ENVIRONMENTAL MONITORING ALONG THE WATERSHED CLASSES OF UPPER PING WATERSHED BY TRICHOPTERA COMMUNITY

SIRAPORN CHEUNBARN

DOCTOR OF PHILOSOPHY
IN BIOLOGY

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23 AUGUST 2002

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Siraporn Cheunbarn

ชื่อเรื่องวิทยานิพนธ์ การติดตามตรวจสอบสภาพแวดล้อมตามชั้นคุณภาพลุ่มน้ำปิงตอนบนด้วยกลุ่มแมลงหนอนปลอกน้ำ

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บทคัดย่อ

ชั้นคุณภาพลุ่มน้ำขึ้นกับลักษณะที่แตกต่างกันของป่าไม้ พื้นที่เกษตรกรรม คุณภาพน้ำ และการตั้งถิ่นฐาน เนื่องจากมีการใช้ที่ดินที่ไม่เหมาะสมเกิดขึ้นในทุกชั้นคุณภาพลุ่มน้ำเหล่านี้ ดังนั้นการศึกษาในครั้งนี้จึงได้ประยุกต์ใช้กลุ่มแมลงหนอนปลอกน้ำ เพื่อเป็นดัชนีตรวจสอบสภาพแวดล้อมที่เสื่อมโทรมลงในลุ่มน้ำปิงตอนบนในภาคเหนือของประเทศไทย โดยได้ทำการเก็บตัวอย่างใน 7 ลุ่มน้ำย่อยของลุ่มน้ำปิงซึ่งได้แก่ แม่แตง แม่ปิงส่วนบน แม่ริม แม่กวง แม่ขาน แม่งัด และแม่ปิงส่วนที่ 2 โดยในแต่ละลุ่มน้ำย่อย ได้ทำการเก็บตัวอย่าง 2 จุดเก็บตัวอย่างในแต่ละชั้นคุณภาพน้ำ สำหรับตัวแทนของน้ำเสียจากชุมชน ได้ทำการเก็บตัวอย่างในลำธารห้วยโจ้ ซึ่งจะได้รับน้ำจากระบบบำบัดน้ำเสียของมหาวิทยาลัยแม่โจ้โดย 2 จุดเก็บตัวอย่างแรกอยู่ส่วนบนของลำน้ำซึ่งใช้เป็นจุดอ้างอิงและ 2 จุดซึ่งอยู่ด้านล่างของลำน้ำใช้เป็นจุดที่ได้รับผลกระทบ

ตัวเต็มวัยของแมลงหนอนปลอกน้ำใช้วิธีการเก็บด้วยการใช้กับดักไฟล่อ พร้อมกับเก็บตัวอย่างน้ำ ในพื้นที่ลุ่มน้ำปิงตอนบน พบแมลงหนอนปลอกน้ำทั้งสิ้น 17 วงศ์ 237 ชนิด ในห้วยโจ้พบ 6 วงศ์ 32 ชนิด ส่วนมากจะพบวงศ์ Hydropsychidae ในขณะที่ วงศ์อื่นๆ พบน้อย จากการศึกษาพบชนิดใหม่ 5 ชนิดที่ได้รับการตั้งชื่อ เป็นวงศ์ Calamoceratidae 1 ชนิด ได้แก่ *Anisocentropus erichthonios* Malicky & Cheunbarn 2001 และ วงศ์ Leptoceridae 4 ชนิด ได้แก่

Leptocerus dryade Malicky & Cheunbarn 2001, *Adicella larentia* Malicky & Cheunbarn 2002, *Ceraclea hera* Malicky & Cheunbarn 2002 โดยมี 1 ชนิด เป็น paratype ได้แก่ *Ceraclea idaia* Malicky & Chaibu 2002 และอีก 20 ชนิดซึ่งคาดว่าจะเป็นชนิดใหม่

คุณภาพน้ำของ 7 ลุ่มน้ำย่อยของลุ่มน้ำปิงตอนบนนั้นแตกต่างกันอย่างมีนัยสำคัญ($P< 0.05$) คุณภาพน้ำส่วนใหญ่อยู่ในชั้น 2 ของมาตรฐานคุณภาพน้ำผิวดินของประเทศไทย ยกเว้นลุ่มน้ำแม่ขานซึ่งอยู่ในคุณภาพน้ำชั้นที่ 3 ส่วนลำธารห้วยโจ้ซึ่งอยู่ในชั้นคุณภาพลุ่มน้ำชั้นที่ 5 ของลุ่มน้ำแม่กวง คุณภาพน้ำอยู่ในชั้นที่ 3 ยกเว้นจุดเก็บที่อยู่หลังจากระบบบำบัดซึ่งได้รับน้ำเสียจะอยู่ในชั้นคุณภาพน้ำที่ 4

จากการวิเคราะห์แบบหลายตัวแปรด้วย TWINSPAN และ Ordination (HMDS) สามารถจำแนกจุดเก็บตัวอย่างออกได้เป็น 4 กลุ่ม ภายใต้ชั้นคุณภาพลุ่มน้ำ 5 ชั้น โดยในกลุ่มที่ 1ประกอบไปด้วยชั้นคุณภาพลุ่มน้ำชั้น 5 โดยพื้นที่ส่วนใหญ่ในกลุ่มนี้เป็นชุมชนและพื้นที่เกษตรกรรม กลุ่มที่ 2 และ 3 เป็นกลุ่มที่ประกอบไปด้วยทุกชั้นคุณภาพลุ่มน้ำ ซึ่งเป็นบริเวณที่มีการเปลี่ยนแปลงการใช้ที่ดินมาก ในขณะที่กลุ่มที่ 4 ประกอบไปด้วย ชั้นคุณภาพลุ่มน้ำที่ 1 และ 2 ซึ่งเป็นป่าไม้และพื้นที่ต้นน้ำลำธาร โดยพบว่าสภาพแวดล้อมและคุณภาพน้ำดี และมีความผันแปรน้อยกว่ากลุ่มอื่นๆ จากผลการศึกษาพบว่ามีการเปลี่ยนแปลงการใช้ที่ดินในทุกชั้นคุณภาพลุ่มน้ำ เนื่องจากพบว่ามีการปะปนกันของชั้นคุณภาพลุ่มน้ำในทุกกลุ่ม ยกเว้นในกลุ่มที่ 1 เพียงกลุ่มเดียวที่ประกอบไปด้วยชั้นคุณภาพลุ่มน้ำชั้น 5 เพียงชั้นเดียวและจากความสัมพันธ์ระหว่างชนิดของแมลงหนอนปลอกน้ำที่พบกับคุณภาพน้ำ และจุดเก็บตัวอย่าง สามารถแบ่งกลุ่มของ indicator species ได้เป็น 2 กลุ่มคือ กลุ่มแรกได้แก่ tolerant indicator species ซึ่งมักพบในชุมชนและที่มีการปนเปื้อน โดยเฉพาะในลุ่มน้ำชั้น 4 และ 5 ได้แก่ *Cheumatopsyche cognita, Ecnomus mammus, Leptocerus chiangmaiensis, Cheumatopsyche globosa, Potamyia panakeia* และ *Amphipsyche meridiana* โดยเฉพาะ *Amphipsyche meridiana* สามารถใช้เป็นดัชนีสำหรับการปนเปื้อนจากน้ำเสียชุมชนได้ และกลุ่มที่ 2 ได้แก่ sensitive indicator species ซึ่งมักพบในบริเวณป่าไม้และพื้นที่ต้นน้ำ โดยเฉพาะในลุ่มน้ำชั้นที่ 1 และ 2 ได้แก่ *Rhyacophila suthepensis, Macrostemum midas, Macrostemum fastosum* และ *Hydropsyche uvana*

สภาพแวดล้อมที่เปลี่ยนแปลงไปในแต่ละชั้นคุณภาพลุ่มน้ำของลุ่มน้ำปิงตอนบนเป็นผลมาจากการใช้ที่ดินที่ไม่เหมาะสมและไม่สอดคล้องตามหลักการจัดการลุ่มน้ำ ซึ่งสามารถใช้กลุ่มแมลงหนอนปลอกน้ำเป็นดัชนีบ่งบอกถึงการเปลี่ยนแปลงการใช้ที่ดินที่เกิดชั้นในชั้นคุณภาพลุ่มน้ำเหล่านี้ได้

Thesis Title Environmental Monitoring Along the Watershed Classes of Upper Ping Watershed by Trichoptera Community

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Ph.D. Biology

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ABSTRACT

Watershed classes are based on various land uses in forest, agriculture, water quality, and human settlement areas. Because of inefficiency of land uses in these watershed classes, Trichoptera communities have been applied in this study to use as indicators for monitoring environmental degradation in the upper Ping watershed, northern Thailand. Seven subwatersheds of Ping river basin were selected for sample collection, viz. Mae Taeng, the upper part of Mae Ping, Mae Rim, Mae Kuang, Mae Khan, Mae Ngat, and the second part of Mae Ping. In each subwatershed, two sample sites were selected from each watershed class. A representative domestic waste study site was located in Huai Jo stream which received water from the Maejo University wastewater treatment plant. Two sample sites were located upstream as control sites and two were located downstream as impacted sites.

Adult Trichoptera were sampled with light traps and at the same time surrounding water was sampled. Seventeen families with 237 species were found in the upper Ping watershed area and 6 families with 32 species were found in Huai Jo stream. Most of them were Hydropsychidae, while other families were sparsely represented. Five species were new and had been described, one Calamoceratidae, *Anisocentropus*

erichthonios Malicky & Cheunbarn 2001, and four Leptoceridae, *Leptocerus dryade* Malicky & Cheunbarn 2001, Adicella *larentia* Malicky & Cheunbarn 2002, *Ceraclea hera* Malicky & Cheunbarn 2002, and one paratype, *Ceraclea idaia* Malicky & Chaibu 2002. Twenty other species possibly are new to science.

The water quality parameters in the seven Ping river subwatersheds were significantly different from each other (P< 0.05). Most of the water quality parameters were in class 2 of the Thai Classification and Surface Water Quality Standard, except Mae Khan watershed, which was in class 3. Huai Jo stream was in watershed class 5 in Mae Kuang watershed, the water quality parameters were in class 3, except site which located after treatment plant and received wastewater was in class 4.

From multivariate analysis with TWINSPAN and Ordination (HMDS), four groups of sites were generated within the five watershed classes. Group 1 consisted of most sites in watershed class 5, which were urban and agricultural areas. Groups 2 and 3 consisted of a mixture of all watershed classes with had various land uses, while Group 4 consisted of sites in watershed classes 1 and 2, which were forest and headwaters. The environment and water quality in Group 4 were good with less variation than in the other groups. From this study there were many changes in land uses patterns in each watershed class because all watershed classes mixed in most groups, except Group 1 which had only sites in watershed class 5. Based on Trichoptera species, water quality parameters, and study sites, Trichoptera indicators could be divided into two groups. The first group was tolerant indicator species that were always found in urban and polluted areas, especially in watershed classes 4 and 5. They were Cheumatopsyche *cognita, Ecnomus mammus, Leptocerus chiangmaiensis, Cheumatopsyche globosa, Potamyia panakeia,* and *Amphipsyche meridiana. Amphipsyche meridiana* can be used as an indicator for domestic waste. The second group was sensitive indicator species that were always found in forest and headwaters areas, especially in watershed classes 1 and 2. They were *Rhyacophila suthepensis, Macrostemum midas, Macrostemu fastosum,* and *Hydropsyche uvana.*

Environmental changes in each watershed class of the upper Ping watershed was due to inappropriate in land use and not corresponded to the principles of watershed management. Trichoptera community has been potentially used as an indicator for land use changing in these watershed classes.

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CHAPTER 1
INTRODUCTION

1.1 Forest situation in Thailand

Forests in Thai watersheds are disappearing at an alarming rate because of the increasing demand of land for agriculture to meet the needs of the growing population and urbanization. Currently, about 43 percent of the land area of Thailand is dedicated to permanent agricultural production. Thai forest cover has been decline rapidly from 70% in 1910 to 38% in 1989 and 33.4% in 1999. The total losses of forestlands of one million acres per year and gradually declined to 200,000 acres annually at the present time. Rapid deforestation and increasing human population in forested areas have caused much degeneration of watercourses, especially in the upper catchment areas. This is why many watersheds in Thailand have been or will soon be seriously degraded. This problem is most serious in northern Thailand, which is the source of many watercourses.

Lotic systems are inherently linked to the terrestrial ecosystems that surround them. Disturbances by land use activities and deforestation, particularly of the headwaters, are affected stream flow and water qualities. Several studies have shown that land use has a strong influence on river chemistry (John, 1997; Mervyn, 1993) and its biotic components (Dance and Hynes, 1980). Much less is known about the relationship between stream conditions and land uses in tropical developing countries. The sequence of such problems has been shown as floods in the wet season and dry spells in the hot season. The depletion of forests induces environmental problems, especially erosion and infertile soils, siltation in streams and reservoirs.

Thai government has attempted to solve these problems with several strategies and policies, e.g. watershed classification for zoning measures for watershed conservation in Thailand besides urging involved agencies to restore forests in the deforestation areas.

However the watershed classification is only a guideline for protecting deforestation but forests are still destroyed because of not only conflicts between forest and other land use activities, but also difficult to investigate and regulate.

Biomonitoring is another useful method to detect environmental quality degradation in watershed.

1.2 Mae Ping river basin, northern Thailand

Mae Ping watershed area is located in Chiang Mai Province, northern Thailand. Development has been hampered by a long history of conflict over water and forest resources. The upland communities, approximately 500,000 people, are ethnically diverse including Karen, Hmong, Akha, and other smaller hill-tribe groups. Traditionally, the hill-tribes utilize two major types of shifting cultivation: 1) cropping an area for three to five years and then abandoning use, and 2) a type of rotating shifting cultivation around permanent villages, often with permanent tree crops and rotating use of areas of row crops, with up to 15 years of fallow before reuse. An additional 30,000 to 40,000 hectares of forest are cleared per year for shifting cultivation.

Various forms of shifting cultivation, including sedentary settlement patterns with rotation of crops, as practiced by the Karen, to highly mobile short-use long-fallow rotations of Hmong and Akha. These people are farmers and therefore rely heavily on the forest, wild animals, and water resources. The natural environment of Ping watershed area has been seriously damaged and depleted due to human activities. Deforestation is also a serious problem. Ping river is unhealthy since the water quality is poor. No effective strategy has yet been devised to protect the river and its ecosystem from systematic destruction (Putta, 2002).

In recent times, as a result of land shortages caused by increasing population, as well as upland expansion of activities of lowland Thai communities to develop orchards and modern agriculture, the scope for traditional shifting agriculture practices has been constrained. Land use in Ping watershed is changing all the time, but has not shown certain direction and magnitude in all classes of watershed (Khaubol, 1990). Ping watershed classification areas are shown in Table 1.1

Table 1.1 Ping watershed classifications.

	Area (km^2)	Watershed Classification Area (%)				Forest area (%)
		1A	1B	2	3-5	
Ping watershed	33,898	36.0	2.0	14.0	48.0	49.0

Source: Forest Department Annual Report, 1996

1.3 Effects of land use on freshwater

Many environmental problems result from increasing rapidly of land use changes and one of the critical facts about these changes in land use is that the effects may be long term and sometimes irreversible. Changing forests to other uses, e.g. agriculture and settlement effect the fauna within a stream as a result of increased concentrations of nutrients (Polpraprut, 1993), decreased stream flow, which decreases the available stream habitat, increased erosion and water temperature (Wongsombat, 1998; Siripong & Sugomoto, 1996) due to the removal of riparian vegetation. Most of the available literatures on the effects of land use activities have dealt primarily with water quality (Keowonpen, 1989; Padongkij, 1989; Clenaghan, 1998). Local ecological factors such as acid water, shading and agricultural input and rapid downstream changes in stream physico-chemistry and seasons (related to life history patterns of invertebrates) are important in explaining variations in macroinvertebrates community compositions.

Many studies have focused on which indicators are useful for evaluating changing land use and environmental concerns in Thai watershed areas, such as physico-chemical parameters (Polpraprut, 1993; Siwasen, 1997), bacteriological parameters (Tesprasit, 1993; Yodpetch, 1997) and algae (Keolek, 1989). Invertebrates are the most commonly used group of bioindicators for water quality studies.

1.4 Purposes of the study

1. To determine the relationship between the watershed classification and distribution of Trichoptera in Ping river and its tributaries.
2. To investigate the impact of land use activities on Trichoptera species and the communities' response to environmental factors.
3. To identify and recommend some species of Trichoptera as bioindicators of organic waste pollution.
4. To clarify the relationship between water quality and the Trichoptera community.

