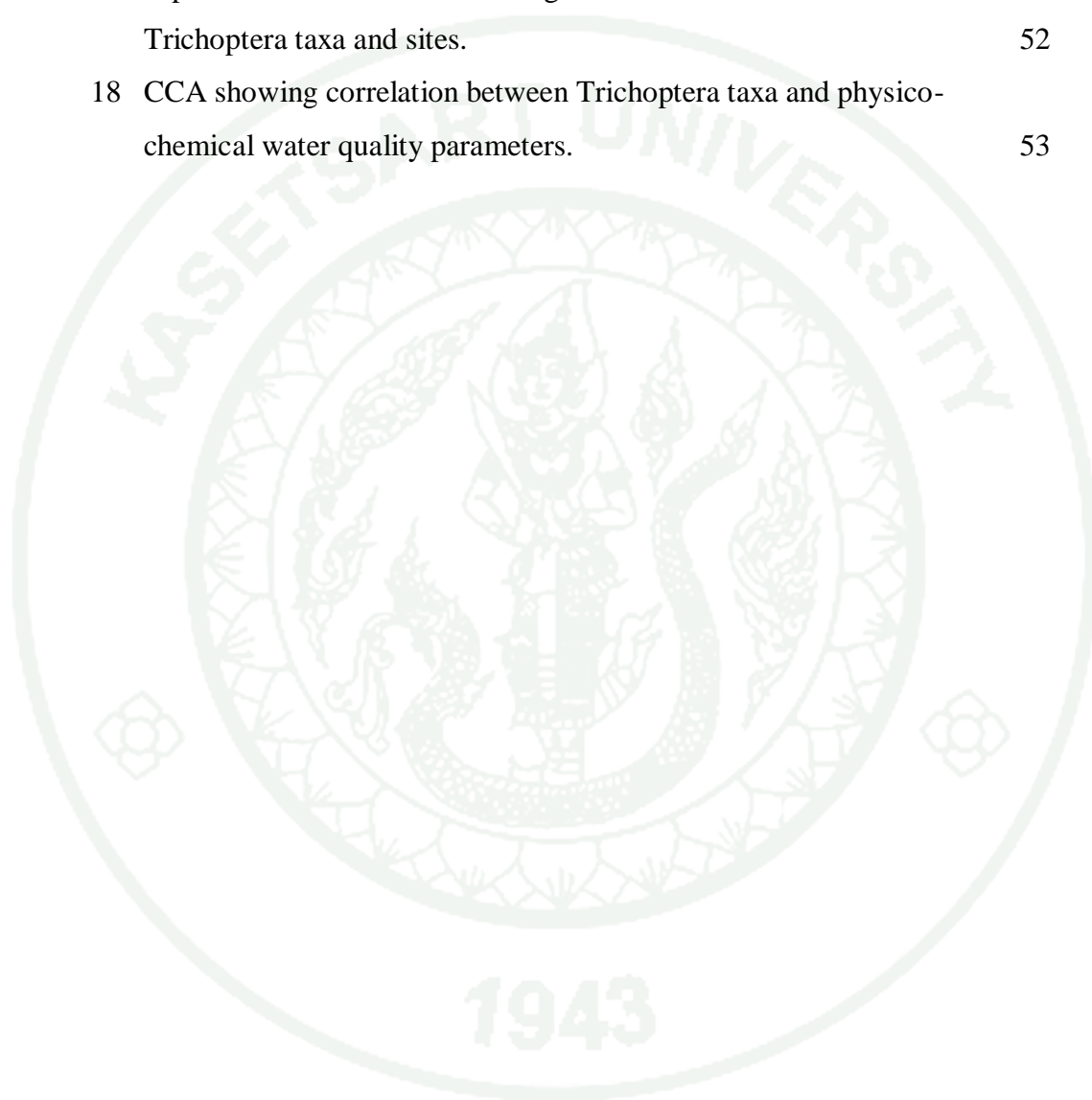
Figure	Page
1 General morphology of the order Trichoptera	6
2 Map showing the sampling sites (MT1-MT5, MK2, MK8) in Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand.	14
3. Stream morphology of sampling sites at MT1-MT4 on Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand	16
4 Method for collection of larvae and pupae of Trichoptera at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province.	18
5 Light trap for collection of adult specimens of Trichoptera at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand	19
6 The percentage individuals of caddisflies larvae collected at seven sites along Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand. (other = Hydroptilidae, Goeridae, Helicopsychidae, Lepidostomatidae and Calamoceratidae).	20
7 The percentage of caddisflies species richness in each family at sampling sites in Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province collected during February to December 2011 (other = Calamoceratidae, Dipseudopsidae, Ecnomidae, Glossosomatidae, Goeridae, Lepidostomatidae, Odontocridae, Polycentropodidae, and Xiphocentronidae).	24
8 Diversity index of Trichopteran larvae at all sampling sites at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province collected during February to December 2011.	33

LIST OF FIGURES (Continued)

Figure	Page	
9	Diversity index of adult Trichopteran species at all sampling sites at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province collected during February to December 2011.	34
10	Mean value of air temperature (A) and water temperature (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	41
11	Mean value of dissolved oxygen (A) and pH of water (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	42
12	Mean value of electrical conductivity (A) and total dissolved solids (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	43
13	Mean value of turbidity (A) and sulfate (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	44
14	Mean value of nitrate-nitrogen (A) and orthophosphate (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	45
15	Mean value of ammonia-nitrogen (A) and alkalinity (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	46
16	Mean value of cadmium in sediment at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.	47

LIST OF FIGURES (Continued)

Figure		Page
17	Biplot of the PCA ordination diagram for the data set between Trichoptera taxa and sites.	52
18	CCA showing correlation between Trichoptera taxa and physico-chemical water quality parameters.	53



**POTENTIAL FOR TRICHOPTERA COMMUNITIES AS
BIOLOGICAL INDICATORS OF WATER QUALITY IN
MAE TAO WATERSHED, MAE SOT DISTRICT,
TAK PROVINCE**

INTRODUCTION

Water pollution from anthropogenic activities, such as, metal contamination on freshwater biota, agricultural activities, and an effluent of industrial and domestic waste water, are one of the most serious environmental problems in Thailand today. Most sewage enters waterways without adequate treatment that is degrading the quality of Thailand's freshwater supply. The traditional water quality monitoring approach has been to applied collect stream water samples and analyze them in a laboratory for suspected physical and chemical pollutants. Because sampling and analysis of the traditional water monitor are expensive and concentrations of pollutants vary greatly with time and location, physical and chemical monitoring often cannot detect non point source pollution problems. In contrast, biological monitoring gives an indication of past conditions as well as current conditions (Resh *et al.*, 1996). It is very important to development efficient, fast, and inexpensive techniques to diagnose and monitor negative perturbations to aquatic ecosystems.

Macroinvertebrates and water quality are interrelated to each other, as macroinvertebrates are a potential indicator of water quality. Benthic macroinvertebrates are one of the most common group of organism used in assessing the health of aquatic ecosystem (Rosenberg and Resh, 1993). They are potential indicators because they represent a diverse group of long living sedentary species that react strongly and often predictably to human influences on aquatic system (Cairns and Prall, 1993). Some macroinvertebrates respond to specific changes in water conditions and have become indicators of river health for aquatic ecologists. The presence and absence of such macroinvertebrates indicate the degree of pollution, though the specific causative physico-chemical pollutant may be identified by

physico-chemical methods. For a variety of reasons, invertebrate are extremely important in the functioning of river and stream, and thus can be viewed as surrogates for river and stream health. First, from a logistic standpoint that they make good study specimens, because, they are abundant, readily surveyed, and taxonomically rich (Dodson, 2001). Secondly, identifying the diversity and community composition of a sample of macroinvertebrate in a selected stream and river will help to determine the overall richness and abundance of the macroinvertebrate fauna within that stream and river. Thirdly, diversity and abundance of macroinvertebrates provides an indication of the overall health of the stream and river.

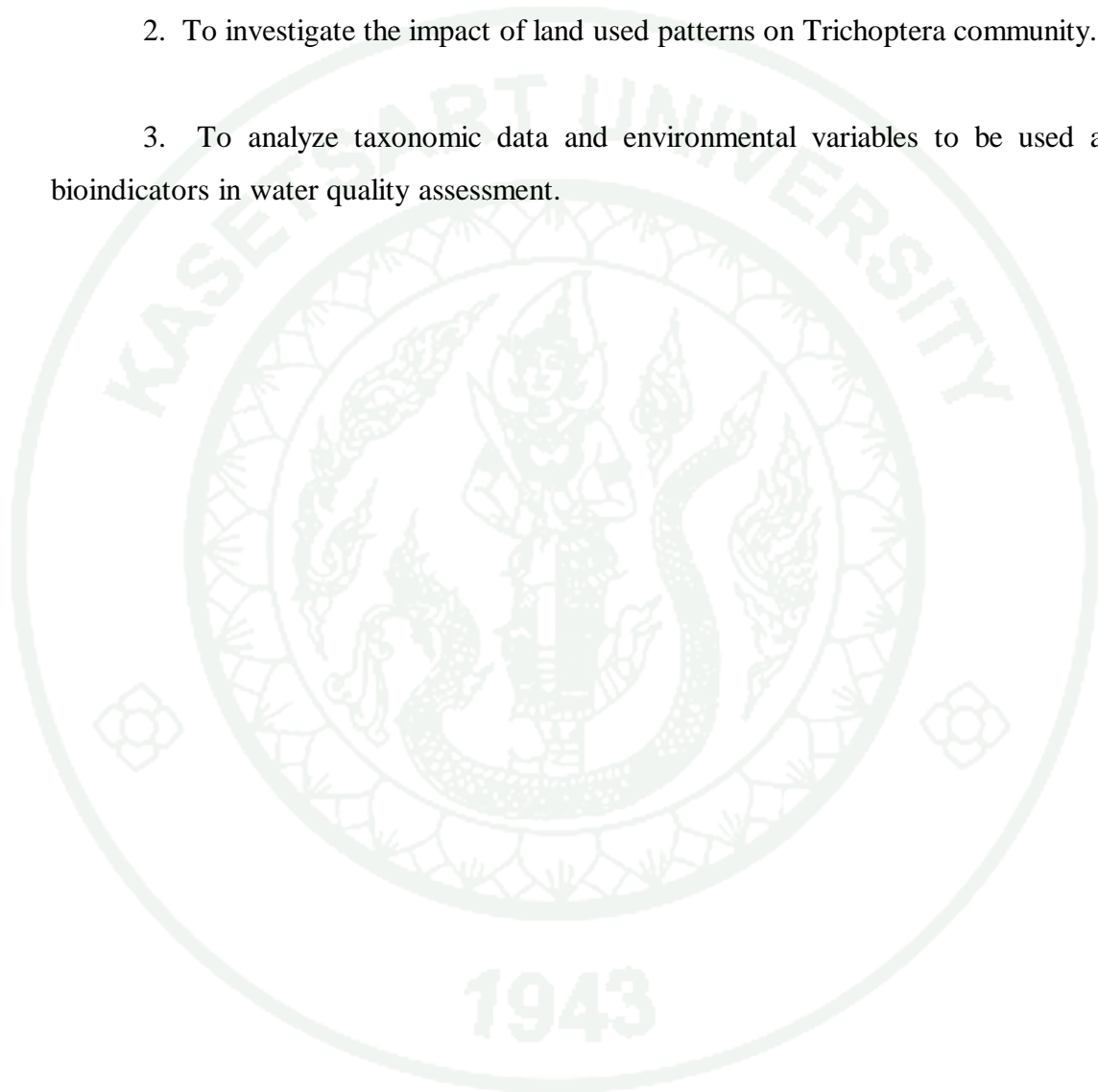
Of all the potential groups of freshwater organisms that have been considered for use in biological monitoring in rivers and streams, benthic macroinvertebrates are most often recommended, especially caddisflies or Trichoptera (Resh *et al.*, 1996). Caddisflies have been described as the most ecologically diverse group of aquatic insects, with nearly 10,000 described species (Wiggins, 1996). As a numerically dominant group in rivers and streams, caddisflies are important to the functioning of freshwater ecosystems because of their ability to partition habitats and trophic resources (Wiggins, 1996). Their response to perturbation and reliance on plant matter for food are reasons why caddisflies are widely used in several aspects of water quality monitoring (Resh, 1992). Furthermore, their well-described biology and taxonomy facilitate interpretation of water quality assessments. The use of species level identification to monitors water quality pollution is much more precise than using family or generic level (Resh and Uzicker, 1975). Adult Trichoptera that emerge from streams live in the nearby riparian zone where they may select streamside trees as preferred sites to complete metamorphosis, to rest while awaiting proper swarming time, to feed in order to produce eggs, or to mate (Jackson and Resh, 1991). Provision of suitable habitat for adult aquatic insects, both in terms of its quality and quantity, is an important consideration as the adult stage can be critical in regulating population numbers of aquatic larvae, and adults can play an important role in terrestrial food webs (Ormerod and Tyler, 1991).

Mae Tao and Mae Ku watersheds located in Mae Sot District, Tak Province, northern part of Thailand. The area is surrounded by agriculture activities, community settlements and mining areas. The water creek was primarily to used as a source of portable water that supplies to community. Also, it provides a daily source of fish and livelihood to the surrounding community.



OBJECTIVES

1. To study the diversity of both larvae and adults of Trichoptera species in different land uses along Mae Tao and Mae Ku watersheds.
2. To investigate the impact of land used patterns on Trichoptera community.
3. To analyze taxonomic data and environmental variables to be used as bioindicators in water quality assessment.



LITERATURE REVIEW

1. Introduction to the order Trichoptera (or caddisflies) (Figure 1)

Trichoptera (*Trichos* = hair, *ptera* = wing) refers to the covering of unmodified setae over the wing surfaces of most species. The order Trichoptera (caddisflies) comprises of a group of holometabolous insects closely related to the Lepidoptera. Together the two orders form the superorder Amphiesmenoptera. Adult Trichoptera range in size over two orders of magnitude, from minute with a wing span of less than 3 mm, to large with a wing span approaching 100 mm. Some species have striking colours and wing patterns but they generally range in colour from dull yellow through grey, or brown to black. They are moth-like insects with wings covered by hairs, not scales as in Lepidoptera. Adults have prominent, and in some species exceptionally long, antennae (more than double the length of the forewing). With some exceptions they have well-developed maxillary and labial palps, but lack of the coiled proboscis that characterises most adult Lepidoptera. Trichoptera larvae are probably best known for the transportable cases and fixed shelters that many, though not all, species construct. Silk has enabled Trichoptera larvae to develop an enormous array of morphological adaptations for coping with life in almost any kind of freshwater ecosystem (Wiggins, 1996; 2004). Larvae can be distinguished from all other insects with segmented thoracic legs by the presence of a pair of anal prolegs, each with a single curved terminal claw and very short, sometimes almost invisible, antennae consisting of a single segment. The trichopteran pupa is exarate and covered by a semitransparent pupal integument and if fully developed reveals the pharate adult inside. The pupa usually possesses a pair of strong functional mandibles, non functional in the adult, and the abdomen has a number of segments adorned with characteristic sclerotised, dorsal hook-bearing plates. The larval and pupal stages of Trichoptera are, with a few exceptions, entirely dependent on an aquatic environment and are usually abundant in all fresh- water ecosystems, from spring sources, mountain streams, large rivers, the splash zones of waterfalls and marshy wetlands, along shorelines and in the depths of lakes, to temporary waters. Certain species are tolerant of high salinities and species in one family, the Chathamidae, have managed

to colonise tidal pools along the sea shore in New Zealand and eastern Australia; some species inhabit the brackish inshore waters of the Baltic and White seas.

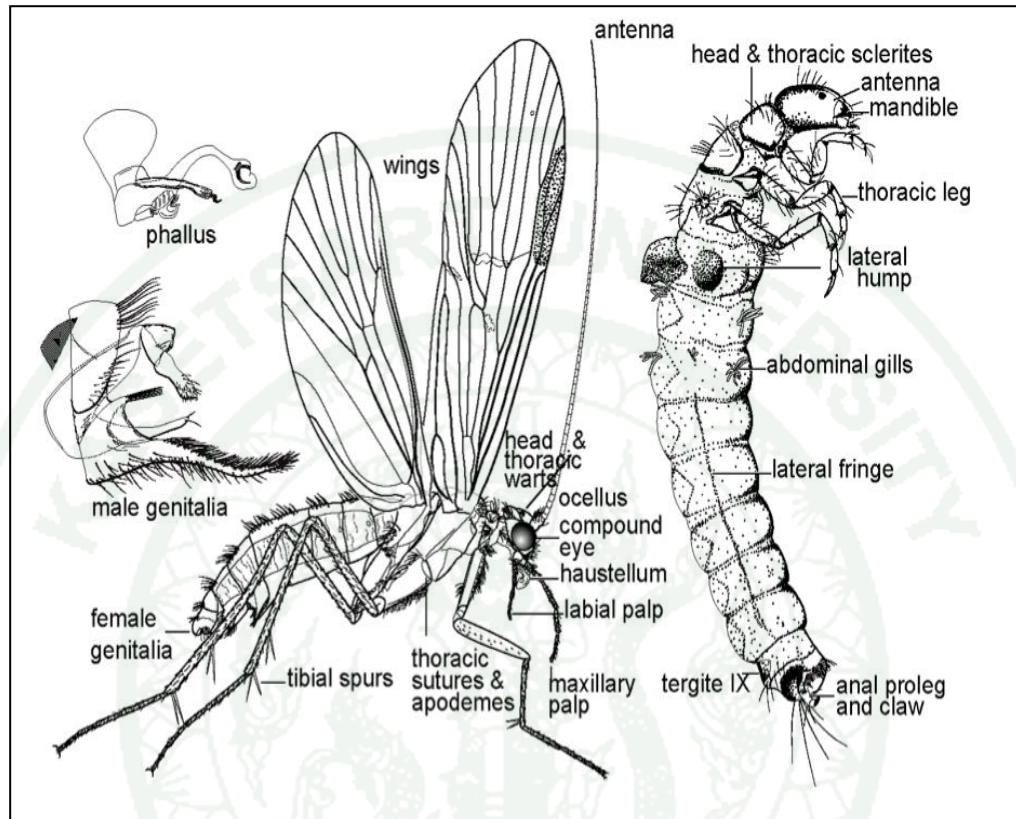


Figure 1 General morphology of the order Trichoptera.

Source: <http://tolweb.org/tree/ToLimages/CaddisLarva.jpg>

2. Species diversity of the order Trichoptera

The caddisflies (Trichoptera) are an order of holometabolous insects found on every continent except Antarctica. Larvae are aquatic and occupy virtually all types of freshwater ecosystems. As of June 2009, the Trichoptera World Checklist (TWC) included records for 13,574 valid, extant species and 308 valid, extant subspecies in 609 genera of 47 families. It also included 650 valid, extinct (fossil) species, 113 extinct genera, and 8 extinct families. The density of species among biogeographic regions is variable, with known species density in the Oriental Region about 7.5 times that in the Afrotropical Region (Morse, 2011).

3. Importance of Trichoptera

Caddisflies are one of the major group of macroinvertebrates in freshwater ecosystems both in terms of species diversity and of density, especially in relatively unpolluted waterways. For this reason, they are significant contributors in the processing of nutrients. The collecting-gathering, collecting-filtering, and scraping caddisflies collect the nutrients of fine particulate organic matter into their own bodies, which makes the nutrients available to invertebrate and vertebrate predators in the food web. On the other hand, shredding- herbivores, shredding-detritivores and predators help break coarse organic materials into small particles, including feces, that is food for many animals in aquatic systems. Because of the many different feeding strategies and habitat preferences of this diverse order, nearly every conceivable food resource is processed by caddisflies.

Although caddisflies generally are not tolerated moderate levels of pollution, the range of tolerance is wide among the various species of caddisflies. For this reason and because of its high species diversity and density in unpolluted surface waters, communities of Trichoptera are often used to detect the presence of pollution. The occurrence of several of the less-tolerant species and high densities of large numbers of species of caddisflies suggest that the water is relatively unpolluted. Pollution may be detected with this technique more reliably and cheaper than chemical analyses. Once it has been established that a given waterway is polluted, follow-up analyses may then be attempted to discover the specific polluting substances or micro-organisms and their concentrations. From these data, land managers, engineers, economists, politicians, and other responsible decision makers may be better able to determine appropriate mitigating measures to reduce or eliminate the pollution (reviewed by Morse, 2003).

In forensic entomology, the casing of caddisflies can also be used to determine how long a body had been in water (e.g. to answer the question when it was dumped in the water). In a case from the 1950s, a caddisfly casing (most likely of *Limnophilus flavicornis*) contained the fibers of the red socks that were worn by the deceased.

However, the fibers were only found at the very top and the very bottom of the casing, which meant that the caddisflies had, for the most part, already built their casing and then finished it at the corpse (fiber on top), and after that and attached it to the red sock (fiber on bottom). Because the attachment procedure takes at least a few days, it was estimated that the body has been in the water for at least 1 week (Benecke, 2004).

4. Use of caddisflies as bioindicators

The combination of rapid population growth, industrialization and urbanization has placed ever-increasing pressure on the water resources of developing countries. However, limited freshwater resources creates concern about the management of its quantity and quality. As one of the Environmental Risk Assessment objectives (Hodgson, 2004) to improve the quality of human life, it is imperative to identify, quantify, and evaluate existing or potential environmental hazards including those to freshwater and other aquatic ecosystems, which are closely related to human life in respect to daily needs, industrial purposes, aquaculture, agriculture, etc. Water usage including the extraction of water and the discharge of effluent wastes leads to specific and more general predictable impacts on aquatic environments. One of the major determinants of water quality is the absence of pollutants. Its effect can be assessed by chemical and physical analyses for suspected chemical and physical pollutants. Unfortunately, because the concentrations of pollutants vary greatly with time and location, physical and chemical monitoring alone often cannot detect non point source pollution problems. In contrast, biological monitoring gives an indication of past conditions as well as current conditions (Resh *et al.*, 1996).