CHAPTER 2
LITERATURE REVIEW

2.1 Trichoptera

The name Trichoptera is derived from the Greek words " *trichos*", meaning hair, and "*ptera*" meaning wings, refer to the long, silky hairs that cover most of the body and wings (Meyer, 2001). The order Trichoptera (caddisflies) one of the largest groups of aquatic insects, are closely related to the Lepidoptera. Like the Lepidoptera, they are holometabolous (Williams and Feltmate, 1992). They occur on all continents expect Antarctica, and are found in fresh and brackish and seawater. Most occur in inland waters where they have evolved to conditions in variety of permanent and temporary running and standing water biotopes (Ward, 1992).

2.1.1 General information on Trichoptera biology

Adult morphology

Adult caddisflies are between 1.5 and 40 mm in length and somewhat similar to moths. Most of them are rather dull colored, but a few conspicuously patterned (Borror and DeLong, 1970).

Head: The antennae are always long, and slender. The compound eyes are usually small, but in some males they are very large and almost meet at the vertex. Ocelli (three in number) are present in some species, absent in others. The mouthparts are the chewing type with well developed palps. The mandibles are vestigial, the maxillae are small and closely associated with the labium.

Thorax: Three thorax segments are distinct. The prothorax is small and ringlike, whilethe mesothorax and metathorax are well developed. Two pairs of membranous wings covered with long hairs are almost always present, though one or both pairs may be greatly reduced in a few species. The hind wings are broader than the fore wings and few cross veins are present in either set of wings. Hair is common on the wing surface as well as on the body. The wings are held rooflike over the body at rest and when flying the fore and hind wings of strong flying species tend to be physically coupled together. The legs are long and slender and the tibias have varying numbers of apical and preapical spurs.

Abdomen: Ten abdominal segments can be distinguished. In males the genitalia comprise a pair of claspers and bilobed aedeagus, or an aedeagus alone. In females of some species the terminal segments are retractile and function as an ovipositor.

Life history

The order Trichoptera is an order of holometabolous neopterans with complete metamorphosis (egg, larva, pupa, and adult). The life cycle is showed in Figure 2.1.

Adult Trichoptera are terrestrial and may be found some distance from water (Romoser and Stoffolano, 1994) and are somewhat similar to moths in general appearance (Borror and DeLong, 1970). They are mostly nocturnal, weak-flying insects that are often attracted to lights. Few species have actually been observed feeding and most adults are relatively short-lived (Meyer, 2001). Mating takes place in flight (sometime in swarms) or on vegetation.

Eggs are deposited in strings or masses near or in the water, on aquatic vegetation, beneath stones, and in similar locations. After hatching the young larvae dropping into the water. Most caddisfly eggs hatch in 10 to 24 days (Borror and DeLong, 1970).

Larvae are aquatic and caterpillarlike (Borror and DeLong, 1970). Some larvae are case makers, others construct nets under water, and a few are free living. The case-making larvae build portable case of various materials and various shapes. In more primitive families larvae do not build cases. They either live under stones or construct a nonportable silken web (Daly *et al.*, 1987; Wiggins, 1996). Larvae pass through five to seven larval instars, but most species include five larval instars. Distribution of larva caddisflies are strongly influenced by the qualities of substrate, current, vegetation, daily photoperiods, altitude, and nutrients (Daly *et al.*, 1987; Wiggins, 1996).

The pupa either lies freely in the case or spins a very flimsy cocoon. Members of non– case– bearing species spin a silken cocoon which is often strengthened by the addition of foreign materials (Daly *et al.*, 1987; Wiggins, 1996). When the pupa is fully developed, it cuts its way out of the case with mandibles, swims to the surface, crawls out of the water on to a stone or stick, and the adult emerges.

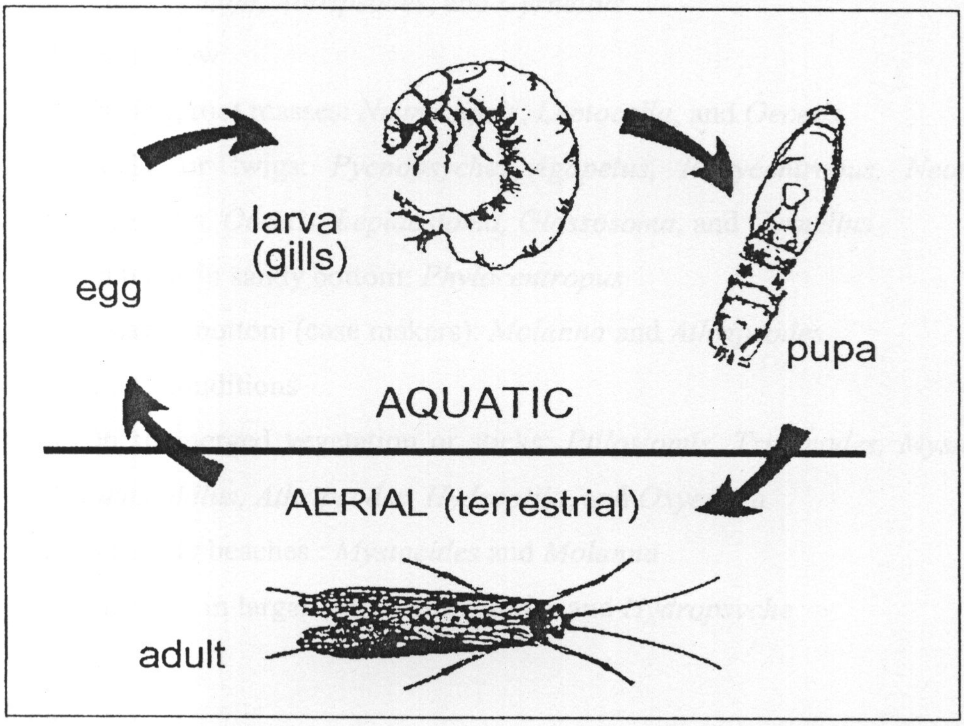


Figure 2.1 Trichoptera life cycles with Complete Metamorphosis (Matthew, 1988).

Habitats

Adult caddisflies, which are usually found close to fresh water, are mainly crepuscular or nocturnal, hiding by day among vegetation and are quite hard to find. They are strongly attracted to light at night (Williams and Feltmate, 1992; Borror and White, 1979). Distribution of is strongly influenced by the qualities of the substrate, as well as by current, presence and type of vegetation, and water temperature (Daly *et al.*, 1987). The list follow are locations within a body of water where various caddisfly larva live (Roback, 1974). Naturally these categories are not mutually exclusive and a great deal of overlap is to be expected.

Fast water and riffles

a. On or under stones: *Rhyacophila*, *Cheumatopsyche*, *Chimarra*, *Hydropsyche*, *Brachycentrus*, *Hesperophylax*, and *Helicopsyche*

b. Attached to upper surfaces of stones: *Leucotrichia*

c. On wood substrate: *Cheumatopsyche*, *Chimarra*, *Hydropsyche*, *Macronemum*, *Athripsodes*, and *Cyrnellus*

Moderate flow

a. Trailing root masses: *Neureclipsis*, *Leptocella*, and *Oecetis*

b. Rocks or twigs: *Pycnopsyche, Agapetus, Platycentropus, Neophylax, Psilotreta, Oecetis, Lepidostoma, Glossosoma*, and *Cyrnellus*

c. In tubes in sandy bottom: *Phylocentropus*

d. In sandy bottom (case makers): *Molanna* and *Athripsodes*

Pond-like conditions

a. On submerged vegetation or sticks: *Ptilostomis, Triaenodes, Mystacides, Limnephilus, Athripsodes, Hydroptila*, and *Oxyethira*

b. On sandy beaches : *Mystacides* and *Molanna*

c. On rocks in larger lakes- *Athripsodes* and *Hydropsyche*

Food

All Trichoptera larvae live in aquatic environments. They may be herbivores, scavengers, predators, or omnivorous (Meyer, 2001). The net builders, especially those in faster water, eat a predominance of planktonic organisms, but will also eat other small organisms, which may be found in stream drift (Roback, 1974).

Economic importance

Trichoptera larvae may serve as food for fish and other aquatic vertebrates. Fishermen often gather them for use as bait for trout and other game fish. The larvae of some Leptocerids have been recorded as pests, which damage the young shoots of rice plants in rice paddy fields (Williams and Feltmate, 1992). Although Trichoptera are not generally considered to be of great economic importance (Meyer, 2001), the larvae of many species are good bioindicators of aquatic pollution (Romoser *et al.*, 1994).

Trichoptera classification

Gillott (1980) divided Trichoptera into three major groups by phylogentic relationships.

1. The Annulipalpia (fixed –retreat makers) includes all of families whose larvae make retreats and capture nets (Figure 2.2 C).

2. The Spicipalpia (close- cocoon makers) includes several rather different groups, each with different larval habits (Figure 2.2B and D).

- Free-living and predator (Rhyacophillidae and Hydropbiosidae)- build no larval structures, but pupate within a domelike enclosure of mineral fragments.
- Purse-case makers (Hydroptilidae) – make a case which is portable or cemented to the substrate.
- Tortoise-case or saddle-case (Glossosomatidae)

3. The Integripalpia (tube case makers) – construct a tubular case which made from very different materials in various species (Figure 2.2A).

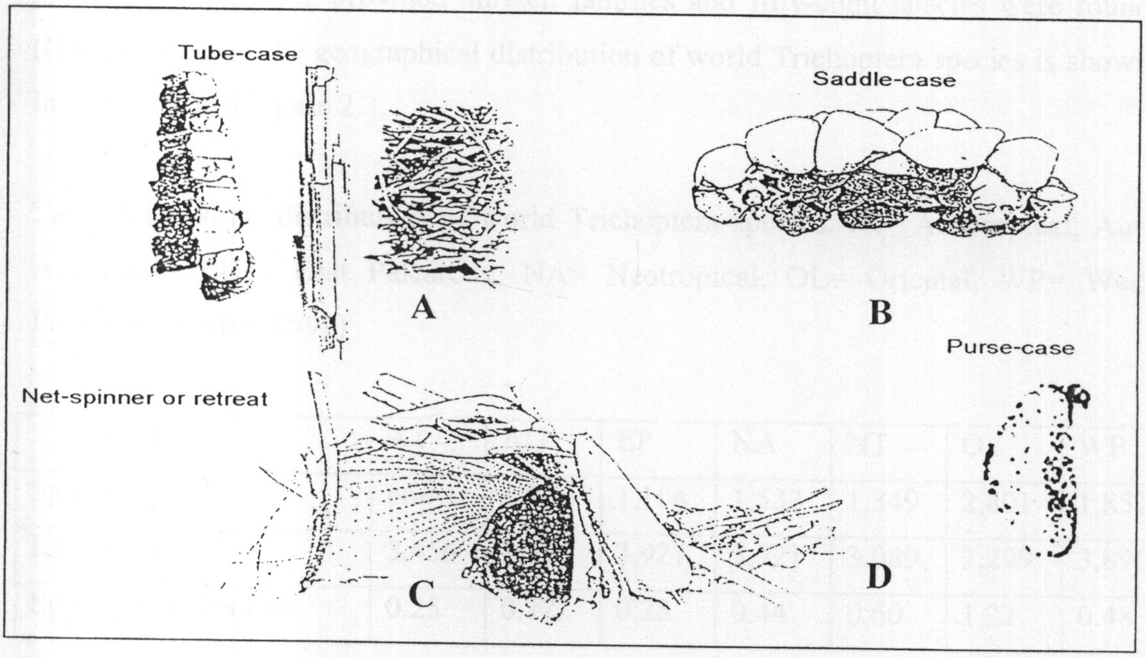


Figure 2.2 Type of Trichoptera case . A. Tube- case, B. Saddle- case, C. Net-spinner or retreat, D. Purse-case (McCafferty,1981; Meritt and Cummins,1984)

2.1.2 Trichoptera distribution

The Trichoptera has a worldwide distribution. Adults are terrestrial, but larvae and pupae are aquatic and live in most types of water bodies, including both cold and warm springs, temporary waters and (rarely) seashores (Williams and Felmate, 1992). There are even a few totally terrestrial species (Mathis, 1999; Noraki, 1999). Forty three families and more than 7,000 species are found worldwide (Meyer, 2001). Trichoptera species in temperate regions, especially North America and Europe, are well known, but the fauna of tropical regions is much less well known. Two thousand one hundred and seventy five species have been recorded from the Neotropics, but this probably represents only a fraction of the actual fauna (Halzenthal & Blahnik, 1997). Eighteen families and one thousand two hundred and sixty-one species are found in North America (Meyer, 2001). More than 600 species are known in Thailand. Adult Trichoptera in Doi Suthep-Pu include 142 species (Malicky *at al.*, 2001; 2002; Malicky and Chantaramongkol, 1999; Prommi, 1999; Thamsenanupap, 2001). In Doi Chiang Dao 127 species of Trichoptera were identified (Luadee, 2002). In Ping river, Chiang province thirteen families and fifty-eight species were found (Chaibu, 2000). The geographical distribution of world Trichoptera species is shown in Table 2.1 and Figure 2.3.

Table 2.1 World distribution of world Trichoptera species: At= Afrotropical, Au= Australasion, EP= East Palearctic, NA= Neotropical, OL= Oriental, WP= West Palearctic (Morse, 1997)

	AT	AU	EP	NA	NT	OL	WP
Species	864	1,000	1,104	1,532	1,849	2,801	1,852
Kilo hectares	3,456	1,395	3,927	3,521	3,089	2,299	3,890
Species/Kilo hectare	0.25	0.72	0.28	0.44	0.60	1.22	0.48

2.1.3 Characters used in identifying Trichoptera

Male and female are distinguished by the abdominal segments. Segment 10 in male is usually strongly modified. Various projection arising from the last segments

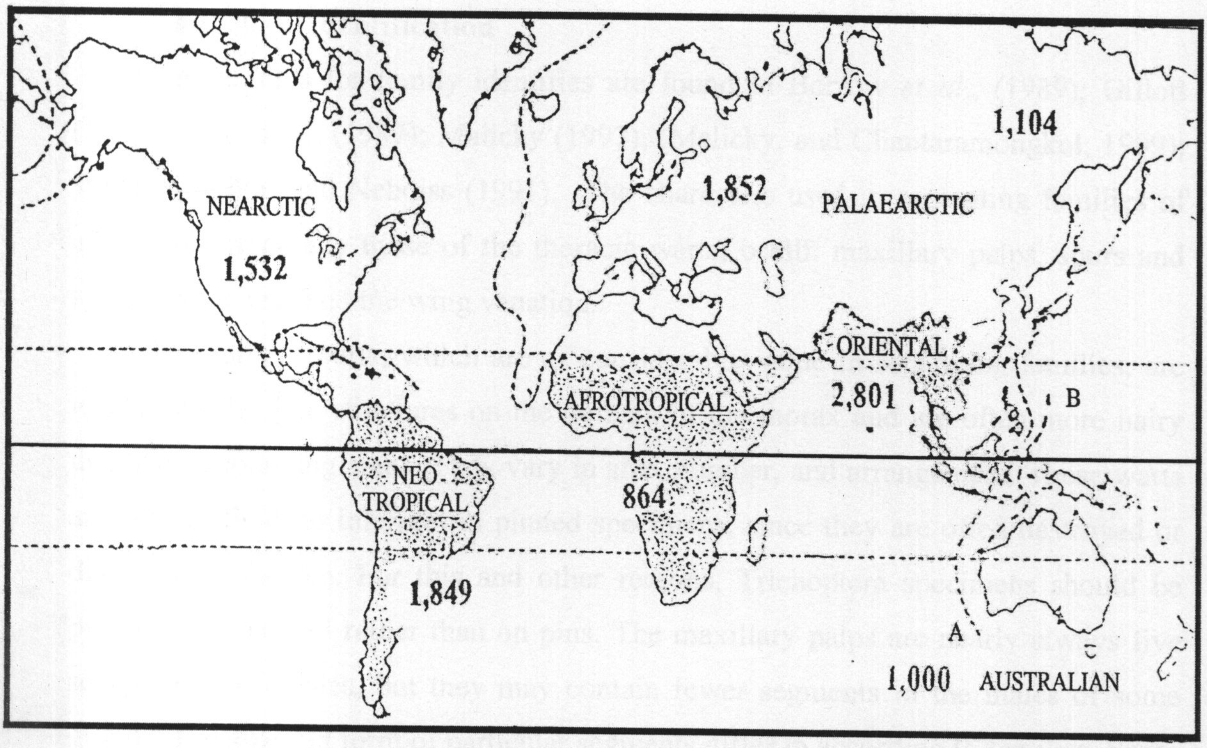


Figure 2.3 World Trichoptera distribution and numbers of species (Morse,1997).

are diverse in form and constitute the outer genitalia armature. These are generally useful aids to specific level identification. In females, segment 10 has one to three pairs of finger-like process.