A study of Trichoptera biodiversity and application for use as indicator species to assess water pollution was conducted in the Ping River, Thailand. The results of study, Trichoptera indicator species were divided into two groups based on correlation to water quality. The first groups had 7 pollution tolerant species *viz.* *Cheumatopsyche cognita*, *Macrostemum floridum*, *Ecnomus puro*. The second group included 11 sensitive species *viz.* *Macrostemum midas*, *Hydropsyche dolosa*, *Cheumatopsyche*

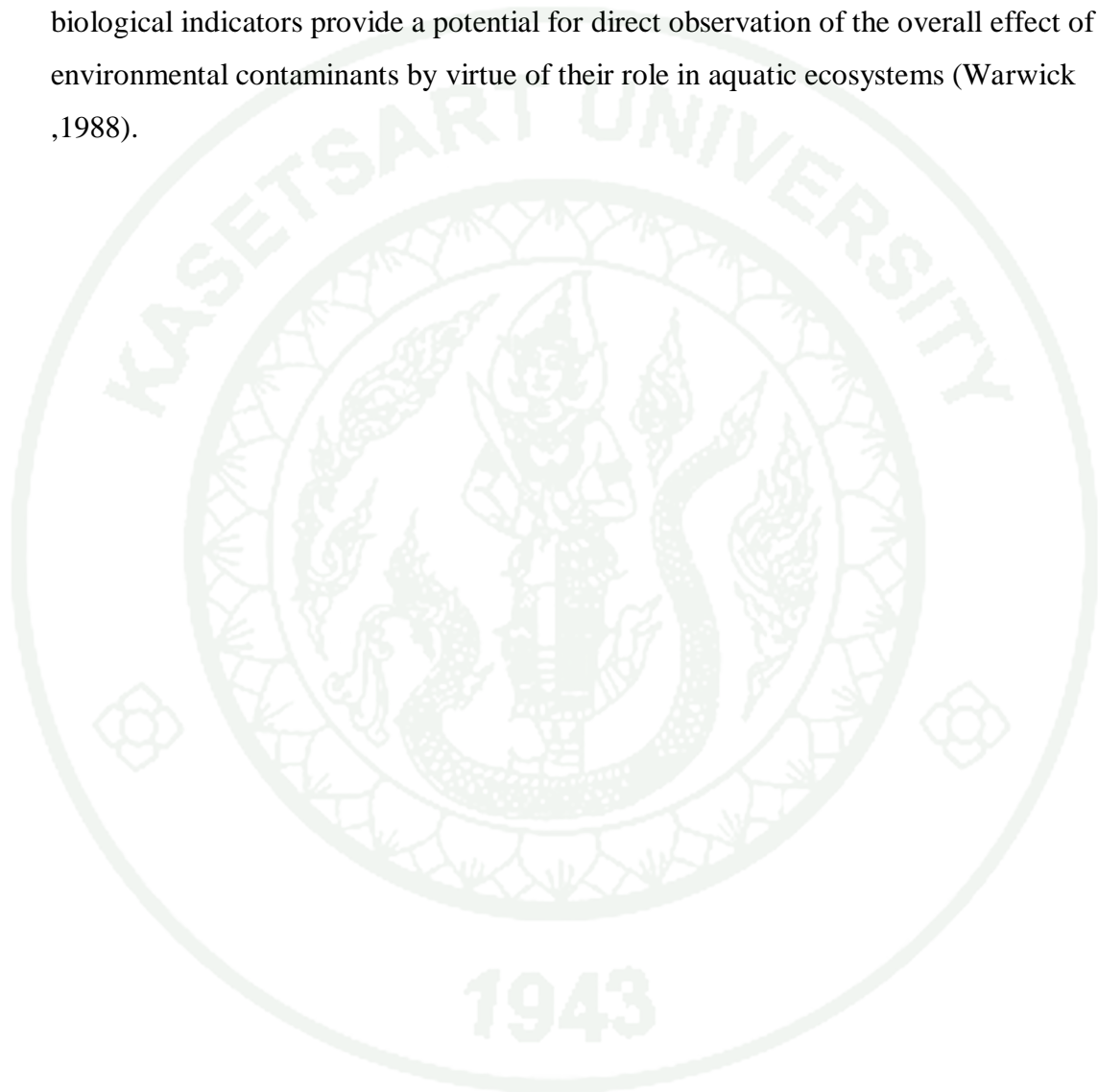
globosa, *Setodes endymion*. They indicate that Trichoptera species can be used as indicators to assess anthropogenic pollution in lowland rivers in tropical regions (Chaibu, 2000).

One of the most important biological indicator taxa for water quality is Trichoptera (caddisflies). This group of insects is ideal because it is high in biodiversity, inhabits many ecological niches, and is abundant (Dohet, 2002; Mackey and Wiggins, 1979; Resh, 1993; Rosenberg and Resh, 1993; Wiggins, 1996). However, many caddisfly species are known for their intolerance of habitat sedimentation and organic pollution (Barbour *et al.*, 1999), and so their numbers may strongly diminish downstream of habitat disturbances (Berlin and Thiele, 2002). In contrast, some species are more tolerant of organic pollution and may increase in abundance of such downstream disturbances (Barbour *et al.*, 1999).

The caddisflies family Hydropsychidae have been increasingly utilized in biomonitoring and impact assessment of pollutants in rivers for several reasons (Vuori, 1994; 1995; Vuori and Kukkonen, 1996). First, hydropsychid larvae are widely distributed and abundant in many types of running waters. Second, they respond to variations in water quality and their autecology is well known enough for the impact of pollutants to be distinguished. Third, due to their robust body, hydropsychid larvae are easily handled and observed for morphological abnormalities. Fourth, the abnormalities in the hydropsychid tracheal gills, the ion-regulatory organ and the anal papillae can be attributed to a disruption of the respiratory and ion regulation functions. Fifth, the relatively large size facilitates sampling and analysis of the concentrations of chemicals in the larvae. Finally, the hydropsychid larvae as facultative filter feeders are more exposed to pollutants in seston, flowing water and the organic matter accumulated in riffle microhabitats

The gills of hydropsychid larvae are one of the most impacted structures on the body of the organism when the environment is altered. They are particularly sensitive due to their large surface area, which increase the accumulation of compounds and gases (Skinner and Bennett, 2007). Direct effluent discharges and

agricultural runoff water mostly contain complex mixtures of contaminants that may produce new compounds due to breakdown and transformation processes and hence contribute to the complexity of the total toxin burden. By the employment of chemical and physical measurements only, the synergistic effect of pollution on its biotic community may not be fully and easily assessed (Resh and Jackson, 1993). In general, biological indicators provide a potential for direct observation of the overall effect of environmental contaminants by virtue of their role in aquatic ecosystems (Warwick, 1988).



MATERIALS AND METHODS

Sampling sites

The seven sampling sites were located along Mae Tao and Mae Ku watersheds in Mae Sot District, Tak Province (Figure 2). Study sites in Mae Tao watershed included Ban Tham Suea (MT1), Huai Mae Tao (MT2), Ban Pha Dae (MT3), Huai Mae Tao Mai Moo4 (MT4), Huai Mae Tao Mai Moo 5 (MT5), and Huai Mae Ku Chua (MK2) and Huai Mae Ku Nuea (MK8) were located in Mae Ku watershed. At each site, the sample was visited bi-monthly of the year of 2011 (February, April, July, October, November, and December). In the flood season (October), both of larvae and adult of Trichoptera were not collected. The locality information of each sampling site were shown in Table 1.

Immature specimen collection

Trichoptera larvae and pupae were collected by handpicking from the surfaces of stones, stone crevices (Figure 4A), gravel (Figure 4B), woody debris (Figure 4C), and other stable substrates for attached filter nets (Figure 4D), and pupal chambers at each collection site. Sampling dates were recorded. The specimens were preserved in 95% ethyl alcohol and brought back to the laboratory where they were sorted to morpho-species level.

Adult specimen collection

At each collection site, adults were collected using portable black-light traps (10-W fluorescent tube, 12-Volt DC battery, (Figure 5) 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 and left around three hours. Insects attracted to the black light were collected in the detergent solution and transferred into 80% ethyl alcohol and transported to the laboratory.

Specimen identification

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 (2010). The association between the adult and fully developed pupa was established with genitalic characteristics. Further, the identified pupa was in-turn associated with the final larval instar. For each species, specimen counts from collections at each sampling site were summed.

Water sampling and physico-chemical variables

Physico-chemical water quality parameters were recorded directly at the sampling site and included pH, measured by a pH-meter Waterproof Model Testr30, water temperature and air temperature were measured by a hand-held thermometer, and dissolved oxygen (DO), which was measured by a HACH® Model sensION 6 DO meter, total dissolved solid (TDS) and conductivity 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 ($\text{NH}_4\text{-N}$), sulfate (SO_4^{2-}), nitrate-nitrogen ($\text{NO}_3\text{-N}$), orthophosphate (PO_4^{3-}) and water turbidity were determined in accordance with the standard method procedures (APHA 1992). Alkalinity was measured by titration (APHA, 1992), whereas metal concentrations (Cd) were established according to the EPA Method 6020.

Data analyses

Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physico-chemical parameters of the seven sampling sites.

Data was analyzed for community structure using PC-ORD program 5.10. Differences in Trichoptera species community structure amongst sample sites were analyzed by Principal Components Analysis (PCA) and Canonical Correspondance Analysis (CCA) was applied to examine correlation between Trichoptera species and physico-chemical parameters.



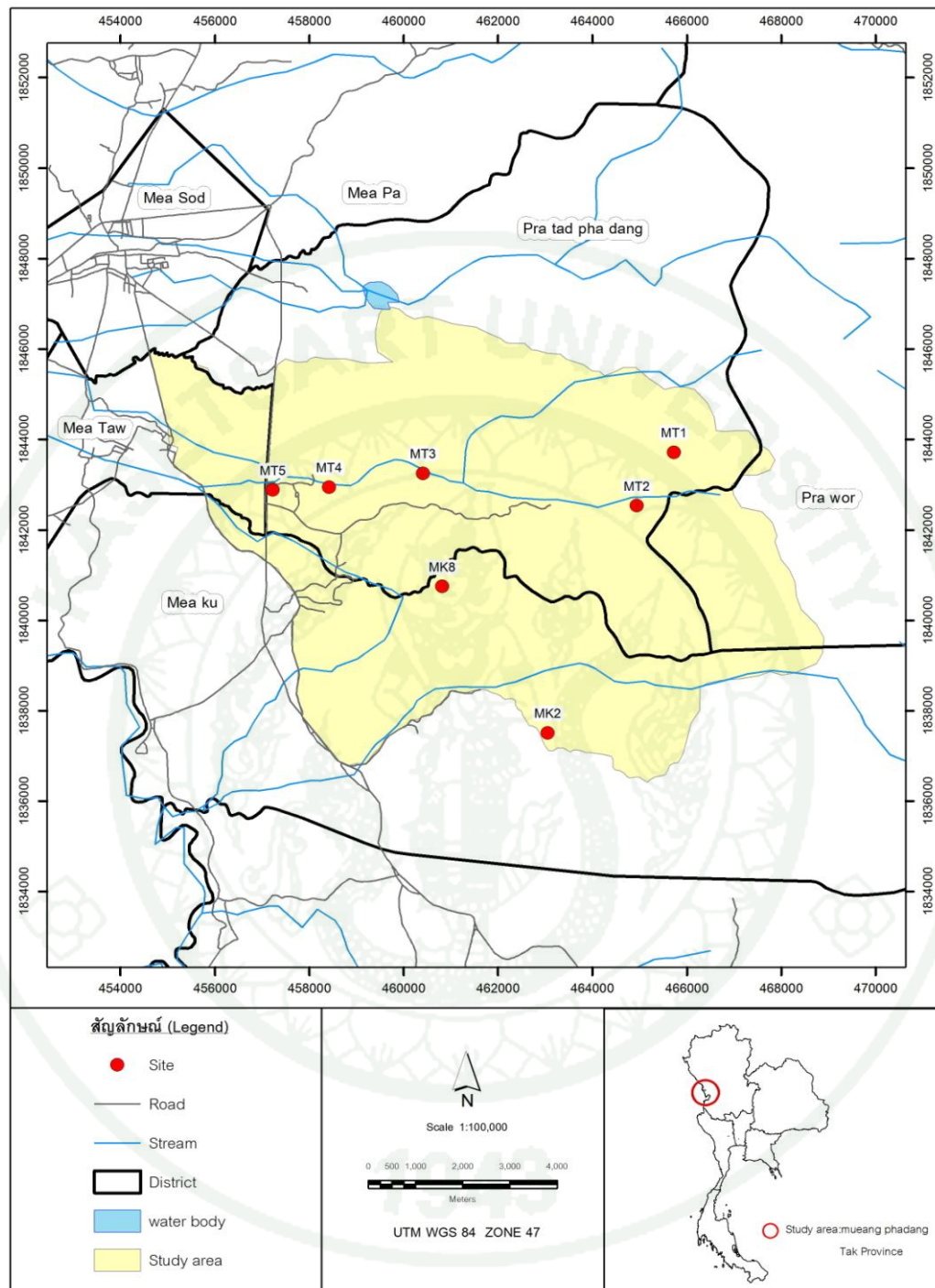


Figure 2 Map showing the sampling sites (MT1-MT5, MK2, MK8) in Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand.

Table1 Details of each sampling site.

Site name and code	Description of substrates	Land use and surrounding environment
Ban Tham Suea (MT1) (Figure 3A)	Man made concrete, gravel, woody debris and other stable substrates	Forest and highland, Village both side
Huai Mae Tao (MT2) (Figure 3B)	Boulders predominant, deep pool in the middle, cobble, gravel and sand	Mining area on side and forest other side, cultivation on both side
Ban Pha Dae (MT3) (Figure 3C)	Cobble predominant, deep pool in the middle, gravel and sand	Village and cultivation on both side
Huai Mae Tao Mai Moo 4 (MT4) (Figure 3D)	Cobble predominant, deep pool in the middle, gravel and sand	Village and cultivation on both side
Huai Mae Tao Moo 5 (MT5) (Figure 3E)	Muddy predominant, gravel and sand	Cultivation on both side
Huai Mae Ku Chuao (MK2) (Figure 3F)	Lime stone, gravel, woody debris	Forest and highland, Village both side
Huai Mae Ku Nuea (MK8) (Figure 3G)	cobble, gravel, sand, woody debris	Forest and highland, Village both side



A: Ban Tham Suea (MT1)



B: Huai Mae Tao (MT2)



C: Ban Pha Dae (MT3)



D: Huai Mae Tao Mai Moo4 (MT4)

Figure 3 Stream morphology of sampling sites at MT1-MT4 on Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand

- A. Ban Tham Suea (MT1)
- B. Huai Mae Tao (MT2)
- C. Ban Pha Dae (MT3)
- D. Huai Mae Tao Mai Moo4 (MT4)
- E. Huai Mae Tao Moo 5 (MT5)
- F. Huai Mae Ku Chua (MK2)
- G. Huai Mae Ku Nuea (MK8)



E: Huai Mae Tao Moo 5 (MT5)



F: Huai Mae Ku Chua (MK2)



G: Huai Mae Ku Nuea (MK8)

Figure 3 (Continued)



A: Handpicking from the surfaces of stones crevices



B: Handpicking from gravel



C: Woody debris



D: Kick sampling by Pond net

Figure 4 Method for collection of larvae and pupae of Trichoptera at Mae Tao and Mae Ku watershed, Mae Sot District, Tak Province.

- A. Handpicking from the surfaces of stones crevices
- B. Handpicking from gravel
- C. Woody debris
- D. Kick sampling by Pond net



Figure 5 Light trap for collection of adult specimens of Trichoptera at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand.

RESULTS AND DISCUSSION

Results

1. Diversity of Trichoptera species in the Mae Tao and Mae Ku watershed

1.1 Larvae of Trichoptera

A total of 3,442 individuals of caddisflies larvae representing 10 families and 18 genera were collected. Hydropsychidae were the most numerous and ubiquitous family, comprising of five genera (Table 1). *Cheumatopsyche* spp., *Hydropsyche* sp., *Marilia* sp. and *Chimara* sp. had the highest mean abundances at all sites. The percentage individuals of caddisflies larvae in the family Hydropsychidae, Philopotamidae, Odontoceridae, Glossosomatidae and Leptoceridae were 77.0, 13.0, 7.0, 3.0 and 2.0 respectively (Figure 6).

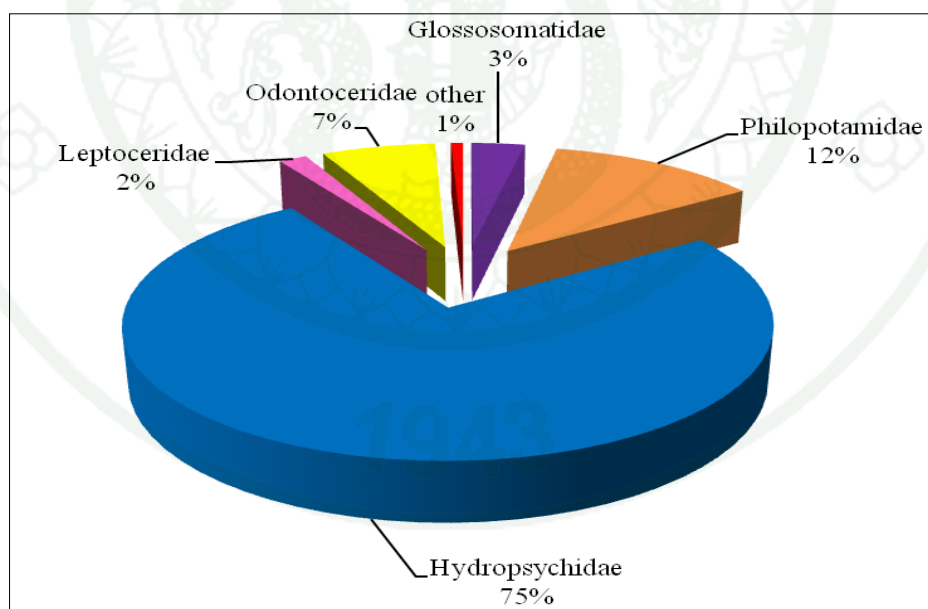


Figure 6 The percentage individuals of caddisflies larvae collected at seven sites along Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province, northern part of Thailand. (other = Hydroptilidae, Goeridae, Helicopsychidae, Lepidostomatidae and Calamoceratidae).

The detail of caddisflies larvae diversity at each sampling site as followed, at MT1 with 12 genera of 7 families; MT2 with 9 genera of 5 families; MT3 with 11 genera of 8 families; MT4 with 13 genera of 6 families; MT5 with 7 genera of 4 families; MK2 with 6 genera of 4 families and MK8 with 11 genera of 7 families (Table 2).

Table 2 List of caddisflies larvae collected in Mae Tao and Mae Ku watersheds during February to December 2011.

Species/site	Species	MT1	MT2	MT3	MT4	MT5	MK2	MK8
	code							
Glossosomatidae								
<i>Glossosoma</i>	sp14	79	9	3		18	1	
Hydroptilidae								
<i>Orthotrichia</i>				1				1
Philopotamidae								
<i>Chimarra</i>	sp10	3	157	34	63	133	42	1
Hydropsychidae								
<i>Cheumatopsyche</i>								
sp.1	sp1	107	346	56	138	281	34	277
<i>Cheumatopsyche</i>								
sp.2	sp2	42	44	28	97	549	1	59
<i>Diplectrona</i>	sp3	60	37	2	3	108	13	
<i>Hydropsyche</i>	sp4	36	91	1	24	21	80	3
<i>Macrostemum</i>	sp5		3		2			
<i>Potamyia</i>	sp6		3		2	32		
Goeridae								
<i>Goera</i>					2			

Table 2 (Continued)

Species/site	Species							
	code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Helicopsychidae								
<i>Helicopsyche</i>	sp13			2				
Lepidostomatidae								
<i>Lepidostoma</i>	sp12	8		1	5			
Leptoceridae								
<i>Ceraclea</i>	sp7	2		5	8			2
<i>Mystacides</i>	sp8	4		7	22			1
<i>Oecetis</i>	sp9		4		2			
<i>Setodes</i>					1			
Odontoceridae								
<i>Marilia</i>	sp11	107	3	37	56	2	3	26
Calamoceratidae								
<i>Anisocentropus</i>		2						
<i>Ganonema</i>	sp15	1			2			
Total number of species		12	10	12	15	8	7	8
Total numbers of individuals		451	697	177	427	1144	174	370

1.2 Adult Trichoptera

The survey of Trichoptera species diversity revealed a diverse and interesting fauna. A summary of the number of species and specimens identified from each site is presented in Table 3. A total of 8,376 specimens were identified to species. Overall, 122 Trichoptera species representing 35 genera and 14 families were identified. The family Leptoceridae contained the greatest number of species (36 species), followed by Hydroptilidae (26 species) Hydropsychidae (21 species) Ecnomidae (9 species) Psychomyiidae (9 species) Polycentropodidae (7 species)

Philopotamidae (6 species) Odontoceridae (2 species) Calmoceratidae (1 species) Dipseudopsidae (1 species) Glossosomatidae (1 species) Goeridae (1 species) Lepidostomatidae (1 species) and Xiphocentronidae (1 species). The percentage of caddisflies species richness in each family is shown in Figure 7.

The greatest number of species and individuals was collected in MT5 (2844 individuals) and *Hydroptila thuna* (3401 individuals). The lowest in both number of species and individuals was collected in MT 1 (175 individuals). The following is the species that was collected only a single time of the whole study: *Hydroptila gapdoi*, *H. suanhom*, *H. verticordia*, *Orthotrichia asimetrus*, *O. litoralis*, *O. maeandrica*, *O. parthenopaios*, *O. tyro*, *Chrysotrichia pallu*, *Chimarra karenorum*, *C. okuihorum*, *C. pipake*, *Nyctiophylax maath*, *Pseudoneureclipsis enos*, *P. sobak*, *Pahamunaya jihmita*, *Psychomyia intorachit*, *P. samanaka*, *Abaria guatila*, *Ecnomus ramayana*, *E. robustior*, *E. uttu*, *E. volovicus*, *Diplectrona gombak*, *Hydropsyche augeias*, *H. cacus*, *H. camillus*, *Oecetis lotis*, *O. momos*, *O. pretakalpa*, *Adicella longicerca*, *A. posticus*, *A. suthepensis*, *Triaenodes dusra*, *T. menestheus*, *Leptocerus rutulus*, *Setodes oinomaos*, and *S. thoneti* (Table 3).

Many caddisfly species, such as the philopotamid species (*Chimarra akkaorum*, *C. chiangmaiensis*), the hydropsychid species (*Potamyia flavata*, *Cheumatopsyche dhanikari*, *C. globosa*), the leptocerid species (*Oecetis scutulata*), the hydroptilid species (*Hydroptila thuna*) were dominant and distributed at all collecting sites.

Of the 122 species collected, 52 were represented by only a single specimen over the entire year. Some of these species might either be rare or, in the case at least of *Nyctiophylax amaltheia*, was not attracted to black lights. Therefore, phenological data of species represented by relatively few specimens over the year can be misleading.

The detail of caddisflies adults diversity at each sampling site as followed, at MT1 found with 27 species of 15 genera and 7 families; MT2 found with 60

species of 26 genera 9 families; MT3 found with 54 species of 23 genera and 11 families; MT4 found with 60 species of 20 genera and 11 families; MT5 found with 45 species of 21 genera and 10 families; MK2 found with 25 species of 14 genera and 8 families and MK8 found with 45 species of 19 genera and 12 families (Table 3).

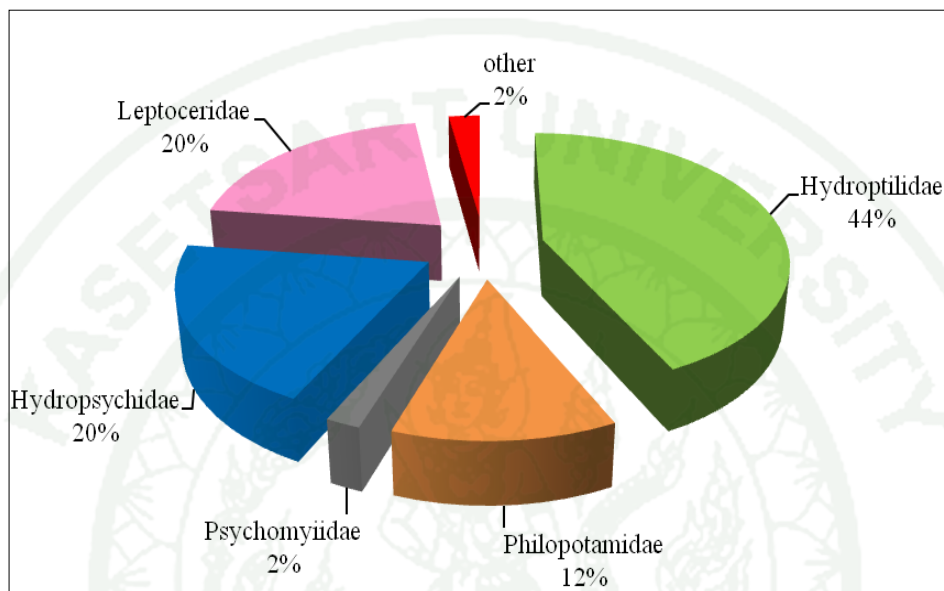


Figure 7 The percentage of caddisflies species richness in each family at sampling sites in Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province collected during February to December 2011 (other = Calamoceratidae, Dipseudopsidae, Ecnomidae, Glossosomatidae, Goeridae, Lepidostomatidae, Odontocridae, Polycentropodidae, and Xiphocentronidae).

Table 3 List of adult trichopteran species collected in Mae Tao and Mae Ku watersheds during February to December 2011.

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Glossosomatidae								
<i>Agapetus halong</i> OLAH 1988		11	9	1	1	2		2
Hydroptilidae								
<i>Hydroptila gapdoi</i> OLAH 1989						1		
<i>Hydroptila kalchas</i> MALICKY 2004					11			
<i>Hydroptila keres</i> MALICKY 2004			3					
<i>Hydroptila psyche</i> M&C 2007		1	1					
<i>Hydroptila sabit</i> WELLS&HUISMAN 1992	sp16		24	5	2	6		
<i>Hydroptila srisungwan</i> M&C 2007			3	2				
<i>Hydroptila suanhom</i> M&C 2007				1				
<i>Hydroptila thuna</i> OLAH 1989	sp17	21	68	126	713	2158	36	279
<i>Hydroptila verticordia</i> M&C 2007					1			
<i>Sarangano-trichia chiangdao</i> M&C 2007			3					
<i>Oxyethira bogambara</i> SCHMID 1958							6	
<i>Orthotrichia asimetrus</i> WELLS & MALICKY 1997						1		
<i>Orthotrichia bencana</i> OLAH 1989					4			
<i>Orthotrichia huaihuat</i> M&C 2007				2				1
<i>Orthotrichia indica</i> MARTYNOV 1935					3			
<i>Orthotrichia lanna</i> M&C 2007	sp18		11	5	7	18		1
<i>Orthotrichia litoralis</i> ULMER 1951				1				
<i>Orthotrichia parthenopaios</i> M&C 2007						1		

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Hydroptilidae								
<i>Orthotrichia penthesileia</i>								
M&C 2007				1	1			
<i>Orthotrichia polyxena</i>								
M&C 2007		1			2			
<i>Orthotrichia typhoeus</i>	sp19	1	21	157	5	15		1
M&C 2007				1				
<i>Parastactobia khakaeng</i>								
M&C 2007			28		2	6		
<i>Chrysotrichia pallu</i>								
MALICKY & PROMMI 2009				1				
<i>Chrysotrichia tydeus</i>	sp20		22			2		2
Philopotamidae								
<i>Chimarra akkaorum</i>	sp21	4	378	305	17	7	60	2
<i>Chimarra chiangmaiensis</i>	sp22	1	30	95	44	31	1	1
<i>Chimarra karenorum</i>								
C&M 1989			1					
<i>Chimarra okuihorum</i>							1	
MEY 1998								
<i>Chimarra pipake</i>							1	
M&C 1993								
<i>Gunungiella myrrha</i>								
M&C 2003			2					

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Polycentropodidae								
<i>Nyctiophylax maath</i>								
M&C 1993					1			
<i>Polyplectropus ahas</i>								
M&C 1993			2		21			
<i>Pseudoneureclipsis enos</i>								
M&C 1993			1					
<i>Pseudoneureclipsis ramosa</i>								
ULMER 1913	sp23		1	3	5	2		1
<i>Pseudoneureclipsis sobak</i>								
M&C 2009			1					
Polycentropodidae								
<i>Pseudoneureclipsis uma</i>								
M&C 1993					2			
<i>Pahamunaya jihmita</i>								
SCHMID & DENNING 1979				1				
Psychomyiidae								
<i>Paduniella anakenam</i>								
M&C 1995				2				
<i>Paduniella semarangensis</i>								
ULMER 1913			1	2		3		
<i>Psychomyia intorachit</i>								
M&C 1993			1					
<i>Psychomyia kerynitia</i>								
MALICKY & NUNTAKWANG 2006	sp24			28	73			2
<i>Psychomyia kuni</i>								8
M&C 1993								
<i>Psychomyia lak</i>								
M&C 1993	sp25		2	1	11	2		4
<i>Psychomyia samanaka</i>								
M&C 1993								1
<i>Tinodes eris</i>								
MALICKY & SAENGPRADAB 2001		1	1					
<i>Lype atnia</i>								
M&C 1993	sp26	1	1	1	2	1	1	4

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Xiphocentronidae								
<i>Abaria guatila</i>							1	
M&C1992								
Ecnomidae								
<i>Ecnomus jojachin</i>					4	3		
M&C 1993								
<i>Ecnomus puro</i>	sp27		11	6	16	16		2
M&C 1993								
<i>Ecnomus ramayana</i>				1				
M&C 1993								
<i>Ecnomus robustior</i>	sp28					1		
ULMER 1951								
<i>Ecnomus thamyris</i>			2					
MALICKY & PROMMI 2006								
<i>Ecnomus thogarma</i>							3	
M&C 2009								
<i>Ecnomus uttu</i>	M&C			1				
1993								
<i>Ecnomus venimar</i>			3			1		1
M&C 1993								
<i>Ecnomus volovicus</i>					1			
M&C 1993								
Dipseudopsidae								
<i>Dipseudopsis robustior</i>					2	4		1
ULMER 1929								
Hydropsychidae								
<i>Diplectrona aurovittata</i>							4	
ULMER 1906								
<i>Diplectrona gombak</i>						1		
OLAH 1993								
<i>Macrostemum fenestratum</i>			2					
ALBARDA 1887								

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Hydropsychidae								
<i>Potamyia dryope</i> MALICKY & THANI 2000	sp29			3	6	1		9
<i>Potamyia flavata</i> BANKS 1934	sp30	21	23	30	42	19	7	10
<i>Potamyia phaidra</i> M&C 1997			3		2			
<i>Cheumatopsyche caieta</i> M&C 1997	sp31		1		5	1		1
<i>Cheumatopsyche carna</i> M&C 1997			25					
<i>Cheumatopsyche carmentis</i> M&C 1997	sp32	2	2	5	387	40		3
<i>Cheumatopsyche chryseis</i> M&C 1997	sp33		1	11	9	1		13
<i>Cheumatopsyche chrysothemis</i> M&C 1997	sp34		3	14		1		
<i>Cheumatopsyche criseyde</i> M&C 1997	sp35		8			1	2	
<i>Cheumatopsyche dhanikari</i> MALICKY 1979	sp36	17	19	15	11	50	52	4
<i>Cheumatopsyche dubitans</i> MOSELY 1942	sp37	1	6				2	
<i>Cheumatopsyche globosa</i> ULMER 1910	sp38	6	132	16	40	31	4	4
<i>Cheumatopsyche jaekam</i> M&C 2009	sp39		133				2	1
<i>Cheumatopsyche lucida</i> ULMER 1907	sp40	9	17	13	97	140		52
<i>Cheumatopsyche tramota</i> M&C 1997		1	3					
<i>Hydropsyche augeias</i> M&C 2000		1						
<i>Hydropsyche cacus</i> M&C 2000			1					
<i>Hydropsyche camillus</i> M&C 2000						1		

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Goeridae								
<i>Geora minor</i>								
MOSELY 1938			11					
Lepidostomatidae								
<i>Lepidostoma doligung</i>								
MALICKY 1979	sp41			2	8			1
Leptoceridae								
<i>Oecetis armadillo</i>								
M&C 2005				1	3			
<i>Oecetis asmada</i>								
MALICKY 1979	sp42	3	3	1	12	6		8
<i>Oecetis biramosa</i>								
MARTYNOV 1936						24	1	
<i>Oecetis devakiputra</i>								
SCHMID 1995					1			1
<i>Oecetis empusa</i>								
MALICKY & CHAIBU 2000	sp43			1	1			2
<i>Oecetis hades</i> M&C 2003		1	3					
<i>Oecetis laodike</i>								
MALICKY & CHEUNBARN 2005	sp44				1	1	1	
<i>Oecetis lotis</i> MALICKY & THAPANYA 2004					1			
<i>Oecetis meleagros</i>								
MALICKY & THANI 2005					12			
<i>Oecetis momos</i>								
MALICKY 2005							1	
<i>Oecetis pretakalpa</i>								
SCHMID 1995					1			
<i>Oecetis raghava</i>								
SCHMID 1995	sp45		2	4	27			9
<i>Oecetis scutulata</i>								
MARTYNOV 1936	sp46	36	64	108	192	106	33	47
<i>Oecetis tripunctata</i>								
FABRICIUS 1793	sp47	1	14	11	53	32		5
<i>Adicella iole</i> M&C 2002	sp48		1	1	6			
<i>Adicella longicerca</i>								
KIMMINS 1963					1			

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Leptoceridae								
<i>Adicella posticus</i>								
BANKS 1911			1					
<i>Adicella suthepensis</i>								
M&C 1991						1		
<i>Tagalopsyche brunnea</i>								
ULMER 1905		1		1				
<i>Triaenodes dusra</i>								
SCHMID 1965				1				
<i>Triaenodes menestheus</i>								
MALICKY 2005			1					
<i>Leptocerus dirghachuka</i>								
GORDON & SCHMID 1987	sp49	1		11	51	25		
<i>Leptocerus faunus</i>								
M&C 2002					3			
<i>Leptocerus ganymedes</i>								
M&C 2002	sp50			1	3			1
<i>Leptocerus rutulus</i>								
MALICKY & PROMMI 2006					1			
<i>Leptocerus suthepensis</i>								
M&C 1991				3	3			
<i>Leptocerus trophonios</i>								
M&C 2006	sp51		1	1	9	4		4
<i>Setodes endymion</i>								
M&C 2000	sp52	12	9	8	10	1	1	
<i>Setodes fluvialis</i>								
KIMMINS 1963	sp53	1	4	4	26	18		7
<i>Setodes isis</i>								
MALICKY & NAWVONG 2006			1					2
<i>Setodes mercurius</i>								
MALICKY & BUNLUE 2006								2
<i>Setodes neptunus</i>								
MALICKY & SAENGPRADAB 2006	sp54			3	16			1

Table 3 (Continued)

Species/site	Species code	MT1	MT2	MT3	MT4	MT5	MK2	MK8
Leptoceridae								
<i>Setodes oinomaos</i>					1			
M&C 2006								
<i>Setodes okypete</i>								
M&C 2006	sp55		46	262	126	56	2	45
<i>Setodes sarapis</i>								
M&C 2006	sp56	3		1	1			1
<i>Setodes thoneti</i>								
M&C 2006			1					
Odontoceridae								
<i>Marilia mogtiana</i>								
MALICKY 1989			1					1
<i>Marilia sumatrana</i>								
ULMER 1951	sp57	16	6	2	1		2	1
Calamoceratidae								
<i>Anisocentropus erichthonios</i>								
MALICKY & CHEUNBARN 2001	sp58			1		2		1
Total number of species		27	60	54	60	45	25	45
Total numbers of individuals		175	1179	1285	2119	2844	224	550

1.3 The diversity indices (H') of Trichoptera species in each sampling sites

The diversity indices (H') of both larvae and adult Trichoptera was compared among sampling site (Figure 8, 9). The diversity indices of larvae at all sampling sites ranged from 0.352 to 0.835. The high diversity of caddisfly larvae was found at MT1 (0.835), followed by MT4 (0.790), MT3 (0.765), MT2 (0.623), MT5 (0.611), MK2 (0.586), and at MK8 was the lowest (0.352).

The diversity indices of adult at all sampling sites ranged from 0.534 to 1.168. The high diversity of caddisfly adult was found at MT2 (1.168), followed by

MT1 (1.127), MT4 (1.085), MK2 (0.913), MK8 (0.907), and at MT5 was the lowest (0.535).

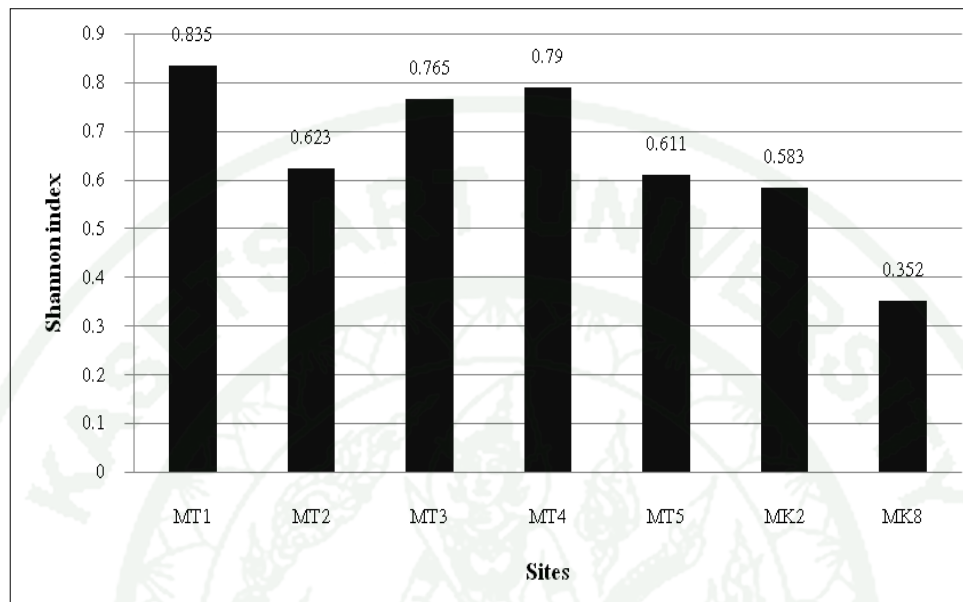


Figure 8 Diversity index of Trichopteran larvae at all sampling sites at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak province collected during February to December 2011.

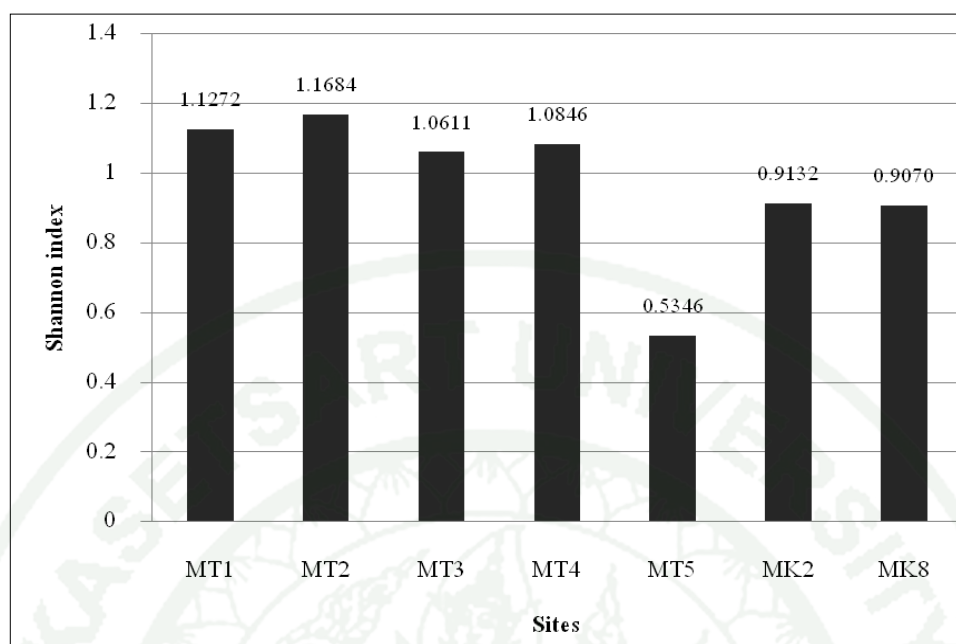


Figure 9 Diversity index of adult Trichopteran species at all sampling sites at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak province collected during February to December 2011.

2. Physico-chemical parameters of water quality in Mae Tao and Mae Ku watersheds

Mean values of selected physico-chemical parameters of water quality and cadmium concentration in sediment at Mae Tao and Mae Ku watersheds during this study are presented in Table 4. Air and water temperature, pH of water, electrical conductivity, total dissolved solids, turbidity, sulfate, nitrate-nitrogen, orthophosphate, alkalinity, and cadmium concentration in stream sediment were varied significantly during the period of study (Table 4). The dissolved oxygen and ammonia-nitrogen concentrations among the sampling sites were not varied significantly ($p < 0.05$), using ANOVA (Table 4).

2.1 Air temperature (T_a)

The mean value of air temperature at all sampling sites ranged from 25.68 to 32.04 °C. The average value of air temperature at each sampling site as followed, MT1 (30.34±1.86), MT2 (28.54±3.45), MT3 (31.37±2.97), MT4 (25.36±2.53), MT5 (27.26±2.30), MK2 (25.68±3.57) and MK8 (32.04±2.25) °C (Table 4).

2.2 Water temperature (T_w)

The mean value of water temperature at all sampling sites ranges from 24.49 - 26.37 °C. The average value of air temperature at each sampling site as followed, MT1 (26.37±2.20), MT2 (25.55±1.75), MT3 (25.94±1.82), MT4 (24.99±2.27), MT5 (25.78±2.27), MK2 (25.78±2.37), and MK8 (24.49±1.80) °C (Table 4).

2.3 Dissolved oxygen (DO)

The mean value of dissolved oxygen at all sampling sites ranges from 4.43 - 5.45 mg/L. The average value of dissolved oxygen at each sampling site as followed, MT1 (4.43±1.08), MT2 (5.39±1.20), MT3 (5.2±0.84), MT4 (5.08±1.30), MT5 (4.44±1.95), MK2 (5.45±1.14) and MK8 (5.09±0.92) mg/L (Table 4).

2.4 pH of water

The mean value of pH of water at all sampling sites ranges from 8.07 - 8.88. The average value of pH of water at each sampling site as followed, MT1 (8.07±0.20), MT2 (8.56±0.12), MT3 (8.65±0.14), MT4 (8.66±0.23), MT5 (8.43±0.30), MK2 (8.8±0.10) and MK8 (8.48±0.07) (Table 4).

2.5 Electric conductivity (EC)

The mean value of EC at all sampling sites ranges from 291.41 – 556.32 $\mu\text{s}/\text{cm}$. The average value of EC at each sampling site as followed, MT1 (291.41 \pm 87.22), MT2 (484.32 \pm 138.15), MT3 (491.97 \pm 119.34), MT4 (443.39 \pm 85.96), MT5 (500.1 \pm 137.78), MK2 (488.25 \pm 144.88) and MK8 (556.32 \pm 232.12) $\mu\text{s}/\text{cm}$ (Table 4).

2.6 Total dissolved solids (TDS)

The mean value of TDS at all sampling sites ranges from 159.30 - 299.65 mg/L. The average value of TDS at each sampling site as followed, MT1 (159.30 \pm 34.84), MT2 (230.04 \pm 23.09), MT3 (227.55 \pm 57.54), MT4 (217.73 \pm 40.05), MT5 (246.16 \pm 53.32), MK2 (240.66 \pm 68.80) and MK8 (299.66 \pm 116.91) mg/L (Table 4).

2.7 Turbidity (Tur)

The mean value of turbidity at all sampling sites ranges from 7.20 – 29.00 FTU. The average value of turbidity at each sampling site as followed, MT1 (16.00 \pm 5.21), MT2 (11.20 \pm 6.37), MT3 (9.80 \pm 9.41), MT4 (7.80 \pm 5.80), MT5 (7.20 \pm 4.23), MK2 (29.00 \pm 21.84) and MK8 (26.00 \pm 23.09) FTU (Table 4).

2.8 Sulfate (SO_4^{2-})

The mean value of SO_4^{2-} at all sampling sites ranges from 16.50-36.83 mg/L. The average value of SO_4^{2-} at each sampling site as followed, MT1 (16.50 \pm 2.94), MT2 (23.83 \pm 7.27), MT3 (33.50 \pm 5.95), MT4 (34.20 \pm 5.67), MT5 (36.83 \pm 7.67), MK2 (20.40 \pm 5.89) and MK8 (24.83 \pm 13.12) mg/L (Table 4).

2.9 Nitrate-nitrogen (NO₃-N)

The mean value of NO₃-N at all sampling sites ranges from 1.98 – 3.15 mg/L. The average value of NO₃-N at each sampling site as followed, MT1 (1.98±0.66), MT2 (2.03±0.51), MT3 (2.13±0.50), MT4 (2.08±1.30), MT5 (2.31±0.67), MK2 (3.10±0.36) and MK8 (3.15±0.56) mg/L (Table 4).

2.10 Orthophosphate (PO₄³⁻)

The mean value of PO₄³⁻ at all sampling sites ranges from 0.21 – 0.88 mg/L. The average value of PO₄³⁻ at each sampling site as followed, MT1 (0.88±0.70), MT2 (0.32±0.30), MT3 (0.23±0.20), MT4 (0.21±0.14), MT5 (0.42±0.40), MK2 (0.34±0.09) and MK8 (0.22±0.13) mg/L (Table 4).

2.11 Ammonia-nitrogen (NH₄-N)

The mean value of NH₄-N at all sampling sites ranges from 0.28 - 0.35 mg/L. The average value of NH₄-N at each sampling site as followed, MT1 (0.29±0.12), MT2 (0.28±0.15), MT3 (0.28±0.13), MT4 (0.29±0.16), MT5 (0.35±0.11), MK2 (0.30±0.17) and MK8 (0.28±0.13) mg/L (Table 4).

2.12 Alkalinity (Alk)

The mean value alkalinity at all sampling sites ranges from 48.83 - 81.0 mg/L. The average value of alkalinity at each sampling site as followed, MT1 (48.83±13.97), MT2 (70.16±13.8), MT3 (81.00±30.84), MT4 (67.80±13.34), MT5 (67.50±10.61), MK2 (68.40±24.36) and MK8 (78.16±24.36) mg/L (Table 4).

2.13 Cadmium (Cd)

The mean value of cadmium concentration in stream sediment at all sampling sites ranges from 0.08- 11.45 mg/kg. The average value of cadmium

concentration in stream sediment at each sampling site as followed, MT1 (0.44 ± 0.35), MT2 (0.38 ± 0.26), MT3 (11.45 ± 6.76), MT4 (9.83 ± 3.34), MT5 (11.15 ± 5.57), MK2 (0.08 ± 0.04) and MK8 (4.02 ± 1.61) mg/kg (Table 4).