Family level identification

Graphic keys for family identifies are found in Borrow *et al.*, (1989); Gillott (1980); Daly *et al.*, (1987); Malicky (1997); (Malicky, and Chantaramongkol, 1999); Wiggins (1996) and Neboiss (1991). The characters used in separating families of adults are principally those of the thoracic warts, ocelli, maxillary palps, spurs and spines on the legs and the wing venation.

The thoracic warts, which are of considerable value in separating families, are wart (tubercle) like structures on the dorsum of the thorax and are often more hairy than the surrounding areas. They vary in size, number, and arrangement. These warts are very difficult to interpret in pinned specimens, since they are often destroyed or distorted by the pin. For this and other reasons, Trichoptera specimens should be preserved in alcohol rather than on pins. The maxillary palps are nearly always five segmented in females, but they may contain fewer segments in the males of some groups. The size and form of particular segments differ in according to families. Some variation in the spunation of the legs is shown in Figure 2.4. The most important variations are in the number of spurs, which may vary up to a maximum of four, i.e. two, apical and two near the middle of the tibia. The leg spines are small, usually black structures. Wing venation is not a very important character in separating the families of Trichoptera. Ocellis are present or absent useful feature.

Species level identification

Male genitalia are useful for species level identification (Figure 2.5). The position and arrangement of veins and apical forks on the wings are important for identification. Various projections arising from the last segments are diverse in form and constitute the outer genitalic armature. Graphic key for family identifies are Keys for identify are Malicky, 1987; 1989; 1994; 1995; 1997; 1997a and Malicky *et al.*, 2000; 2000a; 2001; 2002; Malicky and Chantaramongkol, 1989; 1989a; 1991; 1991a;

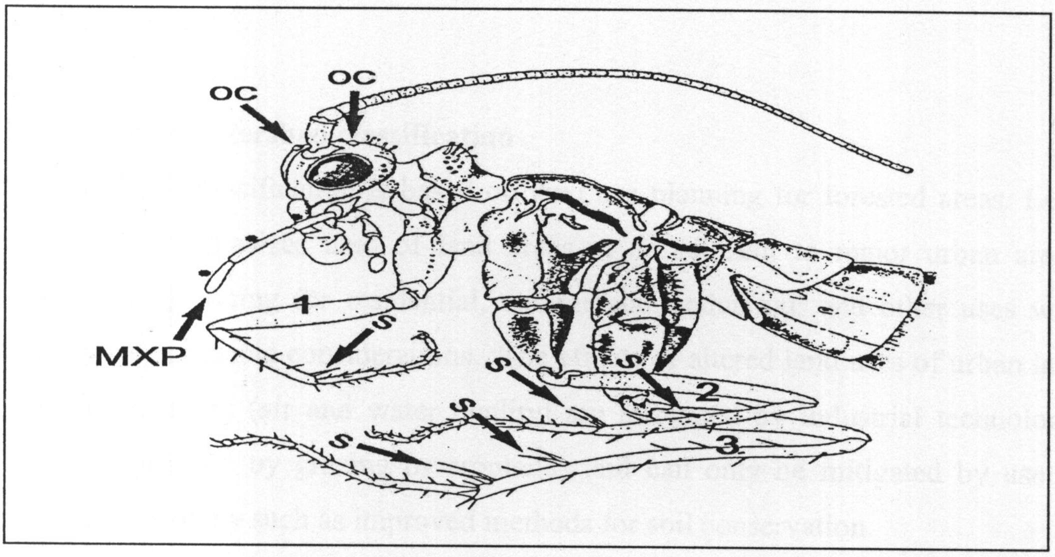


Figure 2.4 Family level identification by Diagnostic family character (Malicky, 1983)

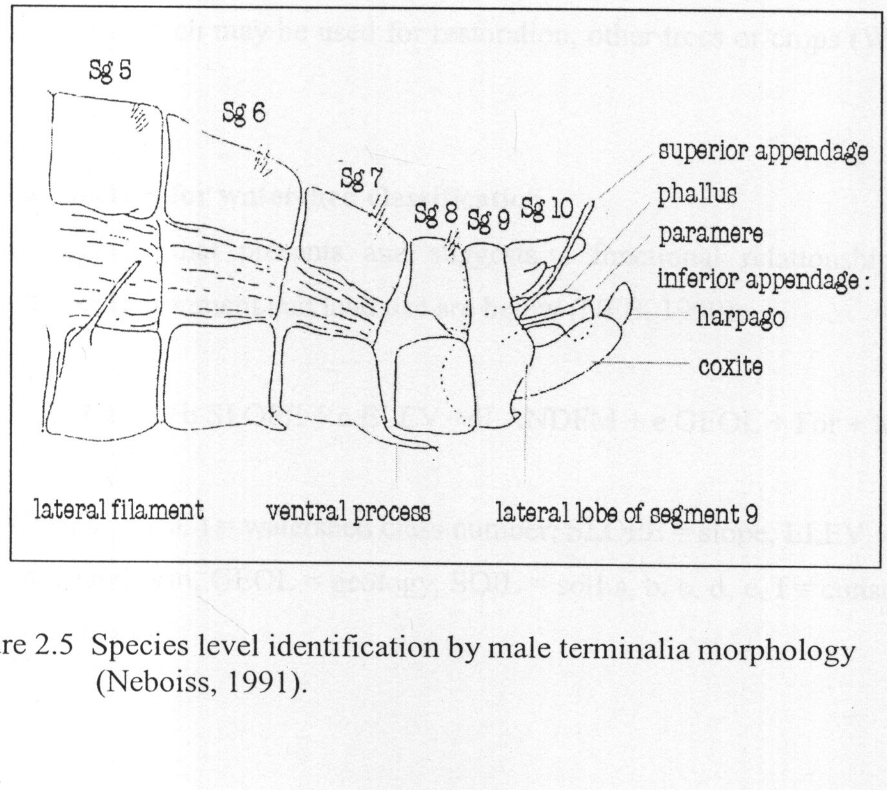


Figure 2.5 Species level identification by male terminalia morphology (Neboiss, 1991).

1991b; 1992; 1992a; 1993; 1994; 1995; 1996; 1997; 1999; Chantaramongkol and Malicky, 1989; 1995.

2.2 Concept of watershed classification

Watershed classification is based on land use planning for forested areas. Land use planning emphasizes uses of land areas in or adjacent to major urban areas. Examples are planning for residential, commercial, industrial, and other uses with certain social economic considerations. The effects of altered land uses of urban land on the environment (air and water quality) are mitigated by industrial technology. Forests are effected by grazing or croplands and can only be mitigated by use of improved technology such as improved methods for soil conservation.

Usually a much larger percentage of catchment area is affected by forestry or agricultural uses with increased effects on the environment. Cutting and burning of forests are examples. Land use planing or watershed classification is an effort to make the land as compatible as possible with features of the environment, thus mitigating on site and off site effects of use. The emphasis in northern Thailand is prevention of soil erosion. Watershed classification will help achieve this goal by identifying which areas should be maintained as protected forests and prescribing guidelines for uses as associated areas which may be used for restoration, other trees or crops (Wooldridge, 1986).

2.2.1 Parameters for watershed classification

The equation that presents and suggests a functional relationship between features of the environment and land use are below (NEB, 1990):

$$Y(WSC) = a+b\ SLOPE + c\ ELEV + dLANDFM + e\ GEOL + For + Min$$

When Y (WSC) = watershed class number, SLOPE = slope, ELEV = elevation LANDFM = landform, GEOL = geology, SOIL = soil a, b, c, d, e, f = constant, For = forest, Min = mining

The seven physical parameters are discussed below.

1. SLOPE: Many physical processes related to rates of soil erosion or mass wasting are a direct function of steepness of slope. Steeply sloping areas and stream channels have increased energy for transportation of eroded material and bed load. Overland flow has similar energy relations with slope steepness. Slope is measured in percent from contour maps.
2. LANDFORM: Current landforms are the product of erosional history. Properly scaled, landforms may be arrayed from the most erosive to the most stable. Scaling of landform is done by giving minimum values to peaks, ridges, canyons and dissected landform. Maximum value is assigned to most stable landforms such as broad plains, broad alluvial valleys, etc. Landform is assigned a numerical value from landform description read from contour maps.
3. ELEVATION: Elevation should have a negative effect on watershed classes as increased elevations represent both steeper landforms and increased erosional potential. Elevation is read from contour lines.
4. SOILS: Soils have been arrayed numerically in relation to the inherent stability.
5. GEOLOGY: Geologic formations are arrayed numerically in a manner similar to soils, based on evolution to a stable soil or dispersion ratios.
6. VEGETATION: Presence or absence of forest cover is included as a variable (0= absent or 1= present) for two reasons; 1, an objective of watershed classification is to maintain a given minimum area of Thailand as permanent forest; and 2, certain areas of Thailand which would be classified as watershed class 1A have been in agricultural use for several decades. It would not be possible to force people living on these lands to leave
7. MINING: Potential use for mining.

Other variables considered include; climate, e.q. rainfall and temperature, (annual or seasonal averages); water yield, water quality, soil depth, endangered species and/ or endangered species habitats, or aesthetic values related to recreation.

2.2.2 Watershed Classes (WSC)

Thai watersheds can be separated and mapped in five major watershed classes (Figure 2.6). There are briefly described by Woodridge (1986).

WSC1: Class 1A are areas of protected forest and headwater source areas usually at higher elevations with very steep slopes. These areas should remain in permanent forest cover.

Class 1B are areas of similar physical features and environment to WSC 1A, but portions of the area have been cleared for agricultural use or have villages. Cleared areas maybe fallow or in cultivation. These areas require special soil conservation protection measures and where possible should be replanted with forest or maintained in permanent agro-forestry.

WSC 2: Class 2 are areas of protected and/or commercial forests (usually commercial forests), usually at higher elevations with steep to very steep slopes. Landforms are less erosive than WSC1A or 1B. Areas may be used for grazing or certain crops with soil protection measures.

WSC 3: Class 3 are areas of uplands with steep slopes and less erosive landforms. Areas may be used for commercial forests, grazing, fruit trees, or certain agricultural crops with need for soil conservation measures.

WSC 4: Class 4 are areas of gently sloping lands suitable for crops, fruit trees, and grazing with a moderate need for a few soil conservation measures.

WSC 5: Class 5 are gentle to flat areas used for paddy fields or other agricultural uses with few restrictions.

Urbanization has long been recognized as a significant factor affecting the water quality of aquatic systems. The impact of urbanization on stream insect communities was studied by Jones and Clark (1987) in northern Virginia (USA). Watershed development had little effect on the total insect numbers (no./m^2), but effected the taxonomic composition markedly. The results of this study indicated the watershed urbanization has a major impact on benthic insect diversity even in the absence of point source discharge. Macroinvertebrate community composition trends to be related to changes in physico-chemical and biotic characteristics of the river and its tributaries and invertebrate density and richness increased with distance from the

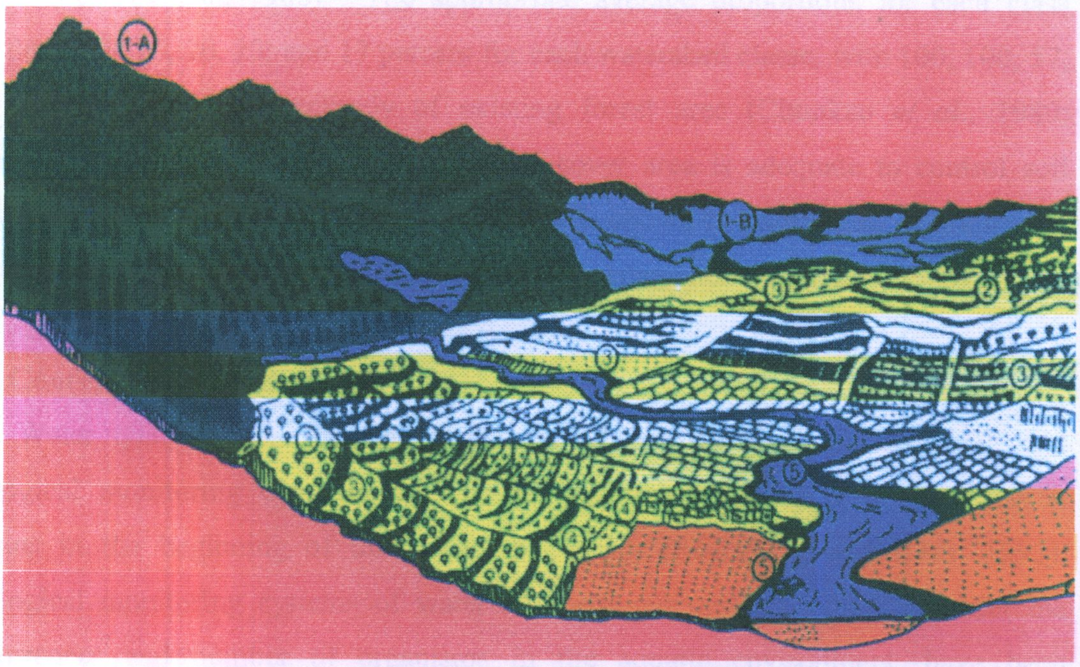


Figure 2.6 Five classes of watershed classification (NEB, 1990).

headwater and associated increases in pH, water hardness, and nutrients (Clenghan *et al.*, 1998). River discharge influences benthic abundance with more invertebrates at lower discharge and fewer invertebrates at higher discharge (Tumwesigye *et al.*, 2000).

The average proportion of each Thai watershed class is related to annual yield of stream flow (Wisan, 1988). The appropriate average proportions for each class should be 15, 25, 20, 23, and 17 percent for each watershed classe, with 100, 100, 57, 59, and 58 percent respectively of existing forest area (Chunkao *et al.*, 1980; Aieophuket, 1991). At least 70 percent of cover area is adequate to control soil erosion and runoff the ideal of watershed class is shown in Figure 2.6. More details about watershed were in principles of watershed management (Chunkao, 1943).

2.3 Concept of biomonitoring

Water quality monitoring programs should involve physical, chemical, and biological monitoring components. The biological monitoring component has it origins in the beginning of the twentieth century (Rosenberg and Resh, 1993). Biological monitoring systems of water and sediment quality, which consider the occurrences and number of organisms in the aquatic environment, have been commonly used during the past few decades (Bendati *et al.*, 1998; Norris and Norris, 1995). Biomonitoring differs from the traditional physical and chemical approaches that also are used in environmental assessment. Physical and chemical measurements are analogous to photographs; they are instantaneous and describe conditions that exist when the sample was collected. This is an appropriate strategy for an unchanging system, but flowing streams, which are constantly changing, especially need continual monitoring, such as that accomplished by the organisms living in them. The reliance on organisms present, which is the basis for biomonitoring, is more like using a movie or a video; a temporal component is added to the still photograph because organisms, such as aquatic insects, are exposed to the past conditions as well (Hauer & Hill, 1996; Resh *et al.*, 1996) so biological methods have an important role to play in the integrated management of water resources and have several advantages over physicochemical methods (Hellawell, 1986).

It is fundamental to ecology that an organism cannot survive indefinitely in an environment that does not provide its physical, chemical, and nutritional requirement (Abel, 1989). The abundance levels and patterns of distribution of aquatic organisms may be affected by the surrounding area in which they live. Biological monitoring, or biomonitoring, is the use of biological responses to assess changes in the environment, generally changes due to anthropogenic causes. Biomonitoring programs may be qualitative, semi-quantitative, or quantitative (Ellenberg, 1991). There are two types of biomonitoring. One type of biomonitoring is surveillance before and after a project is completed or before and after a toxic substance enters the water. The other type of biomonitoring is to ensure compliance with regulations or guidelines or to ensure that water quality is maintained (Rosenberg and Resh, 1993). The most common approach to environmental biomonitoring includes the presence and absence and the abundance of critical species (indicator organisms), changes in species composition and diversity, biomass of various components, biochemical indicators of stress, and analysis of pollutants in organisms (Bendati *et al.*, 1998; Johnson *et al.*, 1993).