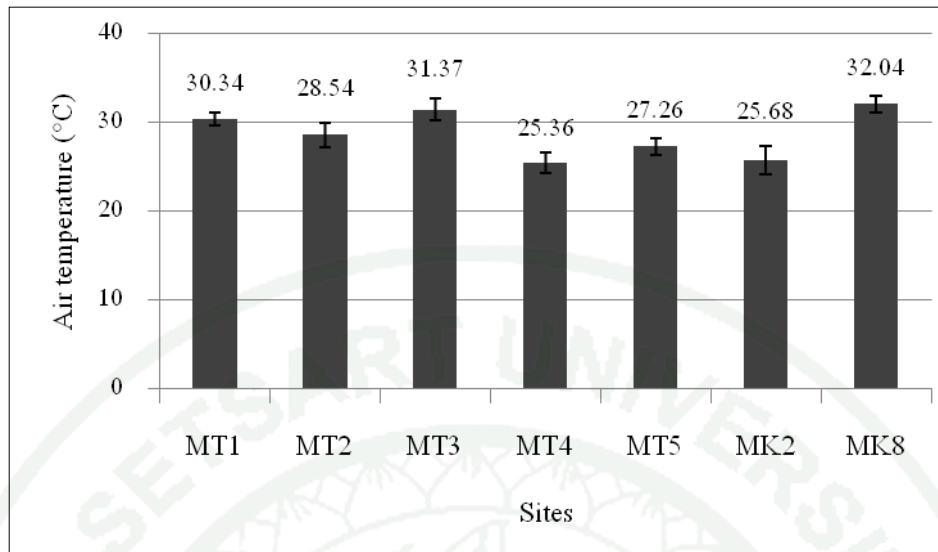
Table 4 Average physico-chemical water quality parameters and cadmium measured at all the sampling sites in Mae Tao and Mae Ku watersheds (mean value \pm S.D.) during February to December 2011.

	MT 1	MT 2	MT 3	MT 4	MT 5	MK 2	MK 8
Air temperature (°C)	30.34 \pm 1.86 ^{bcd}	28.54 \pm 3.45 ^{abc}	31.37 \pm 2.97 ^{cd}	25.36 \pm 2.53 ^a	27.26 \pm 2.30 ^{ab}	25.68 \pm 3.57 ^a	32.04 \pm 2.25 ^d
Water temperature (°C)	26.37 \pm 2.20 ^{ab}	25.55 \pm 1.75 ^{ab}	25.94 \pm 1.82 ^{ab}	24.99 \pm 2.27 ^a	25.78 \pm 2.37 ^{ab}	24.49 \pm 1.80 ^a	27.94 \pm 1.68 ^b
DO (mg/L)	4.43 \pm 1.08 ^a	5.39 \pm 1.20 ^a	5.2 \pm 0.84 ^a	5.08 \pm 1.30 ^a	4.44 \pm 1.95 ^a	5.45 \pm 1.14 ^a	5.09 \pm 0.92 ^a
pH	8.07 \pm 0.21 ^a	8.56 \pm 0.12 ^{bc}	8.65 \pm 0.14 ^{bc}	8.66 \pm 0.23 ^{bc}	8.43 \pm 0.30 ^b	8.8 \pm 0.10 ^c	8.48 \pm 0.07 ^b
EC (μ s/cm)	291.41 \pm 87.22 ^a	484.33 \pm 138.15 ^b	491.97 \pm 119.34 ^b	443.39 \pm 85.96 ^{ab}	500.1 \pm 137.78 ^b	488.25 \pm 144.88 ^b	556.32 \pm 232.12 ^b
TDS (mg/L)	159.3 \pm 34.84 ^a	230.04 \pm 23.09 ^{ab}	227.55 \pm 57.54 ^{ab}	217.73 \pm 40.05 ^{ab}	246.16 \pm 53.32 ^b	240.66 \pm 68.80 ^{ab}	299.66 \pm 116.91 ^b
Turbidity (FTU)	16.0 \pm 5.21 ^a	11.20 \pm 6.37 ^{abc}	9.8 \pm 9.41 ^{ab}	7.8 \pm 5.8 ^{ab}	7.2 \pm 4.23 ^{abc}	29.0 \pm 21.84 ^c	26.0 \pm 23.09 ^{bc}

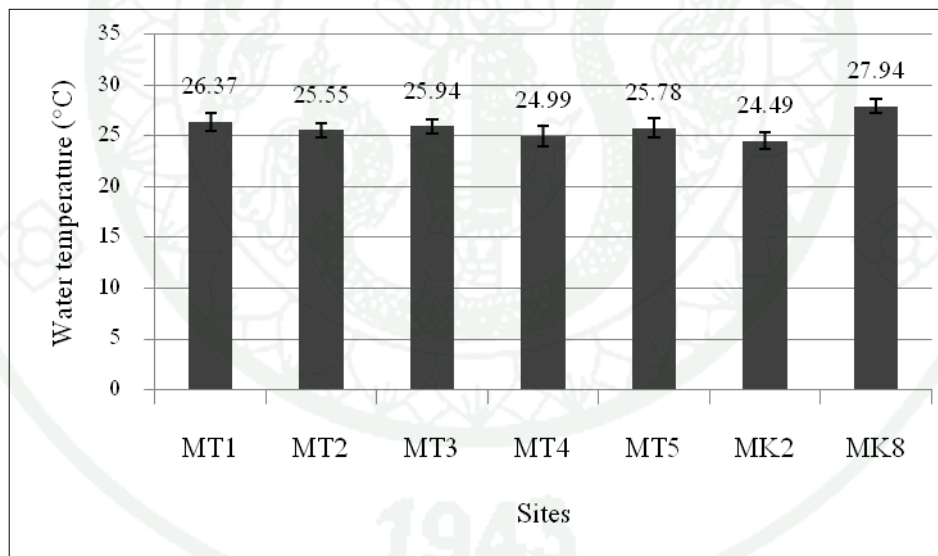
1943

Table 4 (Continued)

	MT 1	MT 2	MT 3	MT 4	MT 5	MK 2	MK 8
SO ₄ ² (mg/L)	16.5±2.94 ^a	23.83±7.27 ^a	33.5±5.95 ^{bc}	34.2±5.67 ^{bc}	36.83±7.67 ^c	20.40±5.89 ^a	24.83±13.12 ^{ab}
NO ₃ -N (mg/L)	1.98±0.66 ^a	2.03±0.51 ^a	2.13±0.50 ^a	2.08±0.30 ^a	2.31±0.67 ^a	3.10±0.36 ^b	3.15±0.56 ^b
PO ₄ ³ (mg/L)	0.88±0.70 ^b	0.32±0.30 ^{ab}	0.23±0.20 ^a	0.21±0.14 ^a	0.42±0.40 ^{ab}	0.34±0.09 ^{ab}	0.22±0.13 ^a
NH ₄ -N (mg/L)	0.29±0.12 ^a	0.28±0.15 ^a	0.28±0.13 ^a	0.29±0.16 ^a	0.35±0.11 ^a	0.30±0.17 ^a	0.28±0.13 ^a
Alkalinity (mg/L)	48.83±13.97 ^a	70.16±13.8 ^{ab}	81.0±30.84 ^b	67.8±13.34 ^{ab}	67.5±10.61 ^{ab}	68.4±24.36 ^{ab}	78.16±24.36 ^b
Cadmium (mg/kg)	0.44 ±0.35 ^a	0.38±0.26 ^a	11.45±6.76 ^b	9.83±3.34 ^{ab}	11.15±5.57 ^{ab}	0.08±0.04 ^a	4.02±1.61 ^a

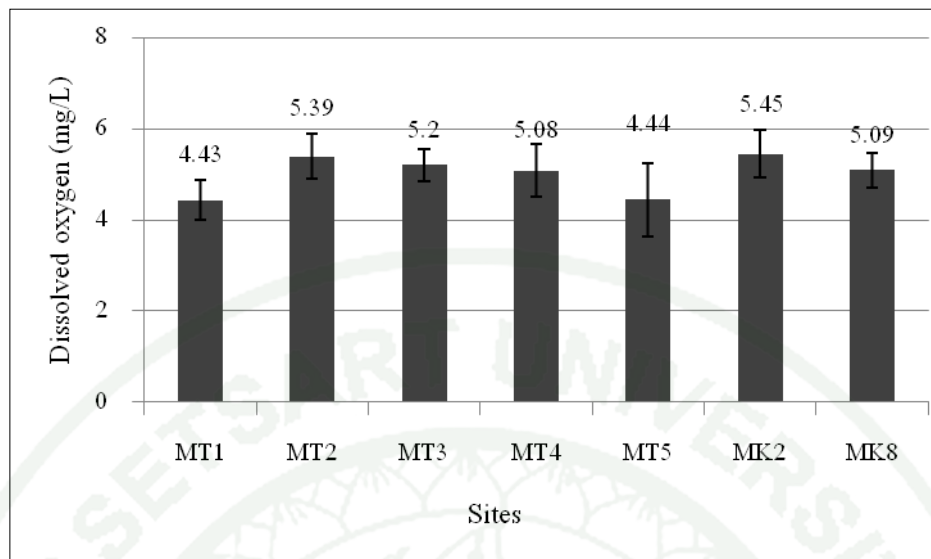


A. Air temperature

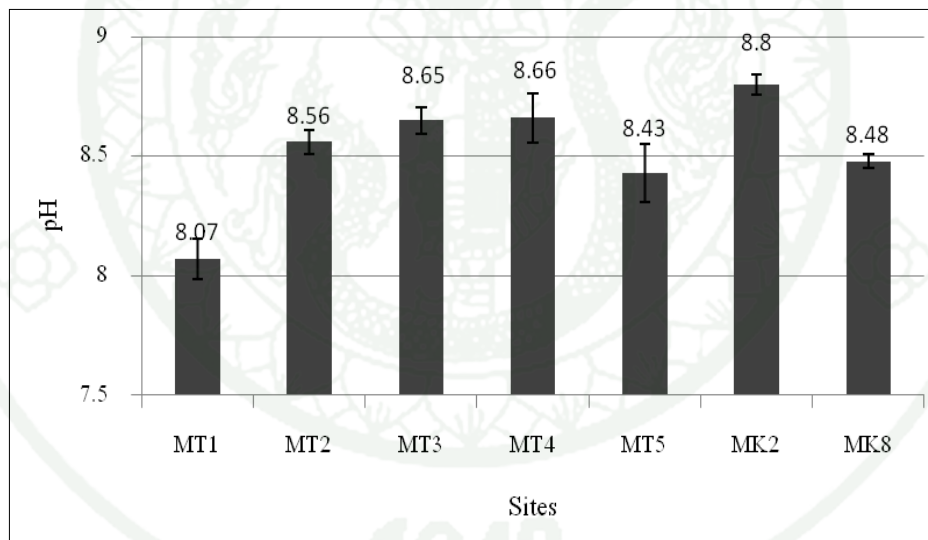


B. Water temperature

Figure 10 Mean value of air temperature (A) and water temperature (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.

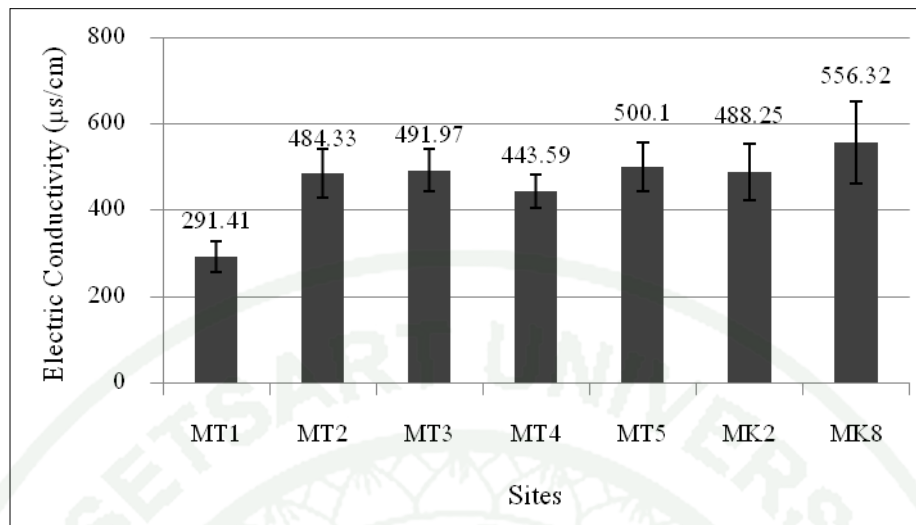


A. Dissolved oxygen

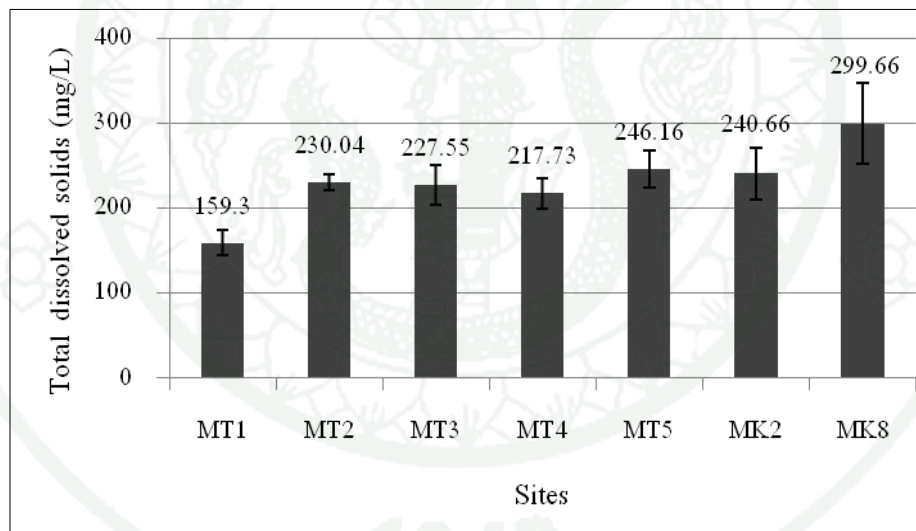


B. pH of water

Figure 11 Mean value of dissolved oxygen (A) and pH of water (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011

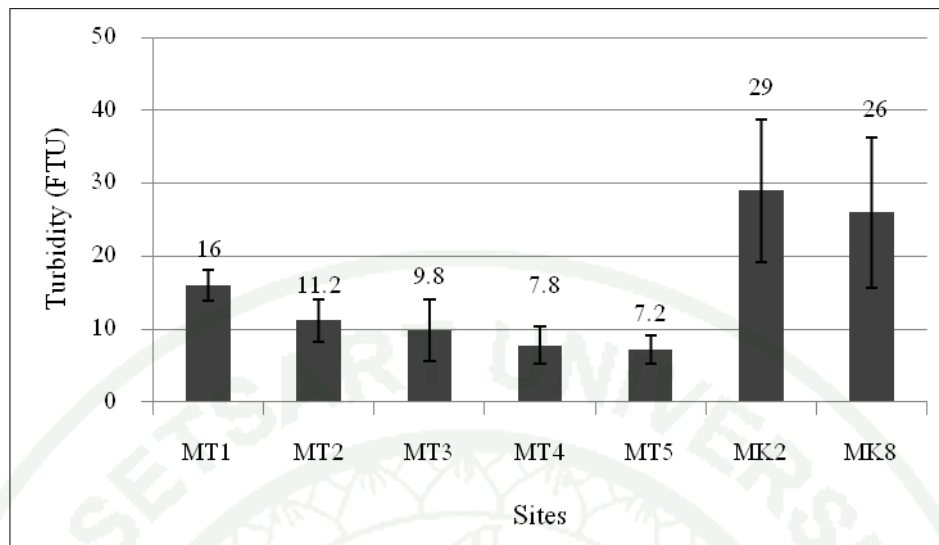


A. Electric conductivity

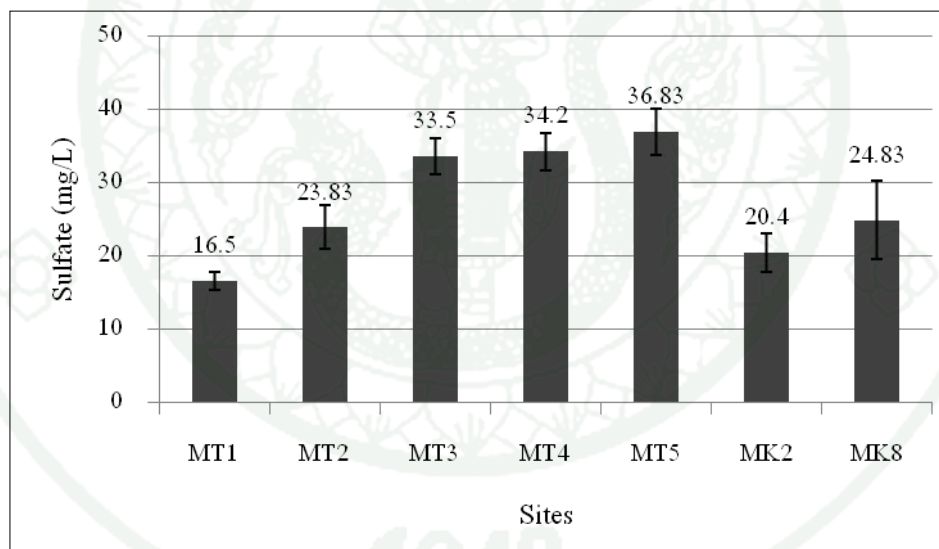


B. Total dissolved solids

Figure 12 Mean value of electrical conductivity (A) and total dissolved solids (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.

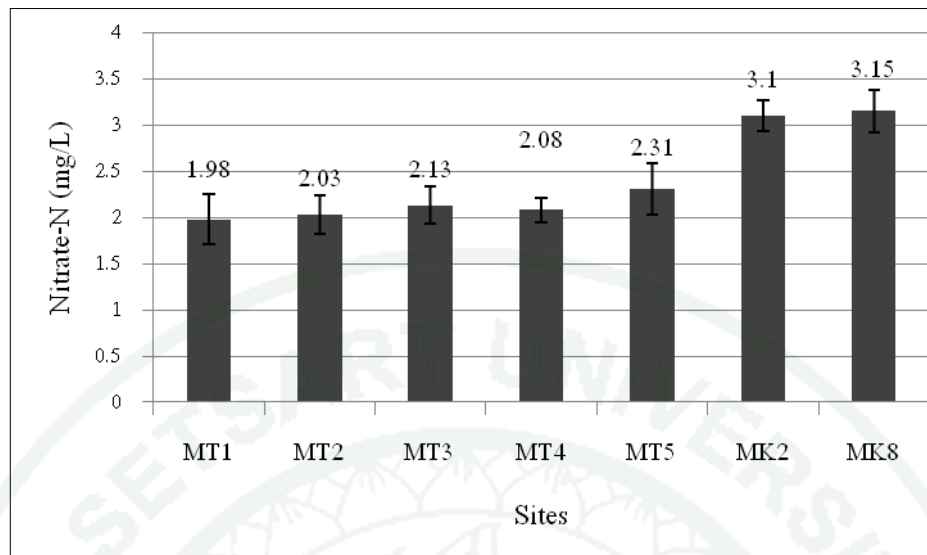


A. Turbidity

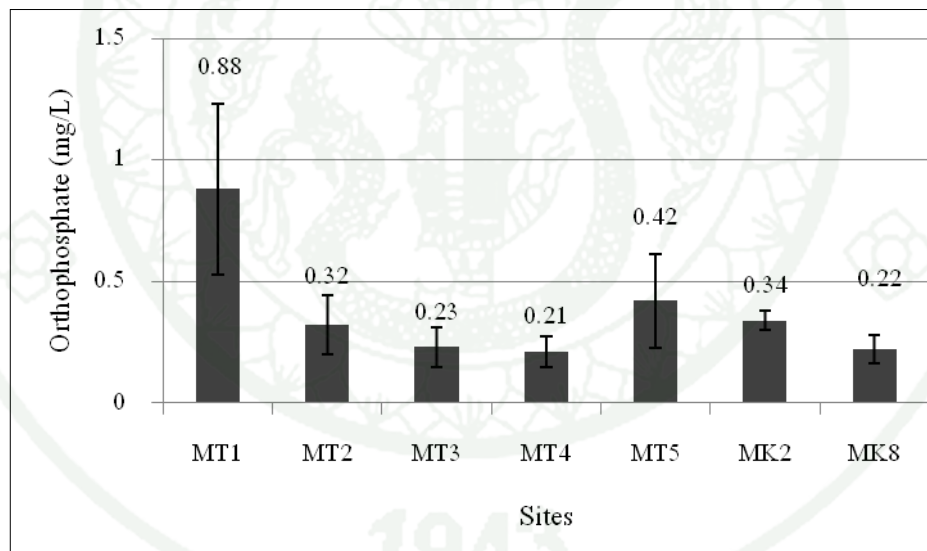


B. Sulfate

Figure 13 Mean value of turbidity (A) and sulfate (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.

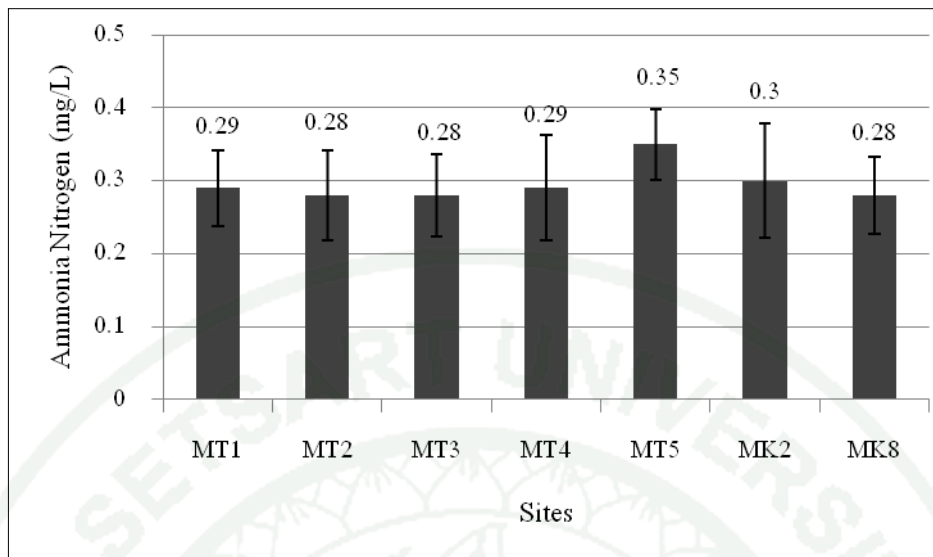


A. Nitrate-nitrogen

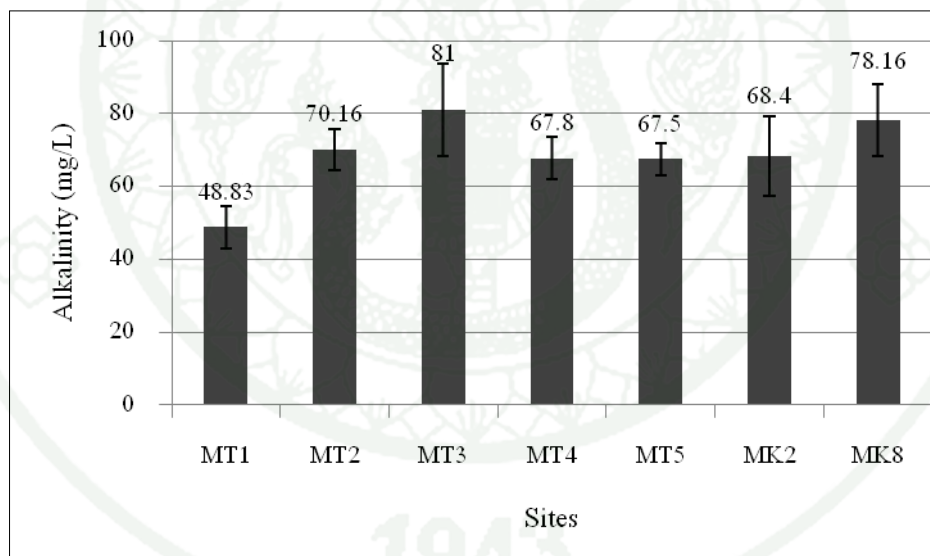


B. Orthophosphate

Figure 14 Mean value of nitrate-nitrogen (A) and orthophosphate (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.

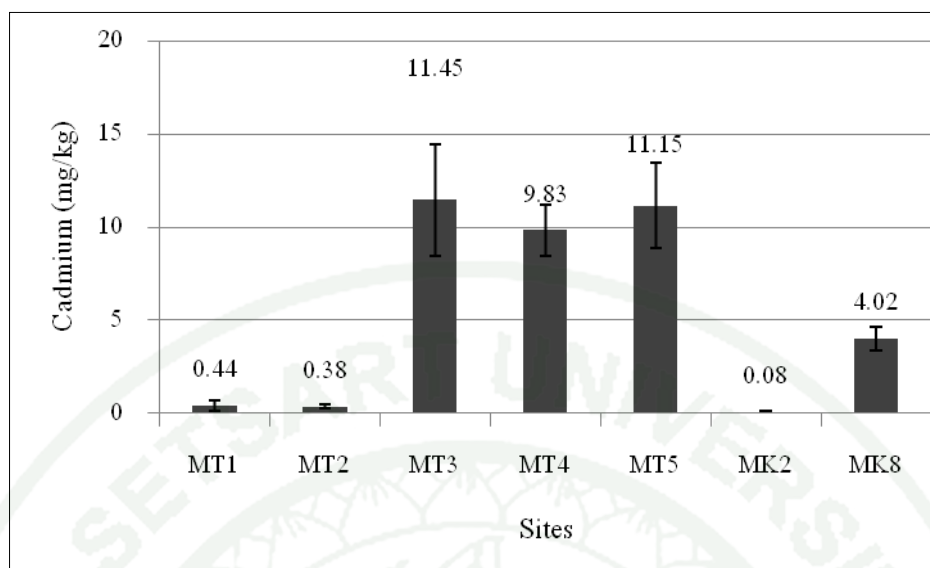


A. Ammonia nitrogen



B. Alkalinity

Figure 15 Mean value of ammonia-nitrogen (A) and alkalinity (B) at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.



A. Cadmium

Figure 16 Mean value of cadmium in sediment at all sampling sites at Mae Tao and Mae Ku watersheds collected during February to December 2011.

3. Ordination and classification

Principal Components Analysis (PCA) is a method with the potential for application in water quality evaluation and also useful in identifying the important environmental factors related to the presence or distribution of Trichoptera taxa. Cumulative percentage of variance by first axes of the analysis was 35.360%, second axes of the analysis was 56.31%. (Table 5)

The correlated between Trichoptera taxa all larvae and adult with sampling sites from analyze of Principal Components Analysis (PCA) (Figure 17). MT1 were correlated with *Cheumatopsyche* sp.1 (sp.1), *Chimarra* (sp10), *Lepidostoma* (sp12), *Glossosoma* (sp14), *Cheumatopsyche chrysothemis* (sp34) and *Marilia sumatrana* (sp57). MT 2 were correlated with *Hydropsyche* (sp4), *Hydroptila sabit* (sp16), *Chrysotrichia tydeus* (sp20), *Chimarra akkaorum* (sp21), *Cheumatopsyche criseyde* (sp35), *C. dubitans* (sp37), *C. globosa* (sp38) and *C. jaekam* (sp39). MT3 were

correlated with *Ceraclea* (sp7), *Marilia* (sp11), *Orthotrichia typhoeus* (sp19), *Chimarra Chiangmaiensis* (sp22), *Setodes okypete* (sp55) and *S. sarapis* (sp56). MT4 were correlated with *Mystacides* (sp8), *Helicopsyche* (sp13), *Ganonema* (sp15), *Pseudoneureclipsis ramosa* (sp23), *Psychomyia kerynitia* (sp24), *P. lak* (sp25), *Ecnomus puro* (sp27), *Potamyia dryope* (sp29), *P. flavata* (sp30), *Cheumatopsyche caieta* (sp31), *C. carmentis* (sp32), *C. chryseis* (sp33), *Lepidostoma doligung* (sp41), *Oecetis asmada* (sp42), *O. empusa* (sp43), *O. raghava* (sp45), *O. scutulata* (sp46), *O. tripunctata* (sp47), *Adicella iole* (sp48), *Leptocerus dirghachuka* (sp49), *L. ganymedes* (sp50), *L. trophonios* (sp51), *Setodes fluvialis* (sp53) and *S. neptunus* (sp54). MT5 were correlated with *Cheumatopsyche* sp.2 (sp2), *Potamyia* (sp6), *Hydroptila thuna* (sp17), *Dipseudopsis robustior* (sp28), *Cheumatopsyche lucida* (sp40) and *Anisocentropus erichthonios* (sp58). MK2 were correlated with *Diplectrona* (sp3) and *Cheumatopsyche dhanikari* (sp36). MK8 were correlated with *Orthotrichia lanna* (sp18), *Lype atria* (sp26), *Oecetis empusa* (sp43) and *O. laodike* (sp44).

Canonical Correspondance Analysis (CCA) is another method with the potential for application in water quality evaluation. CCA allowed for an examination of the correlations among species and environmental factors. The main factors affecting composition of Trichoptera taxa were air temperature, water temperature, dissolved oxygen, pH, electric conductivity, total dissolved solids, turbidity, orthophosphate, sulfate, nitrate-nitrogen, ammonia-nitrogen, alkalinity and cadmium respectively. In this study, CCA of all sites, both reference and assessment, recognized three assemblages of benthic macroinvertebrates. Cumulative percentage of variance by first axes of the analysis was 34.40%, second axes of the analysis was 53.30% and third axes of the analysis was 65.90%. (Table 6)

Figure 18 shows that the physico-chemical parameters of water quality were correlated with Trichoptera taxa for both larvae and adults. Water temperature were correlated negatively with dissolved oxygen, pH, *Potamyia flavata* (sp30), *Cheumatopsyche* sp.1 (sp1), *Pseudoneureclipsis ramosa* (sp23), *Lype atria* (sp26), *Cheumatopsyche dhanikari* (sp36) and *Oecetis scutulata* (sp46). Air temperature were

correlated negatively with *Cheumatopsyche chryseis* (sp33) and correlated positively with *Orthotrichia lanna* (sp18) and *Potamyia dryope* (sp29).

Turbidity were correlated positively with electric conductivity, total dissolved solids, *Cheumatopsyche* sp2 (sp2), *Orthotrichia lanna* (sp18), *O. typhoeus* (sp19), *Cheumatopsyche chrysothemis* (sp34), *Oecetis asmada* (sp42), *O. scutulata* (sp46). Sulfate were correlated positively with *Chimarra chiangmaiensis* (sp22), *Ecnomus puro* (sp27), *Dipseudopsis robustior* (sp28), *Potamyia dryope* (sp29), *Cheumatopsyche chryseis* (sp33), *C. lucida* (sp40), *Oecetis empusa* (sp43), *Setodes okypete* (sp55) and correlated negative with *Cheumatopsyche* sp1 (sp1), *Hydroptila sabit* (sp16), *Chrysotrichia tydeus* (sp20), *Chimarra akkaorum* (sp21), *Lype atnia* (sp26), *Cheumatopsyche criseyde* (sp35), *C. dhanikari* (sp36) and *C. globosa* (sp38) and *C. jaekam* (sp39).

Orthophosphate and ammonia-nitrogen were correlated negative with *Cheumatopsyche* sp2 (sp2), *Marilia* (sp11), *Helicopsyche* (sp13), *Ganonema* (sp15), *Hydroptila thuna* (sp17), *Dipseudopsis robustior* (sp28), *Cheumatopsyche lucida* (sp40), *Setodes sarapis* (sp56), *Marilia sumatrana* (sp57) and correlated positively with *Psychomyia lak* (sp25), *Ecnomus puro* (sp27), *Cheumatopsyche caieta* (sp31), *Oecetis asmada* (sp42), *Leptocerus trophonios* (sp51) and *Setodes fluvialis* (sp53). Alkalinity were correlated positively with *Potamyia flavata* (sp30), *Cheumatopsyche carmentis* (sp32), *Oecetis scutulata* (sp46), *O. tripunctata* (sp47), *Setodes endymion* (sp52) and correlated negatively with *Cheumatopsyche lucida* (sp40) and *Marilia sumatrana* (sp5). Cadmium were correlated positively with *Orthotrichia lanna* (sp18) and correlated negatively with *Cheumatopsyche globosa* (sp38).

Table 5 Summary statistics of the PCA for study site based on larvae and adults of Trichoptera at Mae Tao and Mae Ku watersheds, Mae Sot district, Tak Province during February to December 2011.

	Axis1	Axis2	Axis3
Eigenvalue	20.51	12.15	9.72
Cumulative % variance	35.36	56.31	73.07
Coordinates (Scores) of sites			
MT1	-3.11	4.82	0.85
MT2	-3.25	-5.27	5.26
MT3	0.12	2.06	0.72
MT4	10.28	0.21	1.68
MT5	0.31	-4.85	-5.61
MK2	-4.18	0.62	-0.91
MK8	-0.17	2.42	-1.99

Table 6 Canonical coefficients for significant environmental variables at Mae Tao and Mae Ku watersheds, Mae Sot District, Tak Province during February to December 2011.

	Axis 1	Axis 2	Axis 3
Eigenvalue	0.41	0.23	0.15
Cumulative % variance	34.40	53.30	65.90
Air temperature	-0.53	-0.21	0.54
Water temperature	0.52	-0.001	-0.23
Dissolved oxygen	-0.55	0.46	-0.46
pH	0.30	-0.78	0.19
Electric conductivity	-1.44	-1.22	-0.29
Total dissolved solids	1.35	0.77	0.45
Turbidity	0.002	-0.35	-0.31
SO ₄ ²⁻	0.64	-0.02	0.09
NO ₃ -N	-0.01	0.07	-0.01
PO ₄ ³⁻	0.16	0.33	0.14
NH ₄ -N	0.67	-0.22	-0.21
Alkalinity	0.29	-0.11	-0.31
Cadmium	-0.18	-0.22	0.49

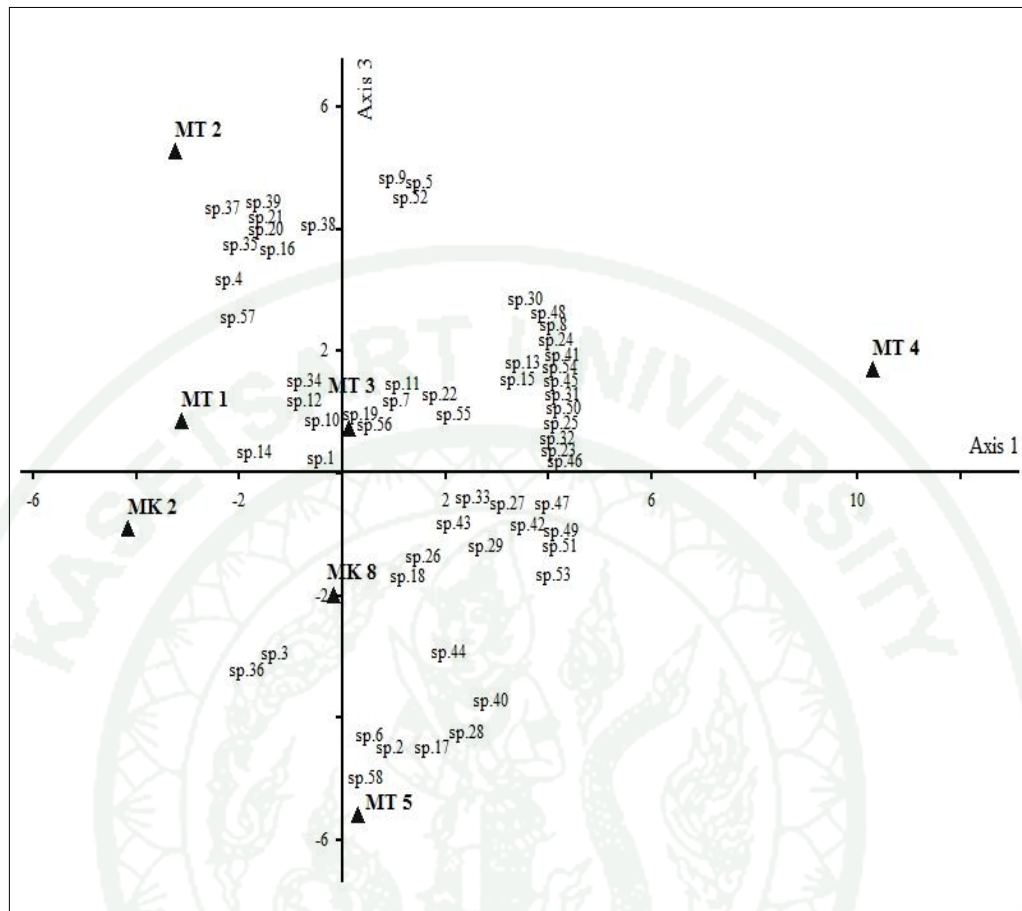


Figure 17 Biplot of the PCA ordination diagram for the data set between Trichoptera taxa and sites.

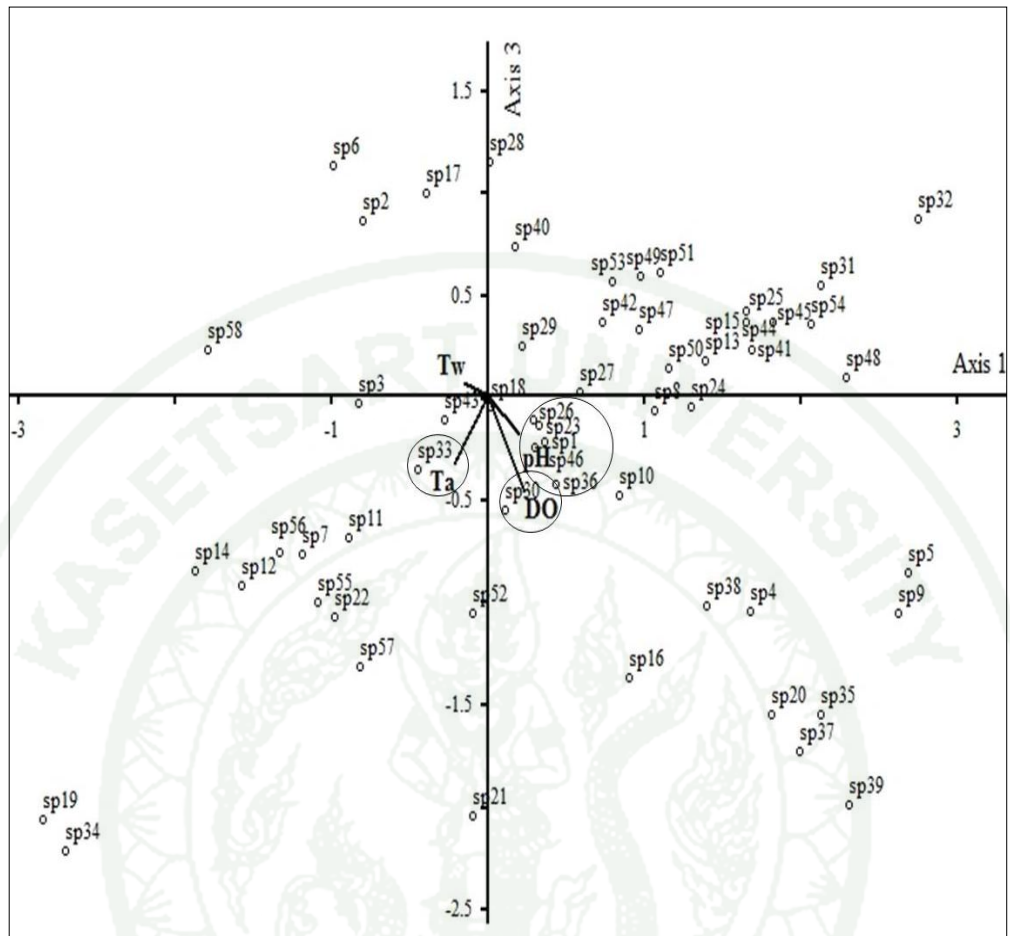


Figure 18 CCA showing correlation between Trichoptera taxa and physico-chemical parameters of water quality parameters.

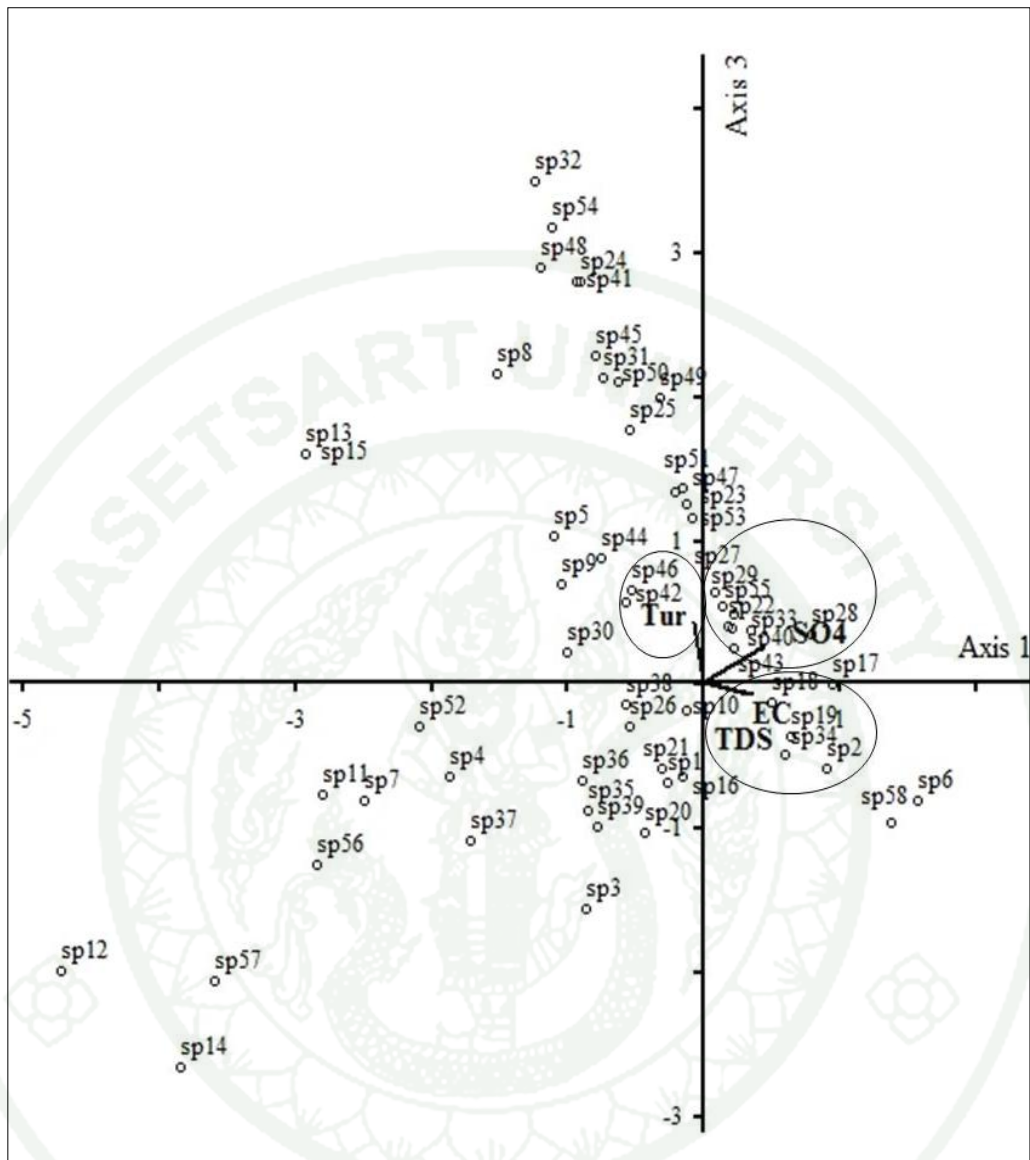


Figure 18 (Continued)

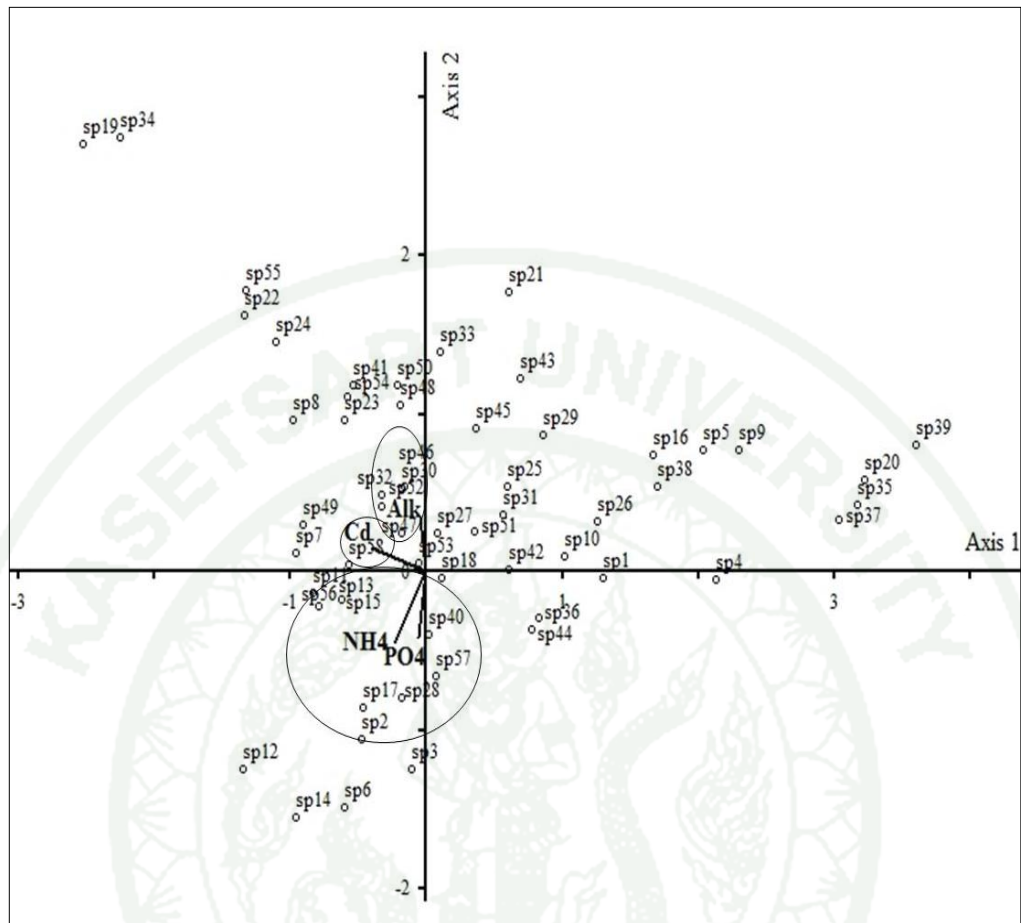


Figure 18 (Continued)

Discussion

1. Diversity of Trichoptera species in the Mae Tao and Mae Ku watersheds

A total of 3,440 individuals of larvae representing 10 families and 18 genera were collected. The caddisfly fauna were represented by Calamoceratidae, Glossosomatidae, Goeridae, Helicopsychidae, Hydropsychidae, Hydroptilidae, Lepidostomatidae, Leptoceridae, Odontoceridae, and Philopotamidae. The highest abundances at all sampling sites were the Hydropsychidae, Leptoceridae, Philopotamidae and Odontoceridae, respectively. The highest diversity of caddisfly fauna was found in Mae Tao Watershed than in Mae Ku Watershed because there were more suitable substrates for trichopteran larvae. In Mae Tao Watershed, the MT4 had a variety of microhabitats and may provide suitable habitat for aquatic larvae, which possibly led to a high species diversity, followed by MT1, MT3, MT2, MT5, MK8 and MK2, respectively. This findings are similar to other tropical streams in Asia (Dudgeon, 1999)

Adult Trichoptera, 8,376 individuals representing 122 species of 35 genera of 14 families and were collected by light traps. The families Leptoceridae was the most species rich, followed by Hydropsychidae, Philopotamidae and Psychomyiidae, respectively. The most diverse adult Trichoptera species was found in MT4 as in larvae found. Chantaramongkol et al. (1998) noted that the differences of number and species of Trichoptera depending on the nature of the habitat that is designated by the environment. Microclimatic conditions experienced during the adult phase have an impact on survival and longevity. Air temperature and relative humidity are of particular important, with higher temperatures and lower humidity, which is reducing the adult lifespan of aquatic groups (Collier and Smith, 2000). Microclimate also plays a major role to the flight activity of aquatic species (Waringer, 1991; Briers *et al.*, 2003). Similar to other terrestrial insects, the flight activity of terrestrial adults of aquatic larvae appears to be affected primarily by air temperature and humidity.