Biomonitoring involves the use of indicator species or indicator communities. Generally benthic macroinvertebrates (Kuhlmann *et al.*, 1998, Gumiero and Salmoiraghi, 1998), fish and algae (Descy and Coste, 1991) are used. Certain aquatic plants have also been used as indicator species for pollutants including nutrient enrichment. Aquatic macroinvertibrates have different tolerance levels to stream pollution and physical characteristics. Each species has it's own ability or inability to adapt to changes in fine sediment input, temperature, chemical pollution, and other habitat changes. By determining the distribution and quantities of the various classes of macroinvertebrates, the water/habitat quality can be assessed (Lewis and Peri, 2002). There are advantages and disadvantages to each. Biochemical, genetic, morphological, and physiological changes in certain organisms have been noted as being related to particular environmental stresses and can be used as indicators. In terms of organisms chosen to study, benthic macroinvertebrates are by far the most commonly used and are mostly recommended for use in assessing water quality (Bendati *et al.*, 1998; Rosenberg and Resh, 1993). Biomonitoring is used in many countries for assessing streams and rivers.

The EPA rapid bioassessment protocol for use in stream and river (Plafkin *et al.*, 1989) uses community diversity in assessing water quality. The absence of pollution sensitive benthic macroinvertebrate groups (Ephemeroptera, Plecoptera and Trichoptera) and dominance of pollution tolerant groups (Oligochaetes or Chironomids), is indicative of pollution. Overall, low richness of benthic macro-invertebrates may indicate impairment.

In Belgium, the Belgian Biotic Index Method is used to assess the quality of running water. It involves the determination of a biotic index with scores between 0 and 10, based on samples of the aquatic macro-invertebrate community collected in situ, using a hand net (De Pauw & Vanhooren, 1983).

In Australia, the Australian River Assessment Scheme (AusRivAS0) models were developed, using macro-invertebrates as indicators to assess the ecological conditions of rivers in Western Australia (Kay *et al.*, 1999).

In Europe, the Biological Monitoring Working Party Score System is used for water quality assessment of running waters. There are three principal approaches to biological assessment, which utilize taxonomic and pollution tolerance data, these being the saprobic, diversity and biotic approaches (Metcalfe, 1989).

A Multivariate analysis approach is also useful to use in biomonitorning assessment. Pattern analysis methods of classification and ordination have proven useful in many of these studies of macroinvertebrate communities. Ormerod and Edwards (1987) used the ordination method to extend the RCC method to multiple gradients and in evaluation of the general model. The same predictive models that relate community variation to environmental variables in biological monitoring and other areas are also useful in the assessment of biological resources of streams for conservation. Harding & Winterbourn (1995) used TWINSPAN and DECORANA analysis of invertebrate in streams associated with each of the land use types (beach forest, pine forest, scrub land, and pasture) indicated a sequential change in faunal composition along this "ecological gradient". Mustow (1997) used Canonical Correspondence Analysis to investigate the differences in macroinvertibrate communities in the Ping River that were related to the environment. Inmuong (1997) used the PATN package (HMDS ordination and UPGMA clustering method) to evaluate the magnitude of water quality impacts in Pong river. In northern Thailand

Chaibu (2000) used PATN package (HMDS ordination and TWINSPAN classification) to aggregate the sampling sites base on quantitative and qualitative data.

Assessment methodology

When the pollutant type is known or well understood, certain indicators are more effectively used or are less expensive. When stressors are not known and/or less is known about species tolerance levels, multiple level assessment and more intensive and expensive studies that may include toxicity tests may be necessary (Johnson *et al.*, 1993). Multiple level assessment involves the monitoring of indicators and behavioral changes of organisms. Indicators must display a biochemical, genetic, morphological, or physiological change. Behavioral indices are determined by particular species, population's dynamics, or community changes. Community level biomonitoring provides information on the magnitude and ecological effects of the stressor on the system. Cause and effect relationships are difficult to establish and few definitely exist, because possible confounding factors are often present (Johnson *et al.*, 1993). Using indicators at different organizational levels (for example, individuals, species, community, ecosystem) may be more reliable. Biomonitoring measures may be used at the different, but related, levels of analysis.

2.4 Relationship between Trichoptera and water quality monitoring

Trichoptera, are one of the largest groups of aquatic insects, are an important component of aquatic ecosystems around the world and are especially abundant in rivers and streams. Among the orders of aquatic insects, it has the most species. Adults are being studied widely because they are easily collected in light traps and can be used as a useful tool for bioassessment (Greenwood *et al.*, 2001). Chantaramongkol (1983) recommend light trapping for assessing water quality in large rivers. Knowledge of the taxonomy and ecology of the species has proven valuable in biomonitoring programs because of very different susceptibility of the various species to pollutants and other types of environmental disturbances. Genus or species level identifications of Trichoptera adults are possible and clearly produce more accurate results than family level identification, thereby giving better ability to assess the change of water quality. Approximately 2.1 % of literature citations of Trichoptera are related to water quality which is comparable to that found for other aquatic insect groups (Resh, 1992). Adult Trichoptera species richness is a potentially useful indicator of environmental condition and general status of the ecosystem (Sykora *et al.*, 1997). The assessment of adults is also known to be valuable, not also because of many species have strong habitat and their dispersal characteristics are species- specific but also taxonomic opportunities (Greenwood *et al.*, 2001). The taxonomy of the group is relatively well known for temperate regions. Unfortunately, the larvae of many species, especially in the tropics, are unknown or have not been correlated with their adult forms (Halzenthal and Blahnik, 1997). Adult Trichoptera , especially those caught by a Malaise trap, can give information about the riparian vegetation preferred by particular species. Abundances of families can be related to their forested environments around them (Sommerhauser *et al.*, 1998). Environmental factors include vegetation, geography, season, altitude, and width of rivers (Huisman, 1989; Malicky & Chantaramonkol, 1993; Prommi, 1999). Furthermore, Thani (1998) and Sompong (1998) found that some families of Trichoptera have a significant relation with some water quality parameters. For these reasons Trichoptera community is useful in assessing the environmental status of watersheds and rivers and provide information on flow requirements to maintain ecological functions and biodiversity in a river. Trichoptera diversity and abundance can be regarded as an integrated source of environmental information on terrestrial characteristics and the health of aquatic ecosystems (De Moor, 1999). Trichoptera communities are applied for bio-monitoring in many ways. Roback (1974) found that the tolerant Trichoptera larvae are mostly noncase-makers, but net builders and as a whole seem to be tolerant of organic loading, but not of toxic pollutants. The net spining Trichoptera, *Hydropsyche angustipennis*, is generally more sensitive to organic pollution than cased Trichoptera (Hawkes, 1979; Peterson and Peterson, 1980). Dohet (1999) found that the usual zonation of Trichoptera species can be influenced by organic pollution. Navia (1997) in a study of the stratified Trichoptera fauna in the Cauca river basin, Columbia, concluded that the most sensitive genera were *Triplectides*, *Rhyacopsyche*, *Chimarra*, and *Marilia*. *Leptonema* species withstood the highest levels of organic load and environmental degradation. The reestablishment of Hydropsyche species viz. *H. angustipennis*, *H. siltalai*, *H. exopellata* and *H. pellicidula* were used for observe Meuse river improvement in Europe (Stuijfzand *et al.*, 1992). Chaibu (2000) found that twenty- four Trichoptera species can be used as indicator species to assess water pollution in Ping river. These included twelve species of Hydropsychidae, eight species of Leptoceridae, and one species each of Odontoceridae, Ecnomidae, Hyalopsychidae, and Psychomyiidae.

CHAPTER 3
MATERIALS AND METHODS

3.1 Study area

Location: Ping watershed is the principal upland catchment of Chao Phraya watershed, which drains most of northern Thailand and exits into the Gulf of Thailand below Bangkok. Ping river headwater originates from Pee Pan Num mountain in Chiang Dao District, Chaingmai Province. It has a total surface area of approximately 34,000 km^2 and is located between 15°24′ 00″ to 19°49′ 00″ N latitude and 98°05′ 30″ to 100°09′ 12″ E longitude. It adjoins Salawin and Kok watersheds to the north and west, Sakrakrung and Khong watersheds to the south, and Yom and Wang watersheds to the east. Ping river is long 720 km, flowing through Chiang Mai, Lumphun, Tak and joins with Nan river at Nakhonsawan Province. The boundary and location of Ping watershed is shown in Figure 3.1.

Climate: Ping watershed has a tropical climate with three seasons. It is under the influence of the southwest northeast monsoons. Rainfall averages are 1,055 mm/ year. Highest rainfalls are in August and September. The highest rainfall is around 1376.6 mm at Chiang Dao District, Chiang Mai Province and the lowest is in Omkoi District, Chiang Mai Province at 843.8 mm. In the upper part of Ping watershed, the average temperature is 25.4°C, with a high of 41.4°C in May and low of 3.7 °C in January (Social Research Institute, 2000).

Geology and Hydrology: Ping basin had found in the Mesozoic to Precambrian. In the upper part of Ping watershed is upland, hill range with terrace in the urban area. Soil types are shown in Figure 3.2. Annual discharge volume is approximately 6,700 m^3 x 10 m^6. Mae Ping river basin contributes approximately 22 percent of the total annual water volume of the lower Chao Phraya river. The basin was an estimated runoff efficiency of 16 percent, based on a mean annual precipitation of 1,200 mm (Social Research Institute, 2000).

Figure 3.1 Ping watershed boundary and location
(Social Research Institute, 2000)

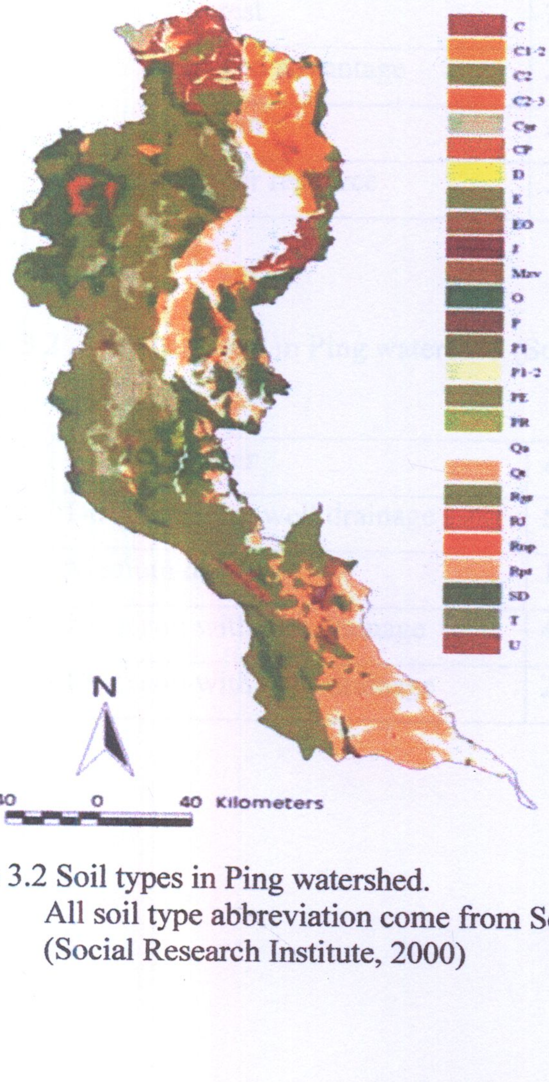


Figure 3.2 Soil types in Ping watershed.
All soil type abbreviation come from Sedimentary and Metamorphic Rocks.
(Social Research Institute, 2000)

Land use: Most of the area in the Ping watershed is uplands and hills. Around 30 percent is agriculture area. The main commercial plants are rice, soybean, green bean, corn, and tropical fruit trees. All these agriculture areas are located in alluvial plains in upper Ping in Chiang Mai, Lumphun Province and some part in lower area in Tak and Kampheangphet Province. The details of land use are shown in Table 3.1 and Figure 3.3, soil characteristics are given in Table 3.2 and Figure 3.4.

Table 3.1 Land use types in Ping watershed (Social Research Institute, 2000).

Land use type	**Area (km^2)**
Agricultural	7,988
Forest	24,379
Mixed advantage	2,146
Urban	209
Water resource	320

Table 3.2 Soil characters in Ping watershed (Social Research Institute, 2000).

Soil character	**Area (km^2)**
Deep soil with well drainage	5,342
Medium deep soil	172
Deep soil with bed drainage	4,353
Deep soil with over drainage	26,858

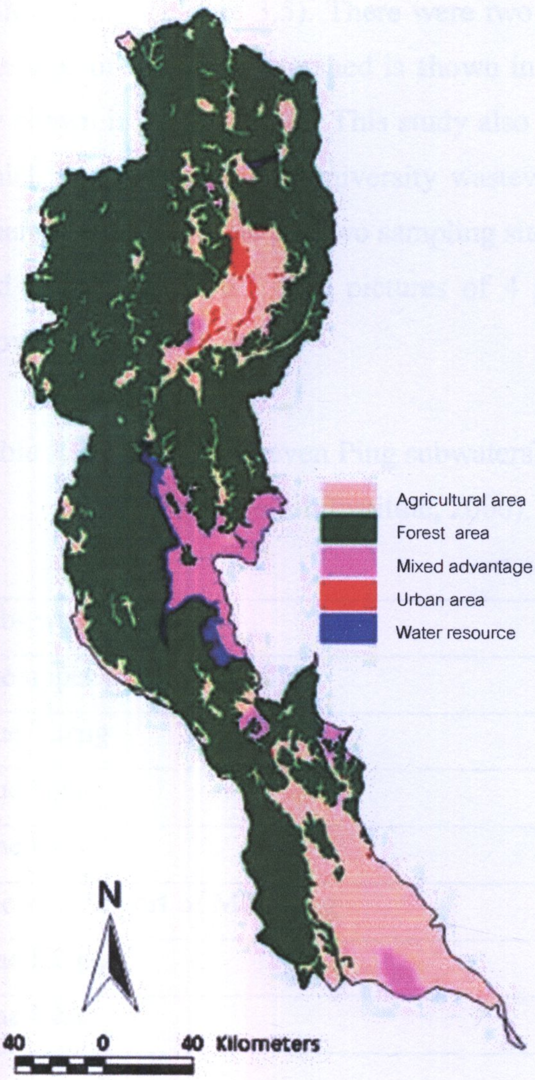


Figure 3.3 Land use types in Ping watershed (Social Research Institute, 2000)

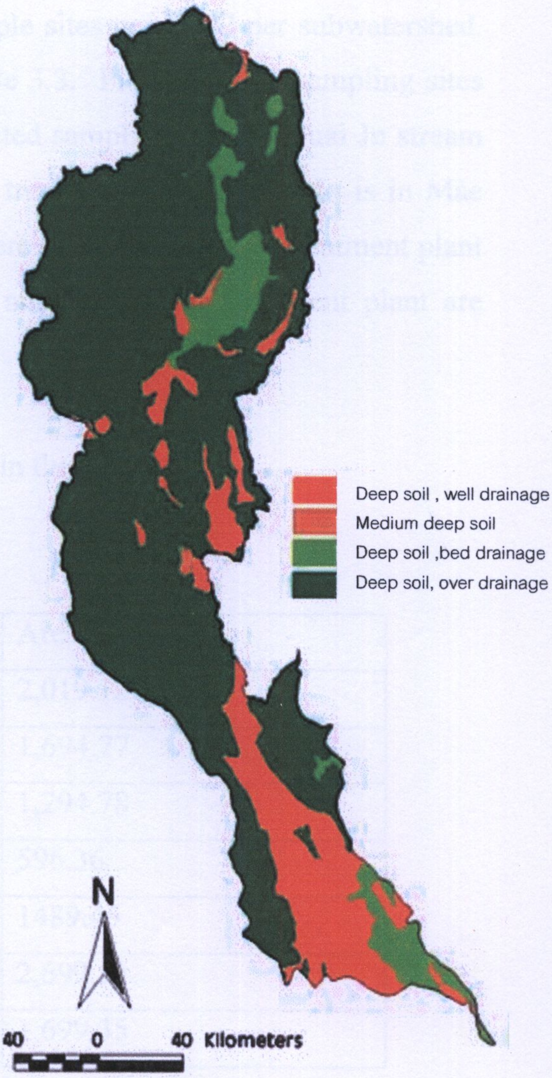


Figure 3.4 Soil characters in Ping watershed (Social Research Institute, 2000)

3.2 Study sites

This study has selected 70 sampling sites in seven subwatersheds (ten sampling sites per subwatershed) of Ping river basin, viz. Mae Taeng, the upper part of Mae Ping (Chiang Dao), Mae Rim, Mae Kuang, Mae Khan, Mae Ngat and the second part of Mae Ping (Figure 3.5). There were two sample sites per WSC per subwatershed. The area of each subwatershed is shown in Table 3.3. Pictures of 70 sampling sites are shown in Appendix A. This study also selected sampling sites in Huai Jo stream which flows pass Maejo University wastewater treatment plant. Huai Jo is in Mae Kuang watershed class 5. Two sampling sites were selected above the treatment plant and two were below. The pictures of 4 sites and wastewater treatment plant are shown in Appendix A.

Table 3.3 Area of the seven Ping subwatersheds in the study (Social Research Institute, 2000).

Sub- watershed name	Area (km^2)
The upper part of Mae Ping	2,019.12
Mae Taeng	1,694.77
Mae Ngat	1,294.78
Mae Rim	596.36
The second part of Mae Ping	1489.45
Mae Kuang	2,699.54
Mae Khan	1,699.35

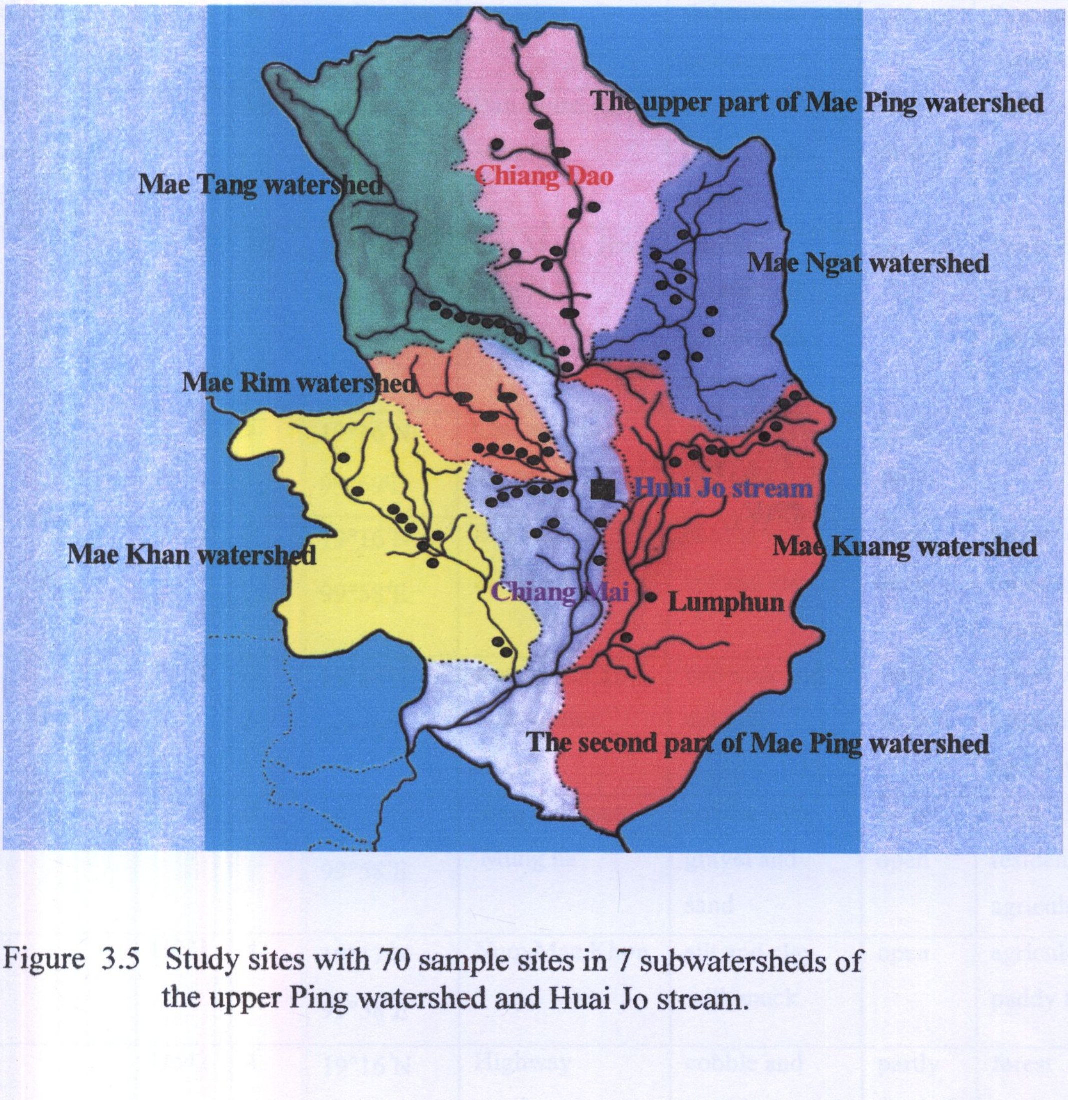


Figure 3.5 Study sites with 70 sample sites in 7 subwatersheds of the upper Ping watershed and Huai Jo stream.

3.3 Site description

Table 3.4 The upper Ping watershed site descriptions

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
The upper part of Mae Ping	UP11	1B	19°15′N 99°59′E	Ban Muso Hua Mae Ja 1	boulders with gravel and sand	partly shaded	forest and agriculture
	UP12	1B	19°15′N 99°58′E	Ban Muso Hua Mae Ja 2	boulders, cobble and gravel with detritus	shaded	forest and moderate erosion
	UP21	2	19°16′N 99°59′E	Chiang Dao district	gravel sand and silt	partly open	forest
	UP22	2	19°16′N 99°58′E	Ban Mae Talai Mung na	cobble with silt and clay	Partly open	forest with residenal and agriculture
	UP31	3	19°17′N 99°58′E	Keang Pan Tao Near police station	bed rock and cobble	partly shaded	forest with residental and agriculture
	UP32	3	19°18′N 99°58′E	Ban Tubkanin Mung na	cobble with gravel and sand	partly open	forest with resident and agriculture
	UP41	4	19°17′N 99°58′E	Num Mae Khon	silt and clay with muck	open	agriculture, paddy field
	Up42	4	19°16′N 99°58′E	Highway service Ban Ping Kong	cobble and boulders, sand and gravel	partly shaded	forest
	UP51	5	19°15′N 99°56′E	Huai Kit Chiang Dao market	boulders , gravel with detritus and mud	open	market, residential with heavy erosion

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	UP52	5	19°15'N 99°55'E	Ban Mae Ja Thung Pong District	sand and silt	open	residential and paddy field
Mae Taeng	T11	1A	19°14'N 98°49'E	Ban Pang Ko Mae Taeng District	cobble and boulder	shaded	forest
	T12	1A	19°13'N 98°49'E	Ban Thung Pa Sang	cobble and boulder	shaded	forest
	T21	2	19°11'N 98°54'E	Ban Huai San	silt	open	forest and Longgan orchard
	T22	2	19°14'N 98°47'E	Ban sop Kai	Sand and cobble	open	residental
	T31	3	19°12'N 98°54'E	Ban Mae Taman Near wat Mae Taman	boulders and cobble	partly shaded	residental
	T32	3	19°11'N 98°54'E	Elephant Training Camp	boulders and cobble	open	forest and recreation
	T41	4	19°13'N 98°51'E	Ban Hua Thung	Boulder, cobble and silt	open	residental
	T42	4	19°11'N 98°55'E	Ban Hua Pa Sang	Silt	open	residental
	T51	5	19°07'N 98°57'E	Amphoe Mae Taeng	mostly gravel with silt and sand	open	urban and agriculture
	T52	5	19°06'N 98°57'E	Taeng river side village	gravel with silt and sand	open	residential and paddy field
Mae Ngat	N11	1A	19°16'N 99°07'E	Huai Mae Phaeng	boulders, cobble, gravel and clay	shaded	forest

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	N12	1A	19°17′N 99°07′E	Mon Hin Lin	mostly boulders with cobble gravel and clay	shaded	forest
	N21	2	19°19′N 99°09′E	Huai Mae Rang	mostly sand with silt and clay	partly shaded	residential
	N22	2	19°23′N 99°09′E	Ban Pha Hin	mostly gravel with silt and sand	shaded	residential and forest
	N31	3	19°119′N 99°07′E	Ban Mae Rangong	mostly cobble with sand, gravel, silt and clay	partly shaded	forest and agriculture
	N32	3	19°19′N 99°08′E	Ban Mae Rangong Noi	mostly gravel with sand and silt	open	agriculture
	N41	4	19°08′N 99°10′E	Ban Thung Dang	mostly are silt with gravel sand and clay	open	forest and agriculture
	N42	4	19°06′N 99°10′E	Ban Na muang	cobble gravel sand and clay	partly open	field/pasture
	N51	5	19°12′N 99°11′E	Ban Sop Pang	boulders, cobble, gravel, silt, sand and clay	open	agriculture
	N52	5	19°11′N 99°11′E	Ban Huai Sai	Boulder, cobble, gravel, silt, sand and clay	open	agriculture
Mae Rim	R11	1A	19°06′N 98°49′E	Ban Mae Luang	cobble, gravel, silt and sand	partlt shaded	forest and residential

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	R12	1A	19°06'N 98°43'E	Ban Yang Mae Luang	cobble,gravel, silt and sand	party shaded	forest and residential
	R21	2	18°58'N 98°51'E	Ban Pang Pa Kha	mostly sand with silt	open	agriculture
	R22	2	19°07'N 98°43'E	Ban Pang Lamyai	sand and cobble	partly shaded	agriculture
	R31	3	18°58'N 98°48'E	Huau Khrau	mostly cobble with silt	partly open	forest and agriculture
	R32	3	18°57'N 98°49'E	Ban Pang Hai	mostly are sand with gravel and silt	partly shaded	residential
	R41	4	18°57'N 98°52'E	Ban Mae Ram Noi	mostly are silt with gravel and sand	shaded	residential
	R42	4	18°56'N 98°54'E	Huai Pang Ban Pang Haeo	sand and gravel	open	forest, agriculture and residential
	R51	5	18°55'N 98°57'E	Amphoe Mae Rim	silt	open	residential
	R52	5	18°55'N 98°57'E	Ban Oi	silt and clay	partly open	residential
The second part of Mae Ping	P11	1B	18°56'N 98°49'E	Huai Nong Hoi Neae Arawan resort	boulders , gravel and sand	shaded	forest and agricultural
	P12	1B	18°49'N 98°55'E	Huai Kaew stream, Doi Suthep	boulders gravel and sand with detritus	shaded	forest and recreation
	P21	2	18°52'N 98°49'E	Na Liu Water fall	bedrock with cobble and sand	open	agriculture, flower and onion gardens

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	P22	2	18°53′N 98°49′E	Huai Mae Hoi	boulders, cobble and sand	partly open	agriculture, flower and onion gardens
	P31	3	18°51′N 98°48′E	Ban Kong Hae	boulders with sand and detritus	partly open	residential
	P32	3	18°52′N 98°48′E	Huai Suwan	clay with little cobble	open	agriculture, flower and onion gardens
	P41	4	18°54′N 98°53′E	Ban Mae Mhae	gravel with sand and silt	partly open	residential and recreation
	P42	4	18°54′N 98°52′E	Nam Mae Sa	bedrock with gravel and sand	partly shaded	forest and recreation
	P51	5	18°46′N 99°00′E	Amphoe Muang Chiang Mai	silt and sand	open	urban and commercial
	P52	5	18°48′N 99°00′E	Meangrai Bridge, Mahidol Road	silt and sand	open	urban and commercial
Mae Kuang	K11	1A	19°02′N 99°21′E	Ban Pang Mun	gravel, boulders and sand	shaded	forest and residential
	K12	1B	19°04′N 99°20′E	Ban Pang Aun	mostly sand with boulder, gravel and silt	partly shaded	forest and residential
	K21	2	19°05′N 99°22′E	Ban Pang Num Thu	boulders, sand gravels and clay	shaded	forest and residential
	K22	2	19°03′N 99°20′E	Ban Moe	mostly cobble with boulder, gravel and sand	partly shaded	forest and residential

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	K31	3	18°57′N 99°15′E	Num Mae Wang	mostly boulders with sand and gravel	open	residential
	K32	3	18°56′N 99°15′E	Num Mae won	cobble, gravel, sand and boulders	open	forest
	K41	4	18°54′N 99°12′E	Ban Sala Pang Sak	mostly silt with gravel	partly open	residential and agriculture
	K42	4	18°55′N 99°15′E	Ban Pong Din	mostly cobble with silt and gravel	open	residential and agriculture
	K51	5	18°40′N 99°05′E	Ban Rom Pa Tong	clay	open	residential and agriculture
	K52	5	18°35′N 99°01′E	Amphoe Muang Lumphun	clay	open	residential and agriculture
Mae Khan	KH11	1A	18°51′N 98°39′E	Huai Chok	gravel with sand and little cobble	partly shaded	forest
	KH12	1A	18°53′N 98°38′E	Ban Hat Som Poi	mixed of boulders, cobble, gravel and sand	partly shaded	forest with residential
	KH21	2	18°51′N 98°39′E	Ban Mae Khan	gravel and sand	partly shaded	field/pasture
	KH22	2	18°47′N 98°44′E	Ban Mae Lan Kham	gravel sand and Bed rock	partly shaded	field/pasture
	KH31	3	18°48′N 98°43′E	Mae Sap Reservoir,	cobble, boulders and gravel	Partly open	forest and reservoir

Sub- basin name	Code	WSC	Ordination	Location	Substrates character	Canopy	Surrounding Land use
	KH32	3	18°55'N 98°37'E	Huai Mai Yang Ban Om Long	cobble gravel and sand	partly shaded	residential and paddy field
	KH41	4	18°51'N 98°44'E	Ban Pa Kluai	sand silt and clay	open	field/pasture
	KH42	4	18°50'N 98°44'E	Ban Lao Saen Tong	sand silt and clay	partly shaded	field/pasture
	KH51	5	18°37'N 98°52'E	Ban Piang San Pa Tong	sand and clay	partly open	field/ pasture
	KH52	5	18°36'N 98°50'E	Ban Makai yon San Pa Tong	silt	open	field/pasture and agriculture

Table 3.5 Huai Jo stream site descriptions

Site	WSC	Location	Substrates character	Canopy	Surrounding Land use
M1	5	Ban Mae Jo Sansai District before wastewater treatment plant	cobble with sand	partly shaded	residential
M2	5	Ban Mae Jo Sansai District before wastewater treatment plant	gravel with sand and silt	shaded	residential
M3	5	Ban Mae Jo Sansai District below wastewater treatment plant	cobble with silt	open	residential
M4	5	Ban Mae Jo Sansai District below wastewater treatment plant e Jo	silt and clay	shaded	residential

3.4 Trichoptera collection

Equipment

1. Fluorescent lamps 12 Volt DC
2. Pond net
3. Containers for sorting
4. Vials
5. Ethanol 70 %
6. Labels
7. Glass sorting dishes
8. Forceps and needles
9. Hot plate
10. Stereomicroscope and compound
11. Slides and cover slips
12. 10 % KOH or NaOH solution
13. Detergent

Method of sampling adult Trichoptera

Light traps (10 W ultraviolet fluorescent lamps powered by 12 Volt DC) were used to collect adult Trichoptera, by being placed near the stream bank before dusk until the next morning for one night each season. Trichoptera specimens were separated into distinct groups on sight identifications, labeled, and preserved in 70% ethanol.

Sorting and identifying of adult Trichoptera

The specimens were sorted by a stereomicroscope to separate males from females, since only adult males could be identified, and separated in to distinct group. Trichoptera are analyzed up to species level by adult males. Abdominal segments of males were cut and cleared in 10 % potassium hydroxide (KOH) or sodium hydroxide (NaOH) solution. Species identification using male terminalia morphology were done by using a stereomicroscope. Keys for identify are Malicky, 1983; 1987; 1989; 1994; 1995; 1997; 1997a and Malicky *et al.*, 2000; 2000a; Malicky and Chantaramongkol, 1989; 1989a; 1991; 1991a; 1991b; 1992; 1992a; 1993; 1994; 1995; 1996; 1997; 1999; Chantaramongkol and Malicky, 1989; 1995.