2. The diversity indices (H') of Trichoptera species in each sampling sites

The diversity indices (H') of both larvae and adults of Trichoptera was compared in each sampling site. The high diversity of caddisfly larvae was found at MT1 (0.835), followed by MT4 (0.79), MT3 (0.765), MT2 (0.623), MT5 (0.611), MK2 (0.586), and at MK8 was the lowest (0.352). Which MT1 was the most abundance in suitable substrates for the larvae (Dudgeon, 1999). The high diversity of caddisfly adult was found at MT2 (1.168), followed by MT1(1.127), MT4 (1.0846), MK2 (0.9132), MK8 (0.907), whereas the lowest was found at MT5 (0.5346).

3. Physico-chemical water quality parameters at Mae Tao and Mae Ku watersheds

The physico-chemical parameters in water bodies vary in composition and concentration on a seasonal, diurnal or even hourly basis. These variations may be related to patterns of water use and rainfall (Abel, 1996). Temperature is an important factor that influences primary production in wetland. It depends on the climate, sunlight, and depth (Gupta and Gupta, 2006). Temperatures were relatively lower during the wet season than during the dry season. Although water temperature in this study generally was higher than water temperature, these two temperature are associated with each other. This might be attributed to the sampling time (day or night). The air and water temperature was maximum in MK8 with 32.04 ± 2.25 C° for air, and 27.94 ± 1.68 C° for water, and minimum in MK2 with 25.68 ± 3.57 C° for air and 24.49 ± 1.80 C° for water. The water temperature was fluctuated with air temperature. The minimum (25.00 C°) and maximum temperatures (35.50 C°) were normal for tropical waters and were required for the normal growth of aquatic organisms. In the upstream site, the surrounding areas were covered by vegetation that may provide the low water temperature. This is similar to reports of Hauer and Hill (1996) that a small shedded stream is with lower temperature because the trees protect the heat to get into water.

The pH of water was maximum (8.8 ± 0.10) in MK2 and minimum (8.07 ± 0.21) in MT1. Accumulation of free carbon dioxide due to little photosynthetic activities of phytoplankton will cause a lower value of pH in water while intense photosynthetic activities of phytoplankton will reduce the free carbon dioxide content resulting in increasing pH values (Egborge, 1994; Gupta and Gupta, 2006). The pH was decreased in the rainy season. This may be attributed to the increased organic matter brought in by rain as a result of runoff during wet season that tends to reduce dissolved oxygen through utilization of organic dehydration giving rise to a fall in pH. Sources of dissolved oxygen in the aquatic environment include the atmosphere and photosynthesis, and depend on its solubility while losses of oxygen include respiration, decay by aerobic bacteria and decomposition of dead decaying sediments (Gupta and Gupta, 2006).

Sources of dissolved oxygen in the aquatic environment include the atmosphere and photosynthesis, and depend on its solubility while losses of oxygen include respiration, decay by aerobic bacteria and decomposition of dead decaying sediments (Gupta and Gupta, 2006). The dissolved oxygen was maximum (5.45 ± 1.14 mg/L) in MK2 and minimum (4.43 ± 1.08 mg/L) in MT1. The water current at MK2 was high resulting in a turbulent flow which increases oxygen in the water all the time (Boulton and Brock, 1999). The total dissolved solids and electrical conductivity was highest (299.66 ± 116.91 mg/L, 556.32 ± 232.12 $\mu\text{s/cm}$) in MK8 and lowest (159.3 ± 34.84 mg/L, 291.41 ± 87.22 $\mu\text{s/cm}$) in MT1. The general trend in this study was that conductivity tended to decrease in the dry season compared with the wet season. Increases conductivities could result from low precipitation, higher atmospheric temperature resulting in higher evapotranspiration rates and higher total ionic concentration, and saline intrusions from underground sources. It could also be due to a high rate of decomposition and mineralization by microbes and nutrient regeneration from bottom sediments (Egborge, 1994). Also, conductivity and total dissolved solids were higher to the contamination of water because of land use for the agricultural activities that degrader water quality (Cooper, 1993; Lenat and Crawford, 1994).

The turbidity was maximum in MK2 (29.00 ± 21.84 FTU) and minimum in MT5 (7.20 ± 4.23 FTU). The higher turbidity was recorded during the wet season compared to the dry season may be due to heavy rainfall leading to an increase in phytoplankton abundance and decay of organic matter in suspension in addition to surface runoff from above sites and adjacent areas carrying heavy sand and silt into the water. The adverse effects of turbidity on freshwater include decreasing penetration of light, which then reduce primary and secondary production, adsorbing nutrient elements to suspended materials, which makes elements unavailable for plankton production, lacking of oxygen, and clogging of filter feeding apparatus and digestive organs of planktonic organisms, which may greatly affect the hatching of larvae (Gupta and Gupta, 2006).

Water bodies in the tropics usually show a wide range of fluctuations in total alkalinity, the values depending on the location, season, plankton population and nature of bottom deposits. Highly productive waters have alkalinity values above 100 ppm and for freshwater aquaculture the values should be between 40-200 ppm. Alaklinity values above 300 ppm have been reported to adversely affect the spawning and hatching of freshwater fish (Gupta and Gupta, 2006). The alkalinity was measured in the Mae Tao watershed ranged from of 48.83 to 81.00 mg/L.

Nitrates are the most oxidized forms of nitrogen and the end product of the aerobic decomposition of organic nitrogenous matter. Natural waters in their unpolluted state contain only minute quantities of nitrates. The recoding highest nitrates value during monsoon/post monsoon season may be primary due to the organic materials receiving from the catchment ares during rainfall (Das et al. 1997). The increasing nitrates level is due to freshwater inflow, litter fall decomposition and terrestrial run-off during the monsoon/post monsoon season (Karuppasamy and permal, 2000). Another possible way of nitrates entry is through oxidation of ammonia from nitrogen to nitrite formation (Rajasegar, 2003). The low value records during summer/pre-monsoon period may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity. In addition, nitrate obtained from natural and from human activities as well, both household of the community or fertilizers

used in agriculture, consistent with Omernik (1977) indicated that the levels of nutrients in stream were positively correlated to percentage of land in agriculture. In this study, the concentration of nitrate - nitrogen ranged from 1.98 to 3.15 mg/L.

Orthophosphate in stream water was also from agricultural fertilizers which are leaching into water when it rains. There was small element in natural. In Mae Tao watershe, phosphorus ranged from 0.21 to 0.88 mg/L, while phosphorus was standard in 0.01 mg/L.

The concentration of cadmium in soil should not exceed 37 mg/kg. All sampling sites ranged from 0.08 to 11.45 mg/kg. In site MT3 was the highest amount of cadmium during flood period.

4. Ordination and classification

Principal Components Analysis (PCA) is a method with the potential for application in water quality evaluation and also useful in identifying the environmental factors important to the presence or distribution of Trichoptera taxa.

The study found that MT4 and MT2 showed a higher abundance of Trichoptera of larvae and adult compare to MK2 and MK8. The PCA of selected group of clearly showed the correlation of sites to Trichoptera taxa, for example MT2 and MT4 found the most abundance of Trichoptera taxa included *Hydropsyche* sp., *Cheumatopsyche* spp. consistent with Chaibu (2000), Trichoptera indicator both species were correlation to water quality, sensitive species viz. *Hydropsyche dolosa*, *Cheumatopsyche globosa*. The result show that MT2 and MT4 have a good water quality.

Canonical Correspondance Analysis (CCA) allowed for an examination of the correlations among species and environmental factors. The sensitive species group, *Potamyia flavata* were correlated negatively with dissolved oxygen and tolerant species group, *Oecetis asmada*, *O. scutulata* were correlated positively with turbidity,

electric conductivity and total dissolved solids. And at agricultural sites found the most abundance of Trichoptera taxa *vis. Hydroptila* sp. that is similar to Chakona *et.al* (2009). The increase in *Hydroptila* sp. at agricultural sites and heavily silted sites may also suggest that this trichopteran genus may be tolerant of increased sedimentation compared to other trichopteran taxa collected during this study. With respect to useful bioindicator taxa for measuring morphological degradation in river systems of the study sites our results suggest that increased abundance of *Hydroptila* sp. was the best bioindicator of agriculturally impacted sites. Therefore, land use activities such as agricultural and community settlements were the most affected in the aquatic insects order Trichoptera. In to changed the areas near watershed such as deforest for agriculture which cause runoff of water, soil erosion and flooding along the banks of a sudden (Dudgeon, 2000) and affect the habitat of the organisms in the water causes of biodiversity decreased (Cooper, 1993).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Diversity of Trichoptera species in the Mae Tao and Mae Ku watershed

A total of 3,440 individual of larvae representing ten families and 18 genera were collected. The caddisfly fauna were represented by Hydropsychidae, Leptoceridae, Philopotamidae, Odontoceridae, Glossosomatidae, Hydroptilidae, Goeridae, Helicopsychidae, Lepidostomatidae, and Calamoceratidae. For adults of Trichoptera, 8,376 individual representing fourteen families, 35 genera, and 122 species were collected by light traps. Leptoceridae were the most specios, followed by Hydropsychidae, Philopotamidae and Psychomyiidae, respectively.

2. The diversity indices (H') of Trichoptera species in each sampling sites

The diversity indices (H') of both larvae and adults of Trichoptera was compared in each sampling site. The highest diversity of caddisfly larvae was found at MT1 (0.835) and the lowest was found at MK8 (0.352). The highest diversity of caddisflie adult was found at MT2 (1.168) and the lowest diversity was at MT5 (0.535).

3. Physico-chemical water quality parameters of the Mae Tao and Mae Ku watersheds

Physico-chemical factors studied were water temperature, air temperature, dissolved oxygen, pH, electrical conductivity, total solids dissolved, water turbidity, nitrate - nitrogen, orthophosphate, sulfate, ammonia - nitrogen and alkalinity. Physico-chemical parameters revealed that mostly the surface water quality in Mae Tao and Mae Ku watersheds were not exceed standard within the Type III (medium clean fresh surface water resources used for consumption, but passing through an

ordinary treatment process before using agriculture) of The Surface Water Standard for Agriculture and Water Quality for Protection of Aquatic Resources.

4. Ordination and classification

The analysis of the Principal Component Analysis and Canonical Correspondance Analysis showed that both larvae and adult of distribution Trichoptera were correlated with water quality and land use. The species group, *Potamyia flavata* were correlated negatively with dissolved oxygen and species group, *Oecetis asmada*, *O. scutulata* were correlated positively with turbidity, electric conductivity, and total dissolved solids. Moreover, results suggest that the high abundance of *Hydroptila* sp. is probably the best bioindicator of agriculturally impacted sites.

5. Potential of Trichoptera communities as biological indicators of water quality

Changes in the caddisfly fauna may indicate changes in water chemistry owing to agricultural pollution, urbanization, or other human activities. Treats to the stream near mining area include increased human use, drainage of adjacent land for agricultural purposed, development of surrounding urban areas, and contamination of the surface runoff by organic and heavy metal pollutants. Overall, the results from this study suggest that Trichoptera taxa can be potentially used as good indicators of biological water quality assessment of watershed.

Recommendations

1. The living organisms in the water quality monitoring efficiency must be conducted in the long term monitoring data at least one year, which will provide more accurate results
2. The water quality should be involved with people in the local community to have a better understanding of the association of aquatic insects and water quality.
3. A Study of the chemical water quality should include more chemical factors, including biological oxygen demand (BOD).

LITERATURE CITED

- Abel, P.D. 1996. **Water Pollution Biology**, Second Edition. Taylor and Francis, London.
- APHA AWWA WPCF. 1992. **Standard methods for the examination of water and wastewater**. 18th(Ed) Washington DC, American Public Health Association.
- Barbour, M. T., Gerritsen, J., Snyder, B. D. and Stribling, J. B. 1999. **Rapid Bioassessment Protocols for Use in Streams and Wadeable River: Periphyton, Benthic Macroinvertebrates and Fish**, 2nd Edition. EPA 841-B-99-002. US Environmental Protection Agency; Office of Water, Washington D.C.
- Benecke M. 2004. Forensic entomology: arthropods and corpses, pp 207-240. *In* M. Tsokos, ed. **Forensic pathology review**. Humana, Totowa, New Jersey.
- Berlin, A. and V. Thiele. 2002. Trichoptera in assessment and classification of streams in the Lowlands of northeastern Germany, pp. 481-490. *In* W. Mey., ed. **Proceedings of the 10th International Symposium on Trichoptera**, 30 July-05 August, Potsdam, Germany. Nova Supplementa Entomologica, Keltern, Germany..
- Briers, R.A., Cariss, H.M. and J.H.R., 2003. Flight activity of adults stoneflies in relation to weather. **Ecological Entomology**, 28, 31-40.
- Boulton A.J. & Brock M.A. 1999. **Australian Freshwater Ecology: Processes and Management**. Gleneagles Publishing, Glen Osmond.

- Cairns, J.R. and Pratt, J.R. 1993. A history of biological monitoring using benthic macroinvertebrates, pp. 10-27. *In* D.M, Rosenberg and V.H. Resh., eds. **Freshwater biomonitoring and benthic macroinvertebrates**. Chapman & Hall, New York.
- Chaibu, P. 2000. **Potential use of Trichoptera as water pollution biomonitoring in Ping river Chiang Mai**. Ph.D. Thesis, Chiang Mai University.
- Chakona, A., Phiri, C. and Day, A.J. 2009. Potential for Trichoptera communities as biological indicators of morphological degradation in riverine systems. **Hydrobiologia** 621:155-167.
- Chantaramongkol, P. and Malicky, H. 1989. Some *Chimarra* (Trichoptera: Philopotamidae) from Thailand (Studies on caddisflies from Thailand, no.2). **Aquatic Insects** 11: 223-240.
- Collier, K.J. and Smith, B.J., 2000. Interactions of adult stoneflies (Plecoptera) with riparian zones I.effects of air temperature and humidity on longevity. **Aquatic Insects** 22,275-284.
- Cooper, C. M. 1993. Biological effects of agriculturally derived surface water pollutants on aquatic systems. **Journal of Environmental Quality** 22: 402-408.
- Das, N., Sengupta, S. and Mukherjee M. 1997. Importance of laccase in vegetative growth of *Pleurotus florida*. *Applied Environ. Microbiology* 63: 4120-4122.
- Dodson, S.I. 2001. Zooplankton communities of restored depressional wetlands in Wisconsin USA. **Wetlands** 21: 292-300.
- Dohet, A. 2002. Are caddisflies an ideal group for the biological assessment of water quality in streams? *Nova Supplementa Entomologica* 15: 507-52.

- Dudgeon, D. 1999. **Tropical Asian streams zoobenthos, Ecology and Conservation**. Hong Kong University Press, Hong Kong.
- Dudgeon, D. 2000. The ecology of tropical asian rivers and streams in relation to biodiversity conservation. **Annual Review of Ecology and Systematic** 31: 239-263.
- Egborge, A. B. M. 1994. Cladocera of costal rivers of western Nigeria. **Hydrobiologia** 272:39-46.
- Gupta SK, Gupta RC. 2006. **General and Applied Ichthyology (Fish and Fisheries)** S. Chand and Company Ltd. Ram Nagar, New Delhi, p. 1130.
- Hauer, F.R. and W.R. Hill. 1996. Temperature, light, and oxygen, pp. 93-106. *In* F.R. Hauer and G.A. Lamberti., eds. **Methods in stream ecology**. California, Academic Press.
- Jackson, J. K. and Resh, V. H. 1991. Periodicity in mate attraction and flight activity of adult caddisflies (Trichoptera). **Journal of the North American Benthological Society** 10:198-209.
- Skinner, K. M. and Bennett, J. D. 2007. Altered gill morphology in benthic macroinvertebrates from mercury enriched streams in the Neversink Reservoir Watershed, New York. **Ecotoxicology** 16:311–316.
- Lenat, D. R. & J. K. Crawford, 1994. Effects of land use on water quality and aquatic biota of three North Carolina piedmont streams. **Hydrobiologia** 294(3): 185–199.
- Mackay, R.J. and G.B. Wiggins. 1979. Ecological diversity in Trichoptera. **Annual Review of Entomology** 24: 185-208.

- Malicky, H. 2010. **Atlas of Southeast Asian Trichoptera**. Biology Department, Faculty of Science, Chiang Mai University. p. 346.
- Morse, J.C., 2011. The Trichoptera World Checklist. **Zoosymposia** 5:372-380.
- Ormerod, S.J. and Tyler, S.J. 1991. The influence of stream acidification and riparian land use on the feeding ecology of Grey Wagtails *Motacilla cinerea* in Wales. **Ibis** 133: 53-61.
- Omernik, J. M., 1977. **Nonpoint Source Stream Nutrient Level Relationships: A Nationwide Study**. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.
- Rajasegar M. 2003. Physico-chemical characteristics of the Vellar estuary in relation to shrimp farming. **Journal of Environmental Biology** 24: 95–101.
- Resh, V.H. 1992. Recent trends in the use of Trichoptera in water quality monitoring. pp. 285-291. *In* Otto, C., eds. **Proceedings 7th Internat. Symposium on Trichoptera**. Umea. Backhyus Publishers, Leiden.
- Resh, V. H. 1993. Recent trends in the use of Trichoptera in water quality monitoring. pp. 285-291. *In* **Proceedings of the 7th International Symposium on Trichoptera**. Backhuys Publishers, Leiden, The Netherlands.
- Resh, V.H. and J.D, Unzicker. 1975. Water quality monitoring and aquatic organisms: the importance of species identification. **Journal Water Pollution Control Federation** 47: 9-19.
- Resh, V.H., M.J., Myers and M.J. Hannaford. 1996. Macroinvertebrates as Biotic Indicators of Environmental Quality. pp. 647-667. *In* Hauer, F.R. and Lamberti, G.A., eds. **Method in Stream Ecology**. Academic Press, New York.

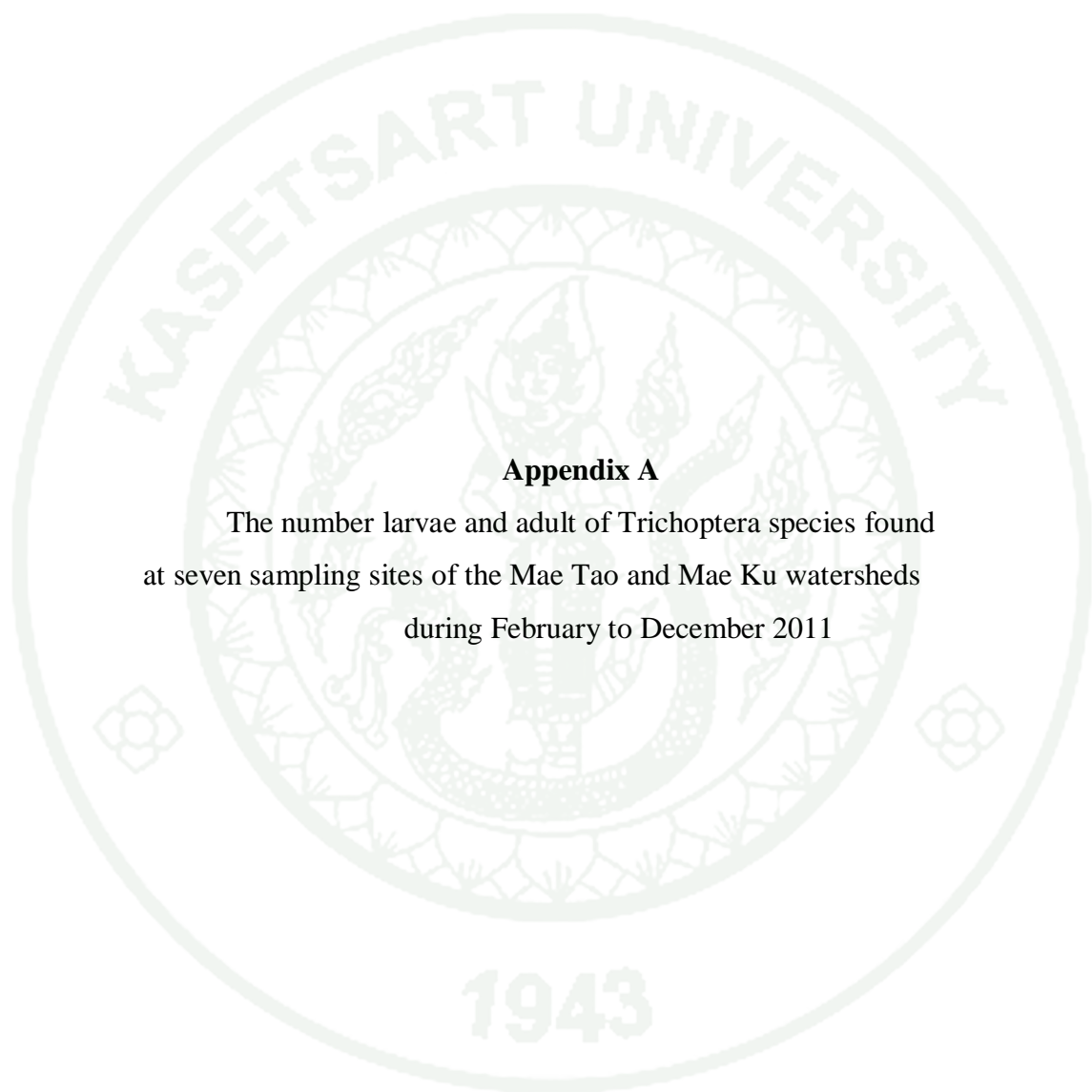
- Rosenberg, D. M. and V. H, Resh. 1993. **Freshwater Biomonitoring and Benthic Macroinvertebrates**. New York, Chapman&Hall.
- Shieh, S.H. and P.S, Yand. 2000. Community structure and functional organization of aquatic insects in an agricultural mountain stream of Taiwan: 1985-1986 and 1995-1996. **Zoological Studies** 39: 191-202.
- Skinner, K.M. and J.D, Bennett. 2007. Altered gill morphology in benthic macroinvertebrates from mercury enriched streams in the Neverink Reservoir Watershed, New York. **Ecotoxicology** 16:311-316.
- Vuori K.-M. 1994. Rapid behavioural and morphological responses of hydropsychid caddis larvae (Trichoptera, Hydropsychidae) to sublethal cadmium exposure. **Environmental Pollution** 84: 291–299.
- Vuori K.-M. 1995. Species and population specific responses of translocated hydropsychid larvae (Trichoptera, Hydropsychidae) to runoff from acid sulphate soils in the river Kyrönjoki, Western Finland. **Freshwater Biology** 33: 305–318.
- Vuori K.-M. and J.Kukkonen. 1996. Metal concentrations in *Hydropsyche pellucidula* larvae (Trichoptera, Hydropsychidae) in relation to the anal papillae abnormalities and age of exocuticle. **Water Research** 30: 2265–2272.
- Waringer, J. 1991. Phenology and the influence of meteorological parameters on the catching success of light-trapping for Trichoptera. **Freshwater Biology** 25: 307-319.
- Warwick, R.M. 1988. Analysis of community attributes of the macrobenthos of Frierfjord/Langesundfjord at taxonomic levels higher than species. **Marine Ecology Progress Series** 46: 167-170.