3.5 Measurement of physical and chemical water quality

Equipment for studying water quality in the field

1. Conductivity meter / TDS meter
2. pH meter
3. DR/2000 HACH spectrophotometer
4. Thermometer
5. Velocity meter
6. Measuring tape.
7. Altimeter
8. GPS

Equipment for keeping and transfer water sample

1. 1 liter polyethylene bottles
2. Cooler container with ice

Equipment and chemical for laboratory studies

1. 300 ml BOD bottles
2. Glass wear
3. Polyvinyl bottles
4. Distilled water
5. Manganese sulfate
6. Alkali-iodide-azide solution
7. Concentrated sulfuric acid
8. Standard sodium thiosulfate titrant (0.02 N)
9. Starch solution
10. Phenolphthalein indicator
11. Methyl orange indicator
12. Phos ver3 Phosphate reagent
13. Nitrate ver 5 Nitrate reagent
14. Nessler reagent
15. Mineral stabilizer

3.6 Water sample

3.6.1 Field parameters

Bottom Substrate Component: Visually estimated the relative proportion of the substrate /particle types that are presents at each sampling sites.

Temperature: Air and water temperatures were measured with a standard mercury thermometer. For precise thermo graphic work, thermometers have at least a minimum scale marking of 0.1 °C. Water temperature measure tree points of water temperature: the surface, middle and as close to the stream bottom as possible.

Predominant Surrounding Land use: Observed the prevalent land use in the vicinity, and noted any other land uses in the area which, although not predominant, could potentially affect water quality.

Estimated Stream Width (m): Estimate the distance from shore to shore at a transect representative of the stream width in the area.

Estimated Stream Depth (m): Riffle, run and pool. Estimated the vertical distance from water surface to stream bottom at a representative depth at each of the three habitat types.

Velocity: Record an estimate of stream velocity in a representative run area.

Discharge: the volume of water flowing through a cross section of stream channel per unit time. Discharge is calculated as

$$Q = \forall / t$$

Where Q is the discharge in m^3/s (or liters/s);$\forall$, volume in m^3 (or liters); and t, time (s).

Canopy cover: Note the general proportion of open to shad area which best describes the amount of cover at the sampling station.

3.6.2 Laboratory parameters

Dissolved Oxygen (DO): Collected samples from each site very carefully in narrow-mouth, glass-stopped, 300 ml BOD bottles and flowing the Azide Modification method (APHA, 1992)

Biochemical Oxygen Demand (BOD)$_5$: Collected samples from each site very carefully in narrow-mouth, glass-stopped, 300 ml BOD bottles and preserved with 1 ml $MnSO_4$solution and 1 ml of the alkali-iodide-azide reagent. Initial dissolved oxygen value (DO_0) was detected by the Azide Modification method (APHA, 1992). Final dissolved oxygen (DO_5) was keep in the incubator at 20°C for 5 days and the final DO value was taken. BOD_5 was then calculated using the formula:

$$BOD_5 = DO_0 - DO_5$$

Alkalinity: Alkalinity was examined by Phenolphthalein methyl orange indicator (APHA, 1992). Water samples were triturated with 0.02 N H_2SO_4 until the pH at the end point was 4.3-4.5. Total alkalinity was computed using the formula:

Total alkalinity (mg/l $caco_3$) = ml 0.02 NH_2SO_4 X10

pH: The pH was measured with the microprocessor pH- meter.

Conductivity: Conductivity was measured at depth of 20±30 cm in the middle of the river with a conductivity meter.

Ammonia-nitrogen (NH_3-N): Ammonia was determined by the Nesslerization technique, using Nessler reagent, mineral stabilizer and Polyvinyl alcohol and measured with a DR/2000 spectrophotometer.

Nitrate- nitrogen (NO_3-N): Nitrate was determined employing the cadmium reduction method using Nitra Ver5 Nitrate reagent and a HACH DR/2000 spectrophotometer.

Orthophosphate-P: the Ascorbic Acid Method, using Phos Ver 3 powder and a HACH DR/2000 Spectrophotometer, determined Phosphate.

Turbidity: Turbidity was determined by a HACH DR/2000 Spectrophotometer.

3.7 Data analysis

Univariate technique

Physical, chemical, and Trichoptera data were tested by ANOVA to investigate differences in land use patterns. Data were first tested for normality and homogeneity of variance. Physical and chemical water qualities and Trichoptera data were analyzed using a parametric one-way ANOVAs or Kruskal-Wallis non- parametric ANOVAs for data which could not be transformed satisfactorily. Use comparisons of means following a significant parametric ANOVA were conducted with LSD test at 0.05 level of significance for parametric and using the Mann-Whitney U test for non parametric (SPSS for Windows 98).

Multivariate technique

The biological structure of the data was examined using two pattern recognition techniques, cluster analysis, and ordination. Clustering of the reference sites was done by using an agglomerative hierarchical fusion method with unweighted pair group mean averages (UPGMA). The sampling sites were classified using the Polythetic Divisive Hierarchical Clustering method (TWINSPAN option). The appropriate number of groups was selected by examining the group structure and, particularly, the spatial location of the groups in the ordination space. A multidimensional scaling method of ordination was used (HMDS, semi-strong Hybrid Multi Dimensional Scaling). These data sets were transformed by $\log_{10} X+1$ (the 7^{th} of TRND option). The ordination result was initially interpreted in terms of the observed species abundance data that were used for the calculation of site dissimilarities. Species abundance values for each site were plotted in the space. Additionally, for taxa showing roughly monotonic response in the space, linear correlations between species abundance and vectors in the ordination space were examined. The direction of the vector is found along which the projections of the sites have maximum linear correlation with abundance. These vectors were calculated using the Principal Axis Correlation procedure (PCC option). The statistical significance of the environmental correlation for each ordination were tested through a Monte Carlo study (repeated simulations using random numbers). The Monte Carlo produce is a test of the hypothesis that a correlation as high as that observed could have been found if the observed values for the data variables were randomly assigned to the sites. A data correlation was regarded as significant (and the hypothesis was rejected) if five or less of the 99 correlations were as high as the observed correlation. All clustering and ordination were done using PATN, a pattern analysis software package developed by CSIRO in Australia (Belbin, 1995).

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Trichoptera species diversity in the upper Ping watershed

4.1.1 Community structure and distribution in the upper Ping watershed

One year study in three seasons from 70 sites in 7 subwatersheds of Ping watershed using light trap, 40914 male Trichopteras specimens were collected representing 17 families, 54 genera and 237 species (Appendix A). Eight families of them were assigned in the suborder Annulipalpia (fixed-retreat makers), seven families were in the superfamily Hydropsychoidae: Arctopsychidae, Ecnomidae, Hydrosychidae, Polycentropodidae, Psychomyiidae, Dipseudopsidae, Stenopsychidae and Philopotamidae. Three families were in the suborder Spicipalpia (close-cocoon makers), superfamily Rhyacophiloidae: Rhyacophilidae, Glossosomatidae and Hydroptilidae. Seven families were in suborder Integripalpia (portable-case maker). Four families were in the superfamilily Limnephiloidae: Goeridae, Brachycentridae, Lepidostomatidae. Three families were in the superfamiliy Leptoceroidae: Odontoceridae, Calamoceridae and Leptoceridae. The percentage of Trichoptera individules in the Hydropsychidae, Psychomyiidae which were net spinners were 67%, 7% and Leptoceridae, Odontoceridae and Ecnomidae which were case makers were 8%, 6% and 5% respectively (Figure 4.1). From these results the Hydropsychidae is widely distributed and diverse family of Trichoptera that comprises a conspicuous component of stream benthic communities in temperature and tropical latitudes (Dudgeon,1997). The top ten most abundant numbers of species are shown in Table 4.1. Six species are Hydropsychidae, one species each in Odontoceridae, Leptoceridae and Psychomyiidae. *Cheumatopsyche charites* was the most frequent species found, representing 24.46 % of the speciemens which were collected, followed by *Cheumatopsyche globosa* (11.72%) and *Amphipsyche gratiosa* (7.48%). The difference in species composition and abundance indicated habitat preferences associated with the environmental setting at each sampling site.

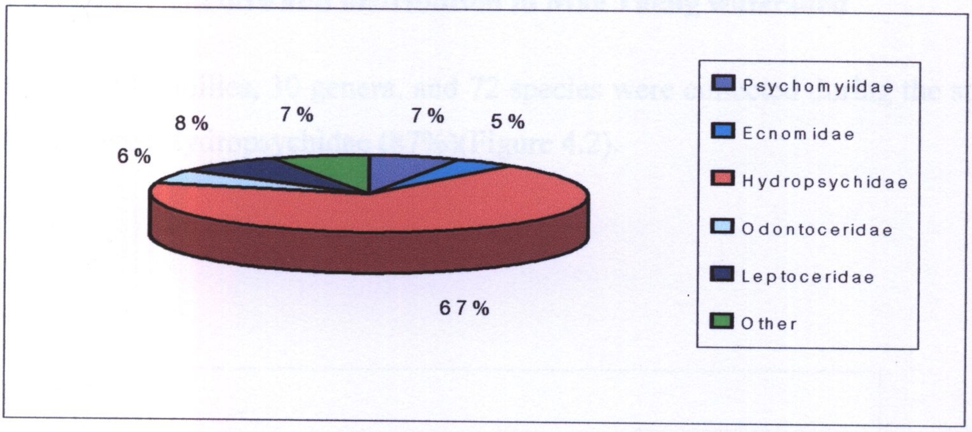


Figure 4.1 Percentage of Trichoptera individuals collected in each family in the upper Ping watershed

Table 4.1 The ten most abundant species found in the upper Ping watershed during one year collecting from January 2000 to December 2000.

Family	Species	No. of individual	percentage (%)
Hydropsychidae	*Cheumatopsyche charites*	10,009	24.463
Hydropsychidae	*Cheumatopsyche globosa*	4,793	11.71
Hydropsychidae	*Amphipsyche gratiosa*	3,059	4.47
Odontoceridae	*Marilia sumatrana*	2,278	5.57
Hydropsychidae	*Cheumatopsyche cognita*	1,707	4.17
Psychomyiidae	*Psychomyia kaiya*	1,628	3.98
Leptoceridae	*Leptocerus chiangmaiensis*	1,374	3.36
Hydropsychidae	*Pseudoleptonema quinquefasciatum*	1,296	3.17
Hydropsychidae	*Phaidra potamyia*	1,135	2.77
Leptoceridae	*Setodes argentiguttatus*	890	2.18

Community structure and distribution in Mae Taeng watershed

A total of 14 families, 30 genera, and 72 species were collected during the study. Most of them were Hydropsychidae (87%)(Figure 4.2).

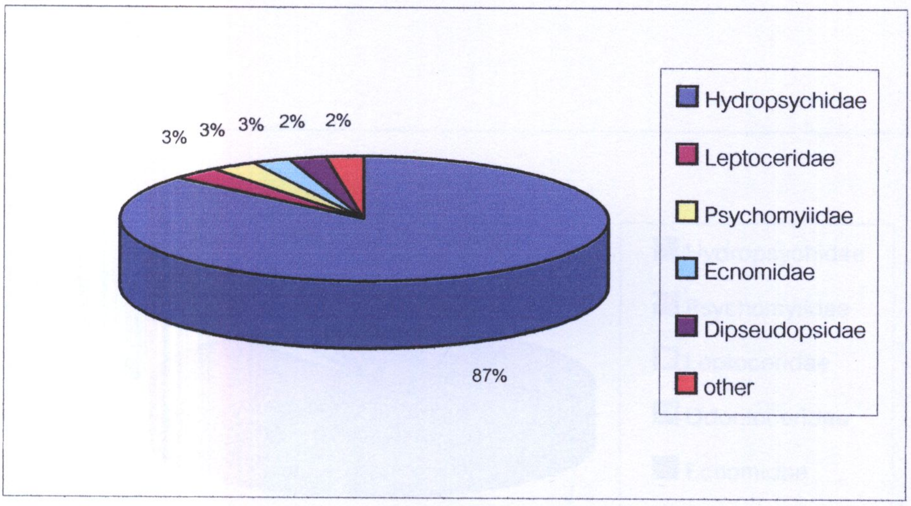


Figure 4.2 Percentage of Trichoptera individuals collected in Mae Taeng watershed during January 2000 to December 2000

The most abundant species, all Hydropsychidae include: *Cheumatopsyche charites* (58.08%), *Amphipsyche gratiosa* (6.69%), *Potamyia panakeia* (5.01%), *Potamyia phaidra* (3.41 %), *Cheumatopsyche globosa* (3.34%), *Cheumatopsyche cognita* (2.83%), *Hydropsyche askalaphos* (1.60%). One species each in Psychomyiidae, *Psychomyia lak* (1.95%), Dipseudopsidae, *Dipsodopsis benardi* (1.69%), and Ecnomidae, *Ecnomus robustior* (1.41%) were also found.

Community structure and distribution in Mae Khan watershed.

A total of 9,159 male specimens were found during the study in Mae Khan watershed with 13 families, 30 genera and 72 species. The Trichoptera fauna was dominated by Hydropsychidae (64%), Psychomyiidae (27%), Leptoceridae (3%), Odontoceridae(2%), Ecnomidae (2 %), and Pilopotamidae (1%) (Figure 4.3).

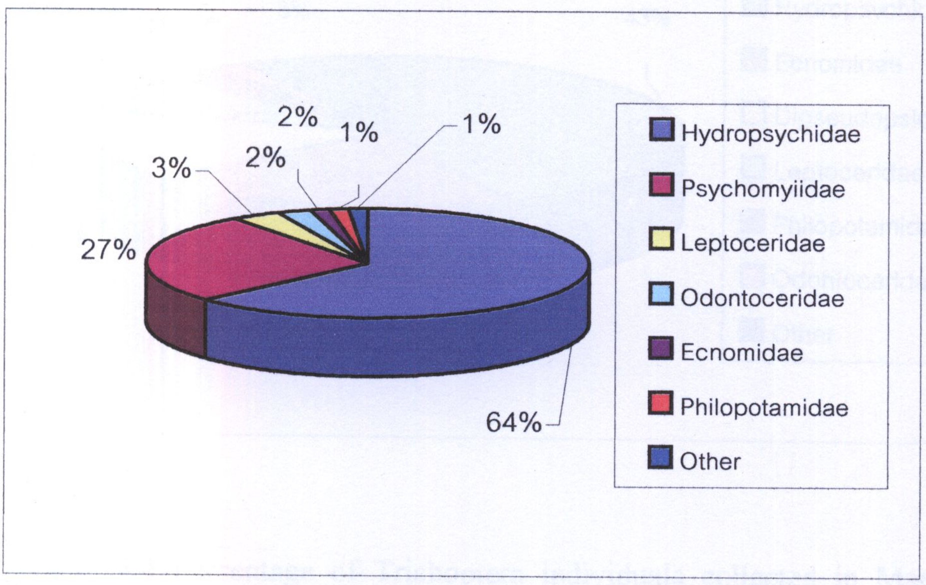


Figure 4.3 Percentage of Trichoptera individuals collected in Mae Khan watershed during January 2000 to December 2000

The most abundant species, all Hydropsychidae are: *Cheumatopsyche charites* (30.51%), *Pseudoleptonema quinquefasciatum* (12.71%), *Cheumatopsyche globosa* (5.58%), *Cheumatopsyche cognita* (3.32%), *Potamyia phaidra* (2.63%), *Hydropsyche camillus* (2.1%), *Macrostemum floridum* (1.9%). Two species were in Psychomyiidae , *Psychomyia kaiya* (11.11%) and *Psychomyia lak* (8.35%). One species was in Odontoceridae, *Marilia sumatrana* (2.38%).

Community structure and distribution in Mae Kuang watershed

A total of 4103 male specimens were found in Mae Kuang watershed, representing 15 families, 39 genera and 110 species. The most diverse families were Hydropsychidae (43%), Ecnomidae (21%), and Dipseudopsidae (15%). The structure composition were showed in Figure 4.4

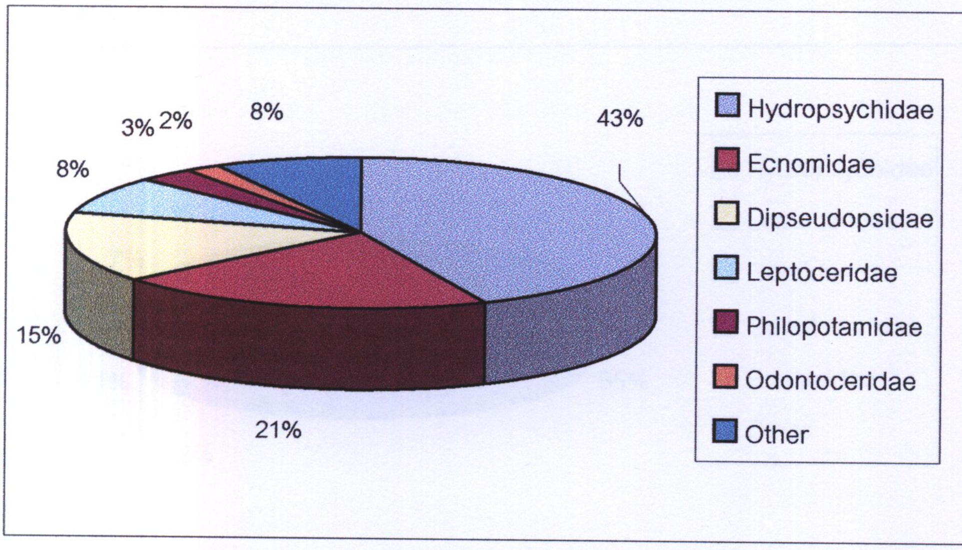


Figure 4.4 Percentage of Trichoptera individuals collected in Mae Kuang watershed during January 2000 to December 2000

The ten most abundant species were in 5 families. Five species in Hydropsychidae (43%), *Cheumatopsyche charites* (10.12%), *Aethaloptera sexpunctata* (10.09%), *Cheumatopsyche chrysothemis* (8.67%), *Pseudoleptonema quinquefasciatum* and *Hydropsyche briareus* (1.96%). Two species were in Ecnomidae, *Ecnomus* atevalus (16.68%) and Ecnomus aktaion (2.39%). One species each in Dipseudopsidae , *Dipsodopsis robustior* (12.49%) , Leptoceridae , *Setodes argentiguttatus*(4.48%) and Odontoceridae, *Marilia sumatrana* (2.42%) were corrected.

Community structure and distribution in Mae Ngat watershed

A total of 2071 male specimens were found in Mae Ngat watershed, represent 15 families 39 generas and 110 species. Fifty- five percent of the specimens was in Hydropsychidae. Twelve percent were in Leptoceridae. Eleven percent was in Goeridae. Seven percent were in Odontoceridae and five percent were in Ecnomidae. All these compositions showed in Figure 4.5

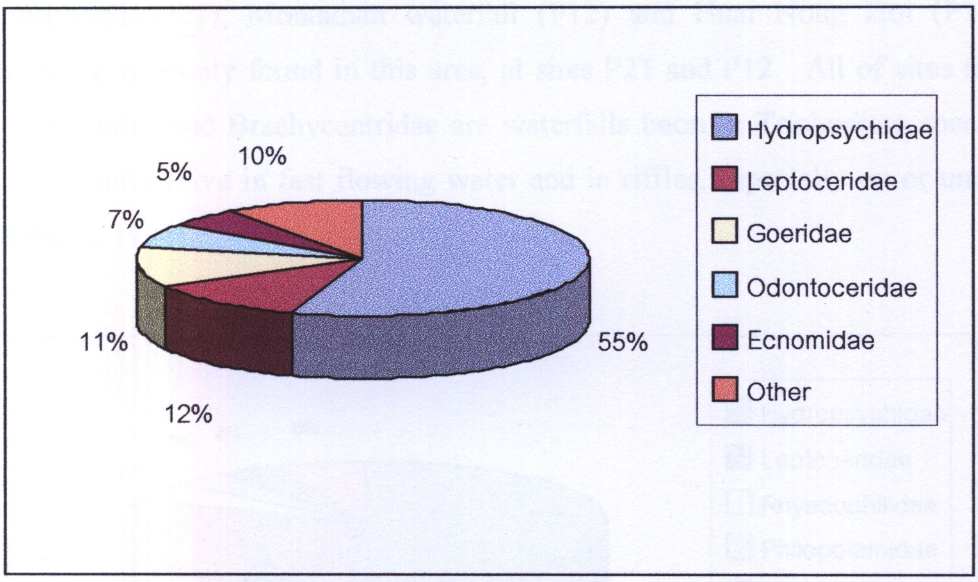


Figure 4.5 Percentage of Trichoptera individuals collected in Mae Ngat watershed during January 2000 to December 2000

The most abundant species were in 4 families,viz. five in Hydropsychidae, *Cheumatopsyche globosa* (18.06%), *Macrostemum midas* (7.73%), *Cheumatopsyche cognita* (5.2%), *Hydropsyche Camillus* (5.22%) and *Cheumatopsyche chryseis* (4.44%). They were belonging to one species in Goeridae, *Goera uniformis* (10.24%) and Odontoceridae, *Marilia sumatrana* (7.05%), three in Leptoceridae, *Oecetis* sp.2 (2.576%), Leptocerus *dirghachuka* (2.51%), and *Setodes argentiguttatus* (2.46%).

Community structure and distribution in the second part of Mae Ping watershed

A total of 4387 male specimens were found in the second part of Mae Ping watershed, represent 14 families, 41 generas and 113 species. Three highest families were Hydropsychidae (51%), Leptoceridae (30%) and Rhyacophilidae (5%)(Figure 4.6). Ninety Percent of Rhyacophilidae were found in the second part of Mae Ping watershed. Five species from nine species were found only at this watershed at site Na Liu waterfall (P21), Montathan waterfall (P12) and Huai Nong Hoi (P11). Brachycentridae was only found in this area, at sites P21 and P12. All of sites that had Rhyacophilidae and Brachycentridae are waterfalls because Trichoptera species in these two families live in fast flowing water and in riffles, especially on or under stones (Roback, 1974).

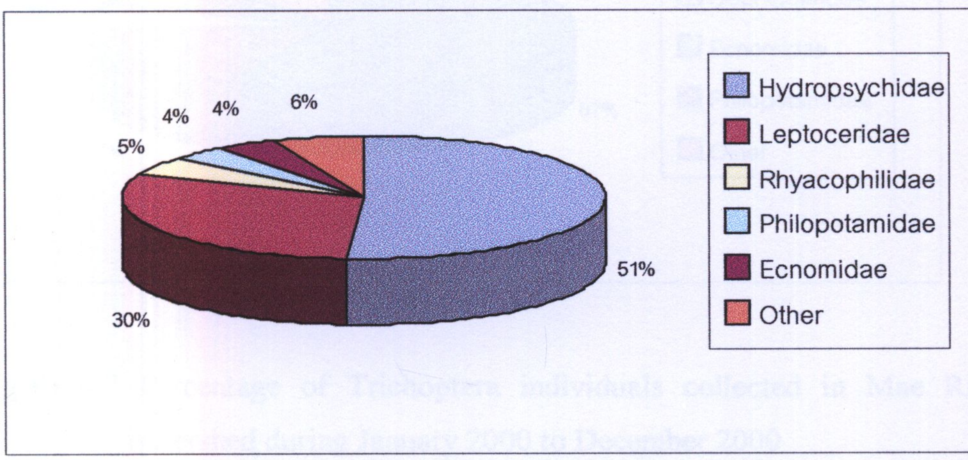


Figure 4.6 Percentage of Trichoptera individuals collected in the second part of Mae Ping watershed during January 2000 to December 2000

The ten most abundant species were in 5 families. Six species were in Hydropsychidae, *Cheumatopsyche cognita* (19.47%), *Cheumatopsyche globosa* (10.69%), *Cheumatopsyche angusta* (3.35%), *Hydropsyche briareus*(3.26%), *Macrostemum floridum* (3.05%), *Hydropsyche uvana* (2.10%), One species in Leptoceridae, *Leptocerus chiangmaiensis* (28.88%), Philopotamidae, *Chimara* *suthepensis* (2.23%), Rhyacophilidae, *Rhyacophila suthepensis* (2.05%) and Ecnomidae, *Ecnomus atevalus* (1.85%).

Community structure and distribution in Mae Rim watershed

A total 14 families 36 genus and 88 species were found in Mae Rim watershed. Only 1429 of male specimens were found which is the lowest number all in 7 watersheds studied. The most species were Hydropsychidae (57%), followed by Leptoceridae (17%) and Odontoceridae (7%). The details are in Figure 4.7

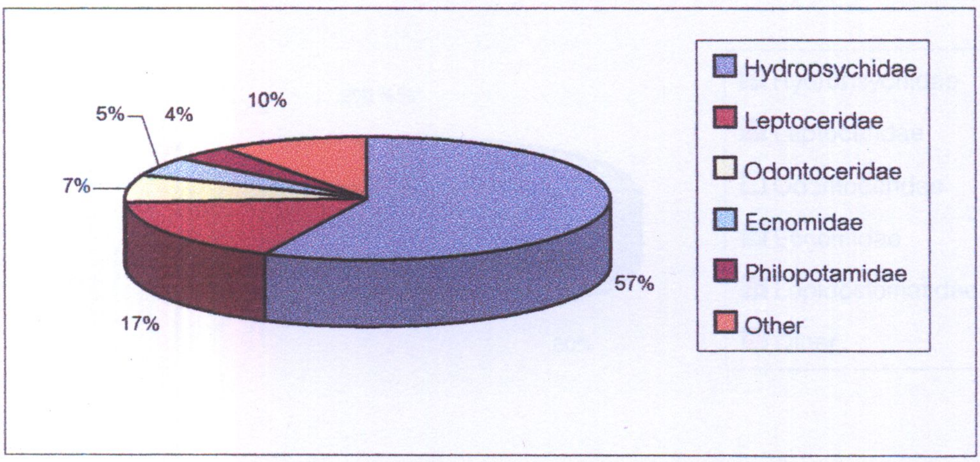


Figure 4.7 Percentage of Trichoptera individuals collected in Mae Rim watershed during January 2000 to December 2000

The ten most abundant species were in 6 families. Three species were in Hydropsychidae, *Cheumatopsyche globosa* (33.1%), *Cheumatopsyche cognita* (10.7%), *Macrostemum floridum* (3.57%), three species in Leptoceridae, *Leptocerus chiangmaiensis* (4.06%), *Parasetodes bakeri* (5.04%) and *Leptocerus dirghachuka* (2.1%). They were belonging to one species each in Odontoceridae, *Marilia mogtiana* (5.39%), Philopotamidae, *Chimara khamuorum* (2.17%) and Ecnomidae, *Ecnomus suadrus* (1.82%).

Community structure and distribution in the upper part of Mae Ping watershed

A total 13 families, 26 genera and 74 species were found in upper part of Mae Ping watershed. The 15,516 of male specimens found were the most from all in 7 subwatersheds in this study. Almost sites, except U11 and U12, were in the main river. Where it is wide, but lacking the diverse habitats. The highest species were Hydropsychidae (80%) then was Odontoceridae (12%) and flowed by Leptoceridae (4%). The details are in Figure 4.8

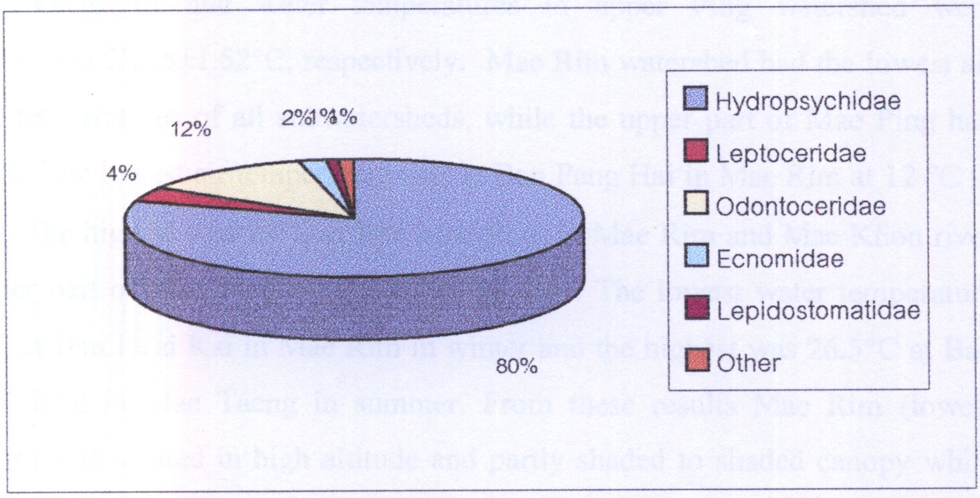


Figure 4.8 Percentage of Trichoptera individuals collected in the upper part of Mae Ping watershed during January 2000 to December 2000

The ten most abundant species were in 6 families. Seven species were in Hydropsychidae, *Cheumatopsyche charites* (27.82%), *Cheumatopsyche globosa* (18.03%), *Amphipsyche gratiosa* (17.79%), *Potamyia phaidra* (4.7%), *Hydropsyche Camillus* (2.6%), *Potamyia flavata* (1.26%) and *Amphipsyche meridiana* (1.39%). One species each in Odontoceridae, *Marilia sumatrana* (11.47%), Leptoceridae, *Setodes argentiguttatus* (3.1%) and Ecnomidae, *Ecnomus volovicus* (1.5%).

4.1.2 Physico- chemical water quality parameters of upper Ping watershed

The physio-chemical and environmental condition of the seven subwatersheds of Mae Ping watershed during the study period (January to December 2000) are presented in Table 4.1. From the results the seven subwatersheds difference significantly from each other ($P< 0.05$). Only one parameter, phosphate was not significantly different. The results of the physio-chemical measurements done in 70 sample sites in seven subwatersheds are more detailed in appendix 2

Air and water temperatures

The average air and water temperatures in upper Ping watershed were 22.6±1.49°C and 22.05±1.52°C, respectively. Mae Rim watershed had the lowest air and water temperatures of all subwatersheds, while the upper part of Mae Ping had the highest. The lowest air temperature was in Ban Pang Hai in Mae Rim at 12 °C in the winter. The highest was 28°C at Ban Mae Ram in Mae Rim and Mae Khon river in the upper part of Mae Ping watershed in summer. The lowest water temperature was 14 °C at Ban Huai Kai in Mae Rim in winter and the highest was 26.5°C at Ban Thung Pa Sang in Mae Taeng in summer. From these results Mae Rim (lowest temperature) was located in high altitude and partly shaded to shaded canopy while upper part of Mae Ping located (highest temperature) was located in low altitude with partly open to open canopy. From the open canopy the air and water temperature can reserved temperature from the sun light and surround environment. In winter temperature was different from the other seasons. Mae Khan and Mae Ngat were significantly different from each other. (Table 4.2 and Figure 4.9 A, B).

Discharge

Discharge is the most fundamental hydrological measurement that characterizes all river and stream ecosystems. It affects the velocity, erosion, depth, width, and materials in the water. The variation of average discharge was not significantly different among all the 7 subwatersheds (Table 4.2). Mae Taeng subwatershed had the highest discharge ranging from 1.3 m^3/s in winter to 49.89 m^3/s in rainy season. Mae Rim subwatershed had lowest discharge ranging from 0.48 m^3/s to 1.514 m^3/s in rainy season. All sites in Mae Rim subwatershed were located in Mae Rim tributary streams, which were small and shallow (Figure 4.10E). All sites in Mae Taeng were located in the main river that was wider and deeper than the other subwatershed, which included streams, and the main river. Mae Tang river varied in discharge than the other subwatersheds because of high water supple for paddy field and residential. In the lower part of Mae Taeng river which dried in some part of the river (Amphoe Mae Taeng (T51) and Taeng riverside village (T52)) were low in species richness and diversity because habitats were destroyed by drought. Decreased discharge also affected aquatic communities by altering thermal characteristics of aquatic habitats and decreasing habitat heterogeneity (Sada and Herbst, 2001).

Turbidity

The main source of turbidity comes from soil erosion where forest removal and cultivation on slopes are major problems in northern Thailand. In Mae Taeng the turbidity was highest, especially in summer because of land use activity affects such as residential, agricultural, and tourism (Figure 4.9D). In summer there were a lot of tourism visited with many activity such as bamboo raffling, elephant camp besides these activities there were Lychee orchards and sift cultivate along the hill side. All these activities could be found from the upper to lower parts in Mae Taeng river and all watershed classes. In Mae Ngat all sediment came from vegetable gardens that were grown in the highlands. From these reasons rapid loss of forest cover in these two drainage basin leads to an increase in sediment – rich surface runoff and stream flood flow so we can see muddy water in some areas not only in the rainy season. Another reasons to increase turbidity in these areas because there were cascade with turbulent and high flow velocity. Turbidity was not significantly different in all subwatersheds ($\chi^2_{7,.05}$= 50.92) (Table 4.2) because most of sites in each subwatershed were in small stream which siltation had increased turbidity by resuspension of particles by wave action in the shallow water. The average turbidity in the seven subwatersheds from lowest to highest were Mae Taeng (181.33 ±40.22 FTU), Mae Ngat (128.33±64.97 FTU), Mae Rim (45.367±12.69 FTU), Mae Khan (45.10±21.54 FTU), the upper part of Mae Ping (33.77±9.8 FTU), Mae Kuang (28.26±9.38) and the second part of Mae Ping (22.30±10.48 FTU).