Wiggins, G.B. 1996. **Larvae of the North American Caddisfly Genera (Trichoptera)**. 2nd edition. University of Toronto Press. Ontario.





APPENDICES



Appendix A

The number larvae and adult of Trichoptera species found
at seven sampling sites of the Mae Tao and Mae Ku watersheds
during February to December 2011

Appendix table A1 Abundance of Trichoptera species at MT1, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT1					
		Feb	Apr	Jul	Oct	Nov	Dec
Hydropsychidae	<i>Cheumatopsyche</i> sp.1	4	1	2		85	15
	<i>Cheumatopsyche</i> sp.2	8	4	8			22
	<i>Diplectrona</i>	1	29			6	24
	<i>Hydropsyche</i>	2		3		23	8
Leptoceridae	<i>Mystacides</i>		4				
	<i>Ceraclea</i>		2				
Philopotamidae	<i>Chimarra</i>	3					
Odontoceridae	<i>Marilia</i>	48	9				50
Lepidostomatidae	<i>Lepidostoma</i>	1	3				
Calamoceratidae	<i>Anisocentropus</i>	1	1				
	<i>Ganonema</i>		1				
Glossosomatidae	<i>Glossosoma</i>	8		8		8	55

Note: October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A2 Abundance of Trichoptera species at MT2, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT2					
		Feb	Apr	Jul	Oct	Nov	Dec
Hydropsychidae	<i>Cheumatopsyche</i> sp.1	75	61	28		1	181
	<i>Cheumatopsyche</i> sp.2	22	9	13			
	<i>Diplectrona</i>	9	13				15
	<i>Hydropsyche</i>	15	3	2		1	70
	<i>Macrostemum</i>	2					1
	<i>Potamyia</i>	3					
Leptoceridae	<i>Oecetis</i>	4					
Philopotamidae	<i>Chimarra</i>	16	127				11
Odontoceridae	<i>Marilia</i>	1	2				
Glossosomatidae	<i>Glossosoma</i>			6			3

Note: October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A3 Abundance of Trichoptera species at MT3, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT3					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Cheumatopsyche</i>						
Hydropsychidae	sp.1	14	5			5	32
	<i>Cheumatopsyche</i>						
	sp.2	22	3	1		2	
	<i>Diplectrona</i>	1	1				
	<i>Hydropsyche</i>					1	
Leptoceridae	<i>Ceraclea</i>		5				
	<i>Mystacides</i>		7				
Philopotamidae	<i>Chimarra</i>	3	30				1
Odontoceridae	<i>Marilia</i>	1	29				7
Hydroptilidae	<i>Ochrotrichia</i>	1					
Lepidostomatidae	<i>Lepidostoma</i>	1					
Helicopsychidae	<i>Helicopsyche</i>		2				
Glossosomatidae	<i>Glossosoma</i>					3	

Note: October cannot collect Trichoptera both larvae and adult because the flood.

Appendix table A4 Abundance of Trichoptera species at MT4, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT4					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Cheumatopsyche</i>						
Hydropsychidae	sp.1	40					98
	<i>Cheumatopsyche</i>						
	sp.2	73				2	22
	<i>Diplectrona</i>						3
	<i>Hydropsyche</i>	1					23
	<i>Macrostemum</i>						2
	<i>Potamyia</i>	2					
Leptoceridae	<i>Ceraclea</i>		5				1
	<i>Mystacides</i>	6	16				
	<i>Oecetis</i>		2				
	<i>Setodes</i>		1				
Philopotamidae	<i>Chimarra</i>	5					58
Odontoceridae	<i>Marilia</i>	2	41				13
Calamoceratidae	<i>Ganonema</i>	1	1				
Goeridae	<i>Goera</i>		2				

Note: October cannot collected Trichoptera both larvae and adult because the flood. July cannot collected at MT4 because of the excavation for the dam to slow the erosion of the banks and heavy rains.

Appendix table A5 Abundance of Trichoptera species at MT5, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT5					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Cheumatopsyche</i>						
Hydropsychidae	sp.1	3		7			271
	<i>Cheumatopsyche</i>						
	sp.2	336	131			1	81
	<i>Diplectrona</i>	1	100				7
	<i>Hydropsyche</i>	4		6		9	2
	<i>Potamyia</i>	32					
Philopotamidae	<i>Chimarra</i>	60	69				4
Odontoceridae	<i>Marilia</i>						2
Glossosomatidae	<i>Glossosoma</i>						18

Note: October cannot collect Trichoptera both larvae and adults because of the flood.

Appendix table A6 Abundance of Trichoptera species at MK2, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MK2					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Cheumatopsyche</i>						
Hydropsychidae	sp.1	1	2			31	
	<i>Cheumatopsyche</i>						
	sp.2	1					
	<i>Diplectrona</i>		2			11	
	<i>Hydropsyche</i>	16	16			36	12
Philopotamidae	<i>Chimarra</i>	29	13				
Odontoceridae	<i>Marilia</i>	2	1				
Glossosomatidae	<i>Glossosoma</i>					1	

Note: October cannot collected Trichoptera both larvae and adult because the flood. July cannot collected at MK2 because of closed the road to repair some of the roads.

Appendix table A7 Abundance of Trichoptera species at MK8, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MK8					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Cheumatopsyche</i>						
Hydropsychidae	sp.1	23	174				80
	<i>Cheumatopsyche</i>						
	sp.2	3	46				10
	<i>Hydropsyche</i>	2	1				
Leptoceridae	<i>Ceraclea</i>		2				
	<i>Mystacides</i>						1
Philopotamidae	<i>Chimarra</i>		1				
Odontoceridae	<i>Marilia</i>	18	3				5
Hydroptilidae	<i>Ochrotrichia</i>						1

Note: July cannot collected adult of Trichoptera because the flood, October cannot collected Trichoptera both larvae and adult because the flood and November cannot find order Trichoptera.

Appendix table A8 Abundance of adult Trichoptera species at MT1, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT1					
		Feb	Apr	Jul	Oct	Nov	Dec
Glossosomatidae	<i>Agapetus halong</i> OLAH 1988						11
	<i>Hydroptila psyche</i> M&C 2007						1
Hydroptilidae	<i>Hydroptila thuna</i> OLAH 1989	6				13	2
	<i>Orthotrichia polyxena</i> M&C 2007					1	
	<i>Orthotrichia typhoeus</i> M&C 2007					1	
	<i>Chimarra akkaorum</i> C&M 1989	4					
Philopotamidae	<i>Chimarra</i> <i>chiangmaiensis</i> C&M 1989	1					
	<i>Tinodes eris</i> MALICKY & SAENGPADAB 2001					1	
Psychomyiidae	<i>Lype atria</i> M&C 1993	1					
	<i>Potamyia flavata</i> BANKS 1934	1				18	2
Hydropsychidae	<i>Cheumatopsyche dhanikari</i> MALICKY 1979	4				8	5
	<i>Cheumatopsyche globosa</i> ULMER 1910					2	4
	<i>Cheumatopsyche lucida</i> ULMER 1907					9	
	<i>Cheumatopsyche</i> <i>tramota</i> M&C 1997	1					
	<i>Cheumatopsyche carmentis</i> M&C 1997					2	
	<i>Cheumatopsyche dubitans</i> MOSELY 1942						1
	<i>Hydropsyche augeias</i> M&C 2000	1					

Appendix table A8 (Continued)

Family	Species	MT1					
		Feb	Apr	Jul	Oct	Nov	Dec
Leptoceridae	<i>Oecetis tripunctata</i> FABRICIUS 1793	1					
	<i>Oecetis scutulata</i> MARTYNOV 1936	11				15	10
	<i>Oecetis asmada</i> MALICKY 1979					1	2
	<i>Oecetis hades</i> M&C 2003						1
	<i>Tagalopsyche brunnea</i> ULMER 1905						1
	<i>Leptocerus dirghachuka</i> GORDON & SCHMID 1987	1					
	<i>Setodes endymion</i> M&C 2000	8				3	1
	<i>Setodes fluvialis</i> KIMMINS 1963						1
	<i>Setodes sarapis</i> M&C 2006						3
	<i>Marilia sumatrana</i> ULMER 1951	15				1	
	Odontoceridae						

Note: April cannot be collected because of a community festival, which is about stress from lights affecting insects. July and October cannot be collected for adult Trichoptera because of the flood.

Appendix table A9 Abundance of adult Trichoptera species at MT2, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT2						
		Feb	Apr	Jul	Oct	Nov	Dec	
Glossosomatidae	<i>Agapetus halong</i> OLAH 1988						9	
	<i>Hydroptila keres</i> MALICKY 2004		2			1		
Hydroptilidae	<i>Hydroptila psyche</i> M&C 2007						1	
	<i>Hydroptila sabit</i> WELLS&HUISMAN 1992		24					
	<i>Hydroptila srisungwan</i> M&C 2007		2				1	
	<i>Hydroptila thuna</i> OLAH 1989	34	20			11	3	
	<i>Saranganotrichia</i> <i>chiangdao</i> M&C 2007		3					
	<i>Orthotrichia lanna</i> M&C 2007		9			1	1	
	<i>Orthotrichia typhoeus</i> M&C 2007		19				2	
	<i>Parastactobia khakaeng</i> M&C 2007		25				3	
	<i>Chrysotrichia tydeus</i> M&C 2007						22	
	Philopotamidae	<i>Chimarra</i> <i>akkaorum</i> C&M 1989	153	215			2	8
		<i>Chimarra</i> <i>chiangmaiensis</i> C&M 1989	1	29				
		<i>Chimarra karenorum</i> C&M 1989		1				
		<i>Gunungiella myrrha</i> M&C 2003		2				
Polycentropodidae		<i>Polyplectropus ahas</i> M&C 1993		2				
		<i>Pseudoneureclipsis</i> <i>enos</i> M&C 1993	1					
	<i>Pseudoneureclipsis</i> <i>ramosa</i> ULMER 1913		1					
	<i>Pseudoneureclipsis sobak</i> M&C 2009		1					

Appendix table A9 (Continued)

Family	Species	MT2					
		Feb	Apr	Jul	Oct	Nov	Dec
Psychomyiidae	<i>Paduniella semarangensis</i>						
	ULMER 1913		1				
	<i>Lype atnia</i> M&C 1993		1				
	<i>Psychomyia intorachit</i>						
	M&C 1993		1				
	<i>Psychomyia lak</i> M&C 1993		2				
Ecnomidae	<i>Tinodes eris</i> MALICKY & SAENGPRADAB 2001		1				
	<i>Ecnomus puro</i> M&C 1993	9	2				
	<i>Ecnomus thamyris</i> MALICKY & PROMMI 2006		2				
	<i>Ecnomus venimar</i> M&C 1993		1			2	
	<i>Macrostemum fenestratum</i>						
	ALBARDA 1887	1	1				
Hydropsychidae	<i>Potamyia flavata</i>						
	BANKS 1934	7				3	13
	<i>Potamyia phaidra</i> M&C 1997	2					1
	<i>Cheumatopsyche caieta</i> M&C 1997					1	
	<i>Cheumatopsyche carna</i> M&C 1997	11	2				12
	<i>Cheumatopsyche carmentis</i> M&C 1997					1	1
	<i>Cheumatopsyche chryseis</i> M&C 1997		1				
	<i>Cheumatopsyche chrysothemis</i> M&C 1997		1				2
	<i>Cheumatopsyche criseyde</i> M&C 1997	5	2			1	
	<i>Cheumatopsyche dhanikari</i> MALICKY 1979	5	1			7	6

Appendix table A9 (Continued)

Family	Species	MT2					
		Feb	Apr	Jul	Oct	Nov	Dec
Hydropsychidae							
	<i>Cheumatopsyche dubitans</i> MOSELY 1942						6
	<i>Cheumatopsyche globosa</i> ULMER 1910	56	26			9	41
	<i>Cheumatopsyche jaekam</i> M&C 2009	104	17			1	11
	<i>Cheumatopsyche lucida</i> ULMER 1907					9	8
	<i>Cheumatopsyche tramota</i> M&C 1997						3
	<i>Hydropsyche cacus</i> M&C 2000						1
	<i>Geora minor</i> MOSELY 1938			11			
Goeridae	<i>Oecetis asmada</i> MALICKY 1979					1	2
Leptoceridae							
	<i>Oecetis hades</i> M&C 2003			3			
	<i>Oecetis raghava</i> SCHMID 1995			1		1	
	<i>Oecetis scutulata</i> MARTYNOV 1936	16	27			3	18
	<i>Oecetis tripunctata</i> FABRICIUS 1793	6	8				
	<i>Adicella iole</i> M&C 2002						1
	<i>Adicella posticus</i> BANKS 1911					1	

Appendix table A9 (Continued)

Family	Species	MT2					
		Feb	Apr	Jul	Oct	Nov	Dec
Leptoceridae							
	<i>Triaenodes menestheus</i> MALICKY 2005	1					
	<i>Leptocerus trophonios</i> M&C 2006		1				
	<i>Setodes endymion</i> M&C 2000	4	2				3
	<i>Setodes fluvialis</i> KIMMINS 1963		4				
	<i>Setodes isis</i> MALICKY & NAWVONG 2006					1	
	<i>Setodes okypete</i> M&C 2006	8	38				
	<i>Setodes thoneti</i> M&C 2006						1
Odontoceridae							
	<i>Marilia mogtiana</i> MALICKY 1989						1
	<i>Marilia sumatrana</i> ULMER 1951	3	2				1

Note: July cannot collected of adult because light trap was the flood washed away. October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A10 Abundance of adult Trichoptera species at MT3, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT3						
		Feb	Apr	Jul	Oct	Nov	Dec	
Glossosomatidae	<i>Agapetus halong</i> OLAH 1988						1	
	<i>Hydroptila sabit</i> WELLS&HUISMAN 1992		4	1				
Hydroptilidae	<i>Hydroptila srisungwan</i> M&C 2007		1			1		
	<i>Hydroptila suanhom</i> M&C 2007		1					
	<i>Hydroptila thuna</i> OLAH 1989		51	57		18		
	<i>Orthotrichia huaihuat</i> M&C 2007		2					
	<i>Orthotrichia lanna</i> M&C 2007			5				
	<i>Orthotrichia litoralis</i> ULMER 1951			1				
	<i>Orthotrichia penthesileia</i> M&C 2007		1					
	<i>Orthotrichia typhoeus</i> M&C 2007		30	126		1		
	<i>Orthotrichia tyro</i> M&C 2007		1					
	<i>Chrysotrichia pallu</i> MALICKY & PROMMI 2009			1				
	Philopotamidae	<i>Chimarra akkaorum</i> C&M 1989		62	240		1	2
		<i>Chimarra chiangmaiensis</i> C&M 1989			88		4	3
	Polycentropodidae	<i>Pseudoneureclipsis ramosa</i> ULMER 1913			3			
		<i>Pahamunaya jihmita</i> S CHMID & DENNING 1979		1				
	Psychomyiidae	<i>Paduniella anakenam</i> M&C 1995		2				
<i>Psychomyia kerynitia</i> MALICKY & NUNTAKWANG 2006			28					
<i>Psychomyia lak</i> M&C 1993				1				
<i>Paduniella semarangensis</i> ULMER 1913			1	1				

Appendix table A10 (Continued)

Family	Species	MT3						
		Feb	Apr	Jul	Oct	Nov	Dec	
Ecnomidae	<i>Ecnomus puro</i> M&C 1993					6		
	<i>Ecnomus ramayana</i> M&C 1993		1					
	<i>Ecnomus uttu</i> M&C 1993		1					
Hydropsychidae	<i>Potamyia dryope</i> MALICKY & THANI 2000		3					
	<i>Potamyia flavata</i> BANKS 1934	6	8			7	9	
	<i>Cheumatopsyche carmentis</i> M&C 1997		1			1	3	
	<i>Cheumatopsyche chryseis</i> M&C 1997	11						
	<i>Cheumatopsyche chrysothemis</i> M&C 1997		11			3		
	<i>Cheumatopsyche dhanikari</i> MALICKY 1979		14			1		
	<i>Cheumatopsyche globosa</i> ULMER 1910		10			1	5	
	<i>Cheumatopsyche lucida</i> ULMER 1907		6			6	1	
	<i>Lepidostoma doligung</i> MALICKY 1979	1	1					
	Leptoceridae	<i>Oecetis armadillo</i> M&C 2005		1				
		<i>Oecetis asmada</i> MALICKY 1979		1				
<i>Oecetis empusa</i> MALICKY & CHAIBU 2000		1						
<i>Oecetis pretakalpa</i> SCHMID 1995			1					
<i>Oecetis raghava</i> SCHMID 1995		1	3					
<i>Oecetis scutulata</i> MARTYNOV 1936		5	102			1		
<i>Oecetis tripunctata</i> FABRICIUS 1793		1	9			1		
<i>Adicella iole</i> M&C 2002						1		
<i>Tagalopsyche brunnea</i> ULMER 1905			1					
<i>Triaenodes dusra</i> SCHMID 1965			1					

Appendix table A10 (Continued)

Family	Species	MT3					
		Feb	Apr	Jul	Oct	Nov	Dec
Leptoceridae	<i>Leptocerus dirghachuka</i> GORDON & SCHMID 1987	4	7				
	<i>Leptocerus ganymedes</i> M&C 2002		1				
	<i>Leptocerus suthepensis</i> M&C 1991	1	2				
	<i>Leptocerus trophonios</i> M&C 2006		1				
	<i>Setodes endymion</i> M&C 2000	6				2	
	<i>Setodes fluvialis</i> KIMMINS 1963		3			1	
	<i>Setodes neptunus</i> MALICKY & SAENGPRADAB 2006	1	2				
	<i>Setodes okypete</i> M&C 2006	8	254				
	<i>Setodes sarapis</i> M&C 2006		1				
	<i>Marilia sumatrana</i> ULMER 1951	1	1				
Odontoceridae	<i>Anisocentropus erichthonios</i> MALICKY & CHEUNBARN 2001		1				
Calamoceratidae			1				

Note: July cannot collected adult of Trichoptera because the flood. October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A11 Abundance of adult Trichoptera species at MT4, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT4						
		Feb	Apr	Jul	Oct	Nov	Dec	
Glossosomatidae	<i>Agapetus halong</i> OLAH 1988						1	
	<i>Hydroptila kalchas</i> MALICKY 2004	11						
Hydroptilidae	<i>Hydroptila sabit</i> WELLS&HUISMAN 1992	1	1					
	<i>Hydroptila thuna</i> OLAH 1989	81	525			8	99	
	<i>Hydroptila verticordia</i> M&C 2007		1					
	<i>Orthotrichia bencana</i> OLAH 1989		4					
	<i>Orthotrichia indica</i> MARTYNOV 1935		3					
	<i>Orthotrichia lanna</i> M&C 2007		6			1		
	<i>Orthotrichia penthesileia</i> M&C 2007	1						
	<i>Orthotrichia polyxena</i> M&C 2007	2						
	<i>Orthotrichia typhoeus</i> M&C 2007		5					
	<i>Parastactobia khakaeng</i> M&C 2007	2						
	Philopotamidae	<i>Chimarra akkaorum</i> C&M 1989	13	4				
		<i>Chimarra Chiangmaiensis</i> C&M 1989		44				
		<i>Nyctiophylax maath</i> M&C 1993		1				
	Polycentropodidae	<i>Polyplectropus ahas</i> M&C 1993	21					
		<i>Pseudoneureclipsis ramosa</i> ULMER 1913		4			1	
<i>Pseudoneureclipsis uma</i> M&C 1993		2						

Appendix table A11 (Continued)

Family	Species	MT4					
		Feb	Apr	Jul	Oct	Nov	Dec
Psychomyiidae	<i>Psychomyia kerynitia</i> MALICKY & NUNTAKWANG 2006	73					
	<i>Psychomyia lak</i> M&C 1993		11				
	<i>Lype atnia</i> M&C 1993	1	1				
Ecnomidae	<i>Ecnomus jojachin</i> M&C 1993		4				
	<i>Ecnomus puro</i> M&C 1993	1	13	2			
	<i>Ecnomus volovicus</i> M&C 1993		1				
Dipseudopsidae	<i>Dipseudopsis robustior</i> ULMER 1929	1	1				
Hydropsychidae	<i>Potamyia dryope</i> MALICKY & THANI 2000		6				
	<i>Potamyia flavata</i> BANKS 1934	6	6	1		1	28
	<i>Potamyia phaidra</i> M&C 1997		2				
	<i>Cheumatopsyche caieta</i> M&C 1997					5	
	<i>Cheumatopsyche carmentis</i> M&C 1997		3			16	3
	<i>Cheumatopsyche chryseis</i> M&C 1997	9					
	<i>Cheumatopsyche dhanikari</i> MALICKY 1979		10	1			
	<i>Cheumatopsyche globosa</i> ULMER 1910	1	14	15		4	6
	<i>Cheumatopsyche lucida</i> ULMER 1907	11	20	11		23	32
	<i>Lepidostoma doligung</i> MALICKY 1979						
Leptoceridae	<i>Oecetis armadillo</i> M&C 2005		7				1
	<i>Oecetis asmada</i> MALICKY 1979		3				
	<i>Oecetis devakiputra</i> SCHMID 1995		11				1
	<i>Oecetis empusa</i> MALICKY & CHAIBU 2000		1				
	<i>Oecetis laodike</i> MALICKY & CHEUNBARN 2005					1	

Appendix table A11 (Continued)

Family	Species	MT4					
		Feb	Apr	Jul	Oct	Nov	Dec
	<i>Oecetis lotis</i> MALICKY & THAPANYA 2004	1					
	<i>Oecetis meleagros</i> MALICKY & THANI 2005	1	10				
	<i>Oecetis raghava</i> SCHMID 1995	1	26				
	<i>Oecetis scutulata</i> MARTYNOV 1936	34	154			2	2
	<i>Oecetis tripunctata</i> FABRICIUS 1793	7	45				1
	<i>Adicella iole</i> M&C 2002	5				1	
	<i>Adicella longicerca</i> KIMMINS 1963	1					
	<i>Leptocerus dirghachuka</i> GORDON & SCHMID 1987	20	31				
	<i>Leptocerus faunus</i> M&C 2002		3				
	<i>Leptocerus ganymedes</i> M&C 2002		3				
	<i>Leptocerus rutulus</i> MALICKY & PROMMI 2006	1					
	<i>Leptocerus suthepensis</i> M&C 1991	1	2				
	<i>Leptocerus trophonios</i> M&C 2006		9				
	<i>Setodes endymion</i> M&C 2000	1	2			4	3
	<i>Setodes fluvialis</i> KIMMINS 1963	1	22				3
	<i>Setodes neptunus</i> MALICKY & SAENGPRADAB 2006	1	15				
	<i>Setodes oinomaos</i> M&C 2006		1				
	<i>Setodes okypete</i> M&C 2006	9	117				
	<i>Setodes sarapis</i> M&C 2006		1				
	<i>Marilia sumatrana</i> ULMER 1951	1					
Odontoceridae							

Note: October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A12 Abundance of adult Trichoptera species at MT5, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MT5						
		Feb	Apr	Jul	Oct	Nov	Dec	
Glossosomatidae	<i>Agapetus halong</i> OLAH 1988							
	<i>Hydroptila gapdoi</i> OLAH 1989	1						
Hydroptilidae	<i>Hydroptila sabit</i> WELLS&HUISMAN 1992	6						
	<i>Hydroptila thuna</i> OLAH 1989	172	1900			11		
	<i>Orthotrichia asimetrus</i> WELLS & MALICKY 1997					1		
	<i>Orthotrichia lanna</i> M&C 2007		18					
	<i>Orthotrichia</i> <i>parthenopaios</i> M&C 2007	1						
	<i>Orthotrichia</i> <i>typhoeus</i> M&C 2007	5	10					
	<i>Parastactobia khakaeng</i> M&C 2007		6					
	<i>Chrysotrichia tydeus</i> M&C 2007							
	Philopotamidae	<i>Chimarra akkaorum</i> C&M 1989		5			1	
		<i>Chimarra Chiangmaiensis</i> C&M 1989		29			1	
<i>Pseudoneureclipsis ramosa</i> ULMER 1913						1		
Polycentropodidae	<i>Paduniella Semarangensis</i> ULMER 1913		3					
	<i>Psychomyia lak</i> M&C 1993		2					
Ecnomidae	<i>Lype atnia</i> M&C 1993							
	<i>Ecnomus jojachin</i> M&C 1993		3					
	<i>Ecnomus puro</i> M&C 1993	4	7	2		1		
	<i>Ecnomus robustior</i> ULMER 1951			1				
	<i>Ecnomus venimar</i> M&C 1993							

Appendix table A12 (Continued)

Family	Species	MT5					
		Feb	Apr	Jul	Oct	Nov	Dec
Dipseudopsidae	<i>Dipseudopsis robustior</i> ULMER 1929		4				
	<i>Diplectrona</i> <i>gombak</i> OLAH 1993	1					
Hydropsychidae	<i>Potamyia dryope</i> MALICKY & THANI 2000		1				
	<i>Potamyia flavata</i> BANKS 1934	4	3	2		5	5
	<i>Cheumatopsyche caieta</i> M&C 1997						1
	<i>Cheumatopsyche</i> <i>carmentis</i> M&C 1997		1	1		35	3
	<i>Cheumatopsyche</i> <i>chryseis</i> M&C 1997	1					
	<i>Cheumatopsyche</i> <i>chrysothemis</i> M&C 1997		1				
	<i>Cheumatopsyche</i> <i>criseyde</i> M&C 1997					1	
	<i>Cheumatopsyche</i> <i>dhanikari</i> MALICKY 1979		43			7	
	<i>Cheumatopsyche</i> <i>globosa</i> ULMER 1910		22	2		3	4
	<i>Cheumatopsyche</i> <i>lucida</i> ULMER 1907	1	10	43		38	48
	<i>Hydropsyche</i> <i>camillus</i> M&C 2000		1				

Appendix table A12 (Continued)

Family	Species	MT5					
		Feb	Apr	Jul	Oct	Nov	Dec
Leptoceridae	<i>Oecetis asmada</i> MALICKY 1979		1			5	
	<i>Oecetis biramosa</i> MARTYNOV 1936		21			3	
	<i>Oecetis laodike</i> MALICKY & CHEUNBARN 2005					1	
	<i>Oecetis scutulata</i> MARTYNOV 1936	12	88	1		3	2
	<i>Oecetis tripunctata</i> FABRICIUS 1793	7	25				
	<i>Adicella suthepensis</i> M&C 1991						1
	<i>Leptocerus dirghachuka</i> GORDON & SCHMID 1987		24	1			
	<i>Leptocerus trophonios</i> M&C 2006		4				
	<i>Setodes endymion</i> M&C 2000						1
	<i>Setodes fluvialis</i> KIMMINS 1963		14				4
	<i>Setodes okypete</i> M&C 2006	26	30				
	<i>Anisocentropus erichthonios</i> MALICKY & CHEUNBARN 2001		2				
	Calamoceratidae						

Note: October cannot collected Trichoptera both larvae and adult because the flood.

Appendix table A13 Abundance of adult Trichoptera species at MK2, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MK2					
		Feb	Apr	Jul	Oct	Nov	Dec
Hydroptilidae	<i>Hydroptila thuna</i> OLAH 1989	20				16	
	<i>Oxyethira bogambara</i> SCHMID 1958					6	
Philopotamidae	<i>Chimarra akkaorum</i> C&M 1989	53				7	
	<i>Chimarra Chiangmaiensis</i> C&M 1989					1	
	<i>Chimarra okuihorum</i> MEY 1998					1	
	<i>Chimarra pipake</i> M&C 1993					1	
	<i>Lype atnia</i> M&C 1993	1					
	<i>Tinodes eris</i> MALICKY & SAENGPRADAB 2001						
	<i>Abaria guatila</i> M&C 1992					1	
Ecnomidae	<i>Ecnomus thogarma</i> M&C 2009	1				2	
	<i>Diplectrona aurovittata</i> ULMER 1906					4	
Hydropsychidae	<i>Potamyia flavata</i> BANKS 1934					7	
	<i>Cheumatopsyche</i> <i>criseyde</i> M&C 1997	2					
	<i>Cheumatopsyche</i> <i>dhanikari</i> MALICKY 1979	2				50	
	<i>Cheumatopsyche dubitans</i> MOSELY 1942					2	

Appendix table A13 (Continued)

Family	Species	MK2					
		Feb	Apr	Jul	Oct	Nov	Dec
Hydropsychidae							
	<i>Cheumatopsyche globosa</i> ULMER 1910	3				1	
	<i>Cheumatopsyche jaekam</i> M&C 2009	2					
	<i>Hydropsyche cacus</i> M&C 2000					1	
Leptoceridae	<i>Oecetis biramosa</i> MARTYNOV 1936					1	
	<i>Oecetis laodike</i> MALICKY & CHEUNBARN 2005					1	
	<i>Oecetis momos</i> MALICKY 2005					1	
	<i>Oecetis scutulata</i> MARTYNOV 1936	29				4	
	<i>Setodes endymion</i> M&C 2000	1					
	<i>Setodes okypete</i> M&C 2006	2					
	<i>Marilia sumatrana</i> ULMER 1951					2	
Odontoceridae							

Note: April and July were trouble in collected of sample. October cannot collected Trichoptera both larvae and adult because the flood.

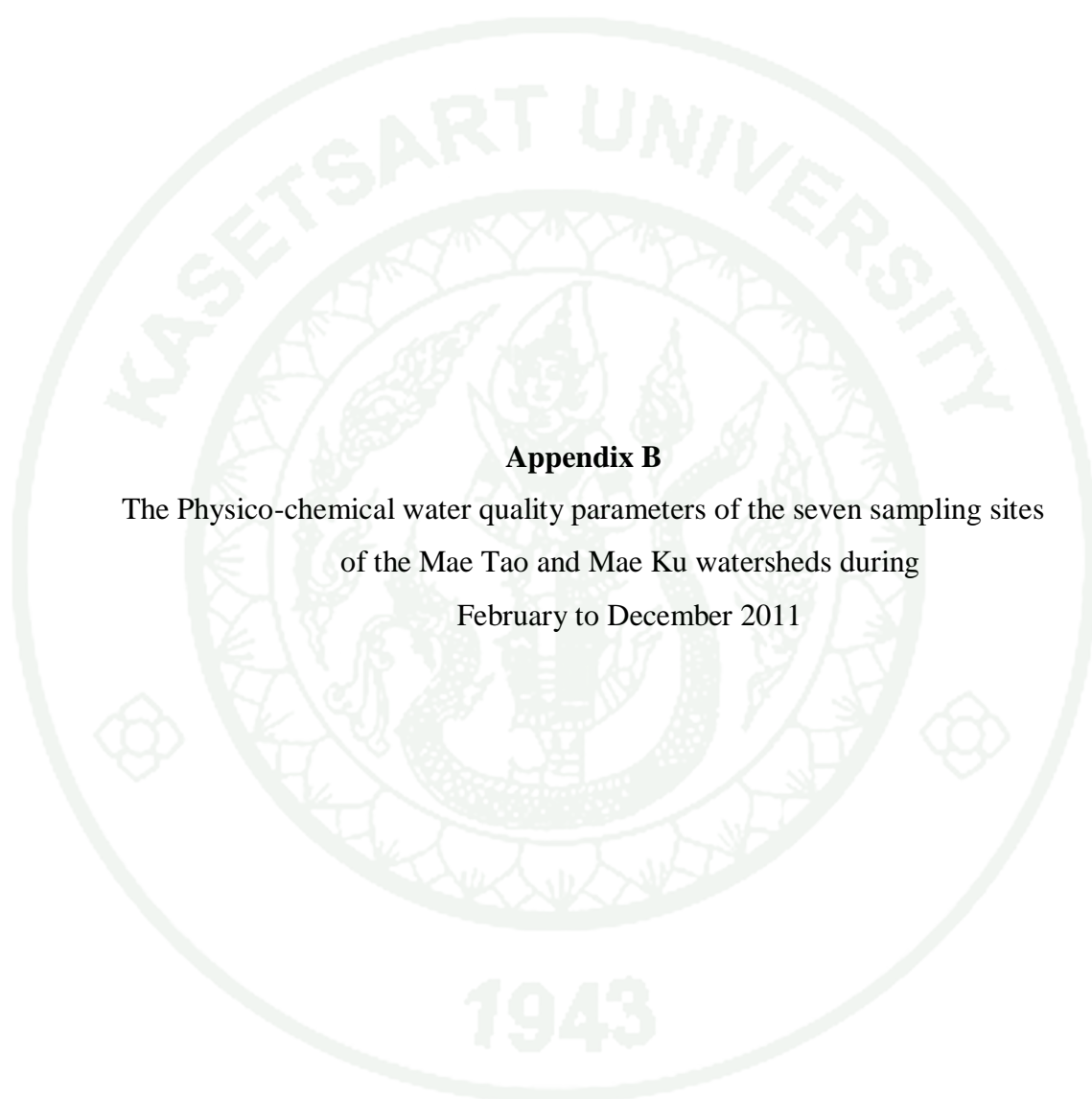
Appendix table A14 Abundance of adult Trichoptera species at MK8, Mae Sot District, Tak Province recorded during February to December 2011.

Family	Species	MK8					
		Feb	Apr	Jul	Oct	Nov	Dec
Ecnomidae	<i>Ecnomus puro</i> M&C 1993						2
	<i>Ecnomus venimar</i> M&C 1993						1
Dipseudopsidae	<i>Dipseudopsis robustior</i> ULMER 1929		1				
	<i>Potamyia dryope</i> MALICKY & THANI 2000		9				
Hydropsychidae	<i>Potamyia flavata</i> BANKS 1934		5				5
	<i>Cheumatopsyche caieta</i> M&C 1997						1
	<i>Cheumatopsyche carmentis</i> M&C 1997						3
	<i>Cheumatopsyche chryseis</i> M&C 1997		13				
	<i>Cheumatopsyche dhanikari</i> MALICKY 1979		4				
	<i>Cheumatopsyche globosa</i> ULMER 1910						4
	<i>Cheumatopsyche jaekam</i> M&C 2009		1				
	<i>Cheumatopsyche lucida</i> ULMER 1907		3			1	48
	<i>Lepidostoma doligung</i> MALICKY 1979		1				

Appendix table A14 (Continued)

Family	Species	MK8					
		Feb	Apr	Jul	Oct	Nov	Dec
Leptoceridae	<i>Oecetis asmada</i> MALICKY 1979		8				
	<i>Oecetis devakiputra</i> SCHMID 1995		1				
	<i>Oecetis empusa</i> MALICKY & CHAIBU 2000		2				
	<i>Oecetis raghava</i> SCHMID 1995		9				
	<i>Oecetis scutulata</i> MARTYNOV 1936		44			1	2
	<i>Oecetis tripunctata</i> FABRICIUS 1793		5				
	<i>Leptocerus ganymedes</i> M&C 2002		1				
	<i>Leptocerus trophonios</i> M&C 2006		4				
	<i>Setodes fluvialis</i> KIMMINS 1963		7				
	<i>Setodes isis</i> MALICKY &NAWVONG 2006		2				
	<i>Setodes mercurius</i> MALICKY & BUNLUE 2006		2				
	<i>Setodes neptunus</i> MALICKY & SAENGPRADAB 2006		1				
	<i>Setodes okypete</i> M&C 2006		45				
	<i>Setodes sarapis</i> M&C 2006		1				
	<i>Marilia mogtiana</i> MALICKY 1989					1	
	<i>Marilia sumatrana</i> ULMER 1951		1				
	<i>Anisocentropus erichthonios</i> MALICKY & CHEUNBARN 2001		1				
	Calamoceratidae						

Note: February and July were trouble in collected of sample. October cannot collected Trichoptera both larvae and adult because the flood.



Appendix B

The Physico-chemical water quality parameters of the seven sampling sites
of the Mae Tao and Mae Ku watersheds during
February to December 2011

Appendix table B1 Physico-chemical water quality parameters at MT1, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MT1					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	27.76	33.6	30.3	30.2	30.2	30
Water temperature (°C)	26.7	29.2	28.7	24.9	24.9	23.83
DO (mg/L)	3.37	3.36	4.65	5.69	5.69	3.84
pH	7.86	7.8	8.1	8.3	8.3	8.1
EC (µs/cm)	175.83	431.66	340.66	255.5	255.5	289.33
TDS (mg/L)	173.83	218.33	166	127	127	143.66
Turbidity (FTU)	8	21	13	22	15	17
SO ₄ ²⁻ (mg/L)	15	15	16	19	21	13
NO ₃ -N (mg/L)	2.4	1.3	2.3	2.3	2.6	1
PO ₄ ³⁻ (mg/L)	0.09	3.2	0.23	1.53	2.5	0.07
NH ₄ -N (mg/L)	0.28	0.35	0.32	0.37	0.39	0.04
Alkalinity (mg/L)	54	60	68	40	32	39
Cadmium (mg/kg)		3.465	0.11	0.142	0.19	1.325

Appendix table B2 Physico-chemical water quality parameters at MT2, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MT2					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	30.53	33.5	29.6	27.1	27.1	23.45
Water temperature (°C)	24.6	28.5	26.66	25	25	23.56
DO (mg/L)	4.66	4.226	4.71	6.92	6.92	4.94
pH	8.5	8.5	8.4	8.7	8.7	8.6
EC (µs/cm)	482.3	603	679.66	338	338	465
TDS (mg/L)	242.6	257.33	243.66	202	202	232.66
Turbidity (FTU)	5	18	73	16	13	4
SO ₄ ²⁻ (mg/L)	35	31	21	18	19	19
NO ₃ -N (mg/L)	1.6	1.6	2.4	2.5	2.6	1.5
PO ₄ ³⁻ (mg/L)	0.06	0.86	0.19	0.38	0.4	0.06
NH ₄ -N (mg/L)	0.22	0.38	0.34	0.36	0.39	0
Alkalinity (mg/L)	76	92	72	68	62	51
Cadmium (mg/kg)	0.478	0.33	0.136	0.852	0.141	0.361

Appendix table B3 Physico-chemical water quality parameters at MT3, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MT3					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	27.36	33.3	28.3	34.1	34.1	31.1
Water temperature (°C)	27.13	27.93	26.23	25.9	25.9	22.6
DO (mg/L)	4.47	4.503	4.79	6.28	6.28	4.91
pH	8.7	8.6	8.6	8.8	8.8	8.43
EC (µs/cm)	686.6	588.66	384.6	416.66	416.66	458.66
TDS (mg/L)	301.33	293.66	192.66	175	175	227.66
Turbidity (FTU)	1	5	48	20	20	3
SO ₄ ²⁻ (mg/L)	42	37	36	27	27	32
NO ₃ -N (mg/L)	2.2	1.5	2.5	2.6	2.5	1.5
PO ₄ ³⁻ (mg/L)	0.02	0.53	0.18	0.25	0.4	0.04
NH ₄ -N (mg/L)	0.32	0.35	0.26	0.38	0.37	0.01
Alkalinity (mg/L)	76	96	136	58	54	66
Cadmium (mg/kg)	10.82	10.893	76.45	3.592	9.696	22.288

Appendix table B4 Physico-chemical water quality parameters at MT4, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MT4					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	25.9	28.6	28.5	25.4	25.4	21.5
Water temperature (°C)	26.03	27.03	27.5	25.4	25.4	21.1
DO (mg/L)	3.78	4.02	5.22	6.47	6.47	4.68
pH	8.4	8.5	8.6	8.9	8.9	8.6
EC (µs/cm)				355.3		455.6
	538.3	513.33	258	3	355.33	6
	257.3			182.6		
TDS (mg/L)	3	264	132	6	182.66	202
Turbidity (FTU)	2	4	912	15	13	5
SO ₄ ²⁻ (mg/L)	38	39	29	28	28	38
NO ₃ -N (mg/L)	1.9	2.1	5.2	2.2	2.5	1.7
PO ₄ ³⁻ (mg/L)	0.07	0.36	0.28	0.29	0.3	0.06
NH ₄ -N (mg/L)	0.34	0.37	0.54	0.37	0.4	0.01
Alkalinity (mg/L)	70	90	60	58	58	63
						12.00
Cadmium (mg/kg)	6.872	11.798	8.219	5.815	14.284	3

Appendix table B5 Physico-chemical water quality parameters at MT5, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MT5					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	28.7	28.7	30.1	24.6	24.6	26.9
Water temperature (°C)	27.6	28.6	27.06	24.6	24.6	22.23
DO (mg/L)	1.65	3.39	4.46	6.66	6.66	3.84
pH	8.1	8.2	8.4	8.8	8.8	8.3
EC (µs/cm)	772.33	443.66	428.66	421.5	421.5	513
TDS (mg/L)	349	227.33	220.33	211	211	258.33
Turbidity (FTU)	5	2	62	11	12	6
SO ₄ ²⁻ (mg/L)	38	39	38	28	29	49
NO ₃ -N (mg/L)	1.9	1.6	3.4	2.5	2.7	1.8
PO ₄ ³⁻ (mg/L)	0.09	2.09	0.13	1.15	0.43	0.3
NH ₄ -N (mg/L)	0.4	0.41	0.36	0.42	0.4	0.11
Alkalinity (mg/L)	74	84	70	58	56	63
Cadmium (mg/kg)	6.526	12.46	5.446	7.254	18.273	16.975

Appendix table B6 Physico-chemical water quality parameters at MK2, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MK2					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	25.23	31.9		24.2	24.2	22.9
Water temperature (°C)	25.26	26.96		24.1	24.1	22.03
DO (mg/L)	4.49	4.703		6.7	6.7	4.66
pH	8.7	8.7		8.9	8.9	8.8
EC (µs/cm)	686.6	554.66		347	347	506
TDS (mg/L)	346	255.66		179	179	243.66
Turbidity (FTU)	5	60		20	42	18
SO ₄ ²⁻ (mg/L)	30	22		16	16	18
NO ₃ -N (mg/L)	2.7	3.6		3.2	3.2	2.8
PO ₄ ³⁻ (mg/L)	0.2	0.45		0.37	0.36	0.33
NH ₄ -N (mg/L)	0.25	0.43		0.42	0.4	0.01
Alkalinity (mg/L)	82	92		70	70	28
	<					
Cadmium (mg/kg)	0.025	0.092		0.131	0.1	0.083

Note: July cannot be collected because of roadworks, so not can access the sampling sites. February, it cannot detect because amount cadmium is less than 0.025 mg / kg.

Appendix table B7 Physico-chemical water quality parameters at MK8, Mae Sot District, Tak Province recorded during February to December 2011.

Parameters	MK8					
	Feb	Apr	Jul	Oct	Nov	Dec
Air temperature (°C)	33.2	33.9	30.1	34.1	34.1	29
Water temperature (°C)	30.66	29	28	27.06	27.06	25.9
DO (mg/L)	4.29	4.74	4.83	6.25	6.25	4.23
pH	8.4	8.6	8.4	8.5	8.5	8.53
EC (µs/cm)	545.3	970	578.66	335.66	335.66	572.66
TDS (mg/L)	366.3	463.33	345.66	167.66	167.66	287.33
Turbidity (FTU)	1	6	146	44	54	25
SO ₄ ²⁻ (mg/L)	28	21	18	16	16	50
NO ₃ -N (mg/L)	2.2	2.9	3.8	3.2	3.2	3.6
PO ₄ ³⁻ (mg/L)	0.05	1.53	0.13	0.37	0.32	0.23
NH ₄ -N (mg/L)	0.27	0.38	0.25	0.38	0.37	0.04
Alkalinity (mg/L)	82	88	120	56	56	67
Cadmium (mg/kg)	1.893	5.453	2.471	4.029	4.312	6.012

CURRICULUM VITAE

NAME :Miss Pronthip Peumwarunyoo

BIRTH DATE :August 24, 1987

BIRTH PLACE :Nakhonpathom, Thailand

EDUCATION	<u>YEAR</u>	<u>INSTITUTE</u>	<u>DEGREE/DIPLOMA</u>
	2010	Kasetsart Univ.	B.S. (Biological Science)

SCHOLARSHIP/AWARDS : Graduate School, Kasetsart University