Phosphates

Phosphates are always common in waters and have been affected by urbanization (Watson *et al.*, 1981). In this study phosphate values ranged from 0.13 to 0.65 mg/l. The upper part of Mae Ping watershed had the lowest value at 0.23±0.01 mg/l while Mae Taeng watershed was highest at 0.52±0.12 mg/l due to detergent from water supply, fertilizer from runoff. High phosphate contents were observed in watershed classes 1 and 2 because agricultural beside the river bank and tribe village that lived along the river. Phosphate values vary among seven subwatersheds, but with no significant difference of phosphate levels ($\chi^2_{7,.005}$= 21.153) among the seven subwatersheds (Figure 4.10A and Table 4.2).

Nitrates

Nutrients are used to determine the organic and inorganic nitrogen compounds in water, which can affect aquatic life. Nitrate in this study was dominated by surface runoff and soil erosion, but had been affected lowly by urbanization. In each watershed class there were agricultural areas that used fertilizers for growing crop. Nitrates are an important part of fertilizer and easy dissolved in water. From my study there were high nitrate values, especially in Mae Ngat, Ban Mae Rangang (N31) Ban Mae Rangang Nai (N32) which grow cabbages and onions and Ban Sop Pang (N51) and Ban Huai Sai (N52) which are paddy fields. Nitrate values in Mae Taeng were variable because of human activity such as tourist and agriculture which occur in every watershed classes. The area was changed from forest to agriculture and residential that supported nitrate turn off to river (Klomjeck, 1997). Besides human activity, nitrates that found in Mae Taeng also came from parent material (granite) that collapsed to soil which increased nitrate concentration level in water body. In summer nitrate values were higher than the other seasons because high rainfall and more application of nitrates. Nitrate levels ($\chi^2_{7,0.05}$=41.0) were significantly different among the seven subwatersheds. The upper part of Mae Ping watershed was lowest at 0.36±0.11 mg/l while Mae Taeng watershed was the highest at 1.94±0.15 mg/l (Figure 4.10C and Table 4.2).

Ammonia

Much of ammonia reaches aquatic systems from agricultural runoff are also from domestic sewage and filth from pets and domestic animals. Ammonia always flows with runoff. The second parts of Mae Ping watershed was lowest at 0.19±0.01 mg/l while Mae Ngat was highest at 0.63±0.27 mg/l (Figure 10.140D and Table 4.2). Ammonia can be found in every parts of the river (from watershed classes 1 to 5) because there are many villages in these areas which are always non point sources and difficult to detect. Ammonia contaminated to ammonia level ($\chi^2_{7,.05}$= 33.441) were significantly different among the seven subwatersheds.

Dissolved oxygen

Oxygen is essential to all forms of aquatic life; include those organisms responsible for the self-purfication process in nature water. Dissolved oxygen values depend on the physical, chemical and biological nature at each site. The average level at all sites ranged from 4.95 to 8.4 mg/l with a mean of 7.42±0.76mg/l. Only Mae Taeng was significantly different from the others. DO levels were low in winter and increased a little in the summer because of the rain. DO level was high in rainy season (Figure 10.10E).

Biochemical oxygen demand (BOD_5)

BOD_5 is an approximate measure of the amount of biochemically degradable organic matter present in a water sample. The BOD_5 level at all sampling sites did not vary significantly, except at Mae Khan. Mae Khan was the highest (3.11±3.70mg/l) and the lowest (1.46 ±0.45 mg/l) was in the upper part of Mae Ping (Table 4.2).

pH.

pH is an important variable in water quality assessment as it influences many biological and chemical process water and all processes associated with water supply and treatment. The natural acid-base balance of water can be affected by industrial pollution and atmospheric deposition of acid forming substances. Changes in pH values can indicate the presence of certain effluents together with the conductivity of the water body. Daily variations in pH can be caused by photosynthesis and respiration of algae in eutrophic waters. The pH values of all 7 subwatersheds were between 6.9-8.2 (Figure 4.9C) which were in the natural water body between 6.0 and 8.5 (Chapman, 1992). Some Trichoptera larvae were tolerant in acid and can be found in acidified waters which no fish present (Leiuven *et al.*, 1986). studie conducted by Gaufin (1973) indicated that a pH approaching 6.0 or slightly below can cause significant reduction in the survivorship of several stream insect taxa within 96 hours.

Alkalinity

Alkalinity is a measure of the river's ability to neutralize acid inputs from precipitation or discharges. Rivers with low alkalinity are subject to great fluctuations in pH that disrupt aquatic life. The average alkalinity of the seven subwatersheds from lowest to highest were the upper part of Mae Ping (96.6±47.82 mg/l), Mae Khan (48.77±13.05 mg/l), the second part of Mae Ping (37.8±20.61 mg/l), Mae Ngat (33.69±13.67mg/l), Mae Taeng (30.74±2.45 mg/l), Mae Rim (29.13±5.98 mg/l), and Mae Kuang (14.9±11.51 mg/l) (Table 4.2).

Conductivity and total dissolved solids (TDS)

Conductivity is used as an indicator of the presence of chlorides, nitrates, sulfates and phosphate anions (ions that carry a negative charge) as well as sodium, magnesium, calcium iron and aluminum cations. High conductivity levels may indicate a potential problem from any of these substrates materials. The average conductivity levels were positively correlated to TDS. Average of conductivity and TDS in the upper part of Mae Ping was highest, ranging from 249.55 µs/cm and 168.97 mg/l, respectively in winter to 361µs/cm and 180.2 mg/l, respectively in rainy season. Average of conductivity and TDS in the Mae Rim was lowest, ranging from 56.87 µs/cm and 28.36 mg/l, respectively in winter to 101.41µs/cm and 44.94 mg/l in rainy season (Figures 4.9E, F and Table4.2).

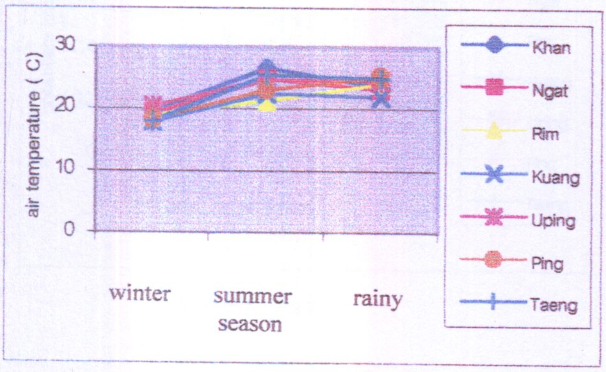
Width, depth and velocity

Mae Taeng had the greatest width (13.33±4.25m), greatest depth (0.85±0.18m) and highest velocity (0.55±0.1m/sec) because most sites in Mae Taeng were located on the main Ping river. The lowest value was at Mae Rim, viz. width (2.57±1.99m), depth (0.56±0.1m) and velocity (0.32±0.11m/sec). Water velocity has been implicated in limiting the distribution of Trichoptera but this depends on species.

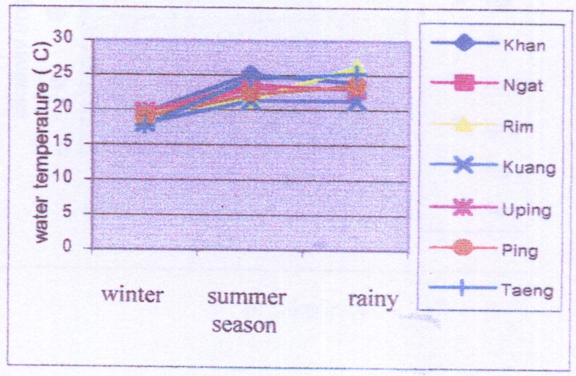
Table 4.2 Comparison of the mean environmental variables for 7 subwatersheds of the upper Ping watershed.

	Mae Khan	Mae Ngat	Mae Rim	Mae Kuang	The upper part of Mae Ping	The second part of Mae Ping	Mae Tang	Statistic
Air Temperature, °c	23.04 ± 0.67^{a}	22.36 ± 1.37^{b}	21.79 ± 1.89	23.02 ± 2.04	23.12 ± 1.32	22.15 ± 1.75	22.71 ± 0.52	$\chi^2_{3,0.05}$ = 6.996
Water Temperature, °C	22.93 ± 0.86^{a}	21.78 ± 1.19^{b}	21.06 ± 1.63	22.45 ± 1.84	22.13 ± 1.20	21.59 ± 2.29	22.45 ± 0.42	$\chi^2_{3,0.05}$ = 10.787
PH	7.95 ± 0.39^{a}	7.78 ± 0.39^{a}	7.49 ± 0.33^{b}	7.20 ± 0.20^{c}	7.97 ± 0.33	7.97 ± 0.43	7.99 ± 0.32	$\chi^2_{3,0.05}$ = 28.7
Conductivity, µs/cm	301.75 ± 102.49^{acd}	193.59 ± 112.28^{abc}	140.39 ± 60.76^{b}	95.23 ± 82.56^{c}	320.48 ± 73.28^{d}	196.20 ± 118.54^{e}	157.85 ± 16.93^{a}	$\chi^2_{3,0.05}$ = 31.78
Total Dissolved Solids, mg/l	150.51 ± 51.61^{acd}	96.49 ± 55.95^{ab}	69.84 ± 30.25^{b}	45.33 ± 40.92^{a}	167.37 ± 45.76^{d}	98.24 ± 58.98^{e}	79.02 ± 8.55^{e}	$\chi^2_{3,0.05}$ = 31.992
Phosphate, mg/l	0.39 ± 0.01	0.40 ± 0.14	0.39 ± 0.17	0.40 ± 0.11	0.23 ± 0.01	0.36 ± 0.13	0.52 ± 0.12	$\chi^2_{3,0.05}$ = 21.5 ,ns
Nitrate, mg/l	0.57 ± 0.01^{a}	0.94 ± 0.55^{b}	0.82 ± 0.11^{a}	0.55 ± 0.20^{ab}	0.36 ± 0.11^{c}	1.15 ± 0.43	1.34 ± 0.15^{c}	$\chi^2_{3,0.05}$ = 41.007
Ammonia, mg/l	0.28 ± 0.31^{a}	0.63 ± 0.27^{b}	0.36 ± 0.11^{c}	0.28 ± 0.14^{ac}	0.31 ± 0.21^{ac}	0.19 ± 0.01^{d}	0.56 ± 0.01^{b}	$\chi^2_{3,0.05}$ = 33.441
Turbidity	45.10 ± 21.55	128.33 ± 64.97^{a}	45.37 ± 12.70	28.27 ± 9.39^{c}	33.77 ± 9.80	22.30 ± 10.49^{c}	181.33 ± 40.4^{a}	$\chi^2_{3,0.05}$ = 50.928
Alkalinity, mg/l as $CaCO_3$	48.77 ± 13.05^{a}	33.70 ± 13.67^{ae}	29.13 ± 5.98^{ad}	14.90 ± 11.51^{b}	96.60 ± 47.82^{c}	37.80 ± 20.61^{d}	30.74 ± 2.46 ^{e}	$\chi^2_{3,0.05}$ = 32.891
Dissolved Oxygen, mg/l	6.88 ± 1.14	7.45 ± 0.54	7.34 ± 0.78	7.60 ± 0.79	7.40 ± 0.47	7.16 ± 0.44	8.14 ± 0.45^{b}	$\chi^2_{3,0.05}$ = 15.892
BOD_5, mg/l	3.11 ± 3.70^{a}	1.81 ± 0.86	2.02 ± 1.29	1.50 ± 0.70	1.46 ± 0.45	1.89 ± 0.50	1.12 ± 0.48	$\chi^2_{3,0.05}$ = 40.12
Width, m	5.50 ± 4.98	3.81 ± 4.63	2.57 ± 1.99	7.70 ± 9.99	5.49 ± 3.75	9.15 ± 13.34	13.33 ± 4.25 ^{b}	$\chi^2_{3,0.05}$ = 17.834
Depth, m	0.47 ± 0.28^{a}	0.27 ± 0.30^{b}	0.56± 10.96	0.59 ± 0.66	0.56 ± 0.37	0.64 ± 0.80	0.85 ± 0.18^{c}	$\chi^2_{3,0.05}$ = 15.112
Velocity, m/s	0.42 ± 0.32	0.45 ± 0.17	0.32 ± 0.11	0.43 ± 0.21	0.45 ± 0.15	0.36 ± 0.17	0.55 ± 0.10^{a}	$F_{3,69}$= 1.503
Discharge, m^3/s	2.61 ± 4.33	3.90 ± 11.22	0.73 ± 0.78	2.75 ± 4.55	1.63 ± 2.22	3.50 ± 6.10	16.62 ± 7.40 ^{a}	$\chi^2_{3,0.05}$ = 20.858
Altitude, m	487.0 ± 118.7	456.0 ± 69.95	626.0 ± 238.3^{a}	568.0 ± 223.9^{a}	454.0 ± 189.4	698.0 ± 269.5^{a}	363.0 ± 71.50^{b}	$\chi^2_{3,0.05}$ = 15.712

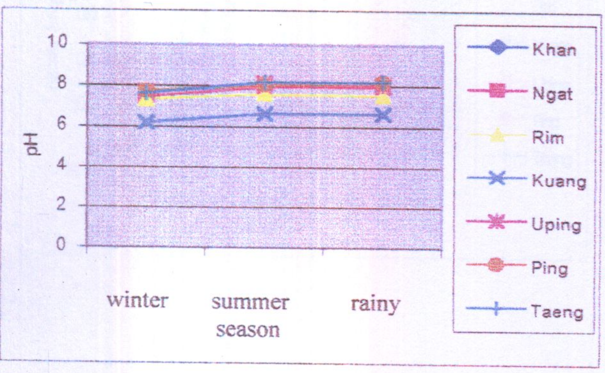
Note : A difference letter in the same horizontal row indicates significantly difference $P<0.05$
statistical value; F- value by ANOVA , χ^2 value by Kruskall – Wallis test



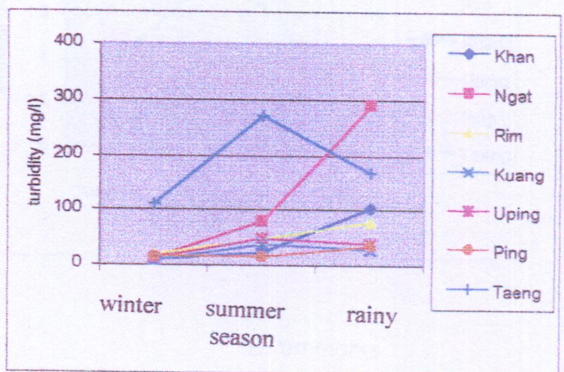
A. air temperature



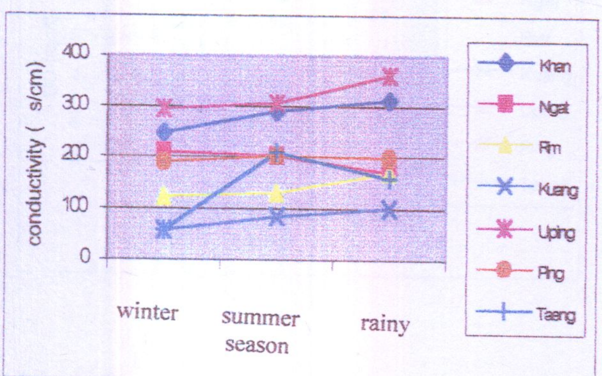
B. water temperature



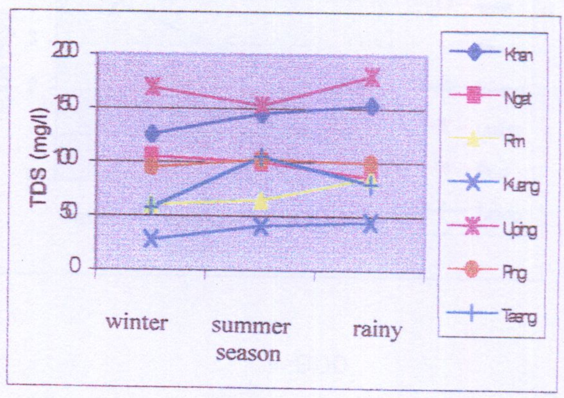
C. pH



D. turbidity



E. conductivity



F. TDS

Figure 4.9 The water quality parameters at 7 subwatersheds of the upper Ping watershed A. air temperature, B. water temperature, C. pH, D. turbidity, E. conductivity, F. TDS

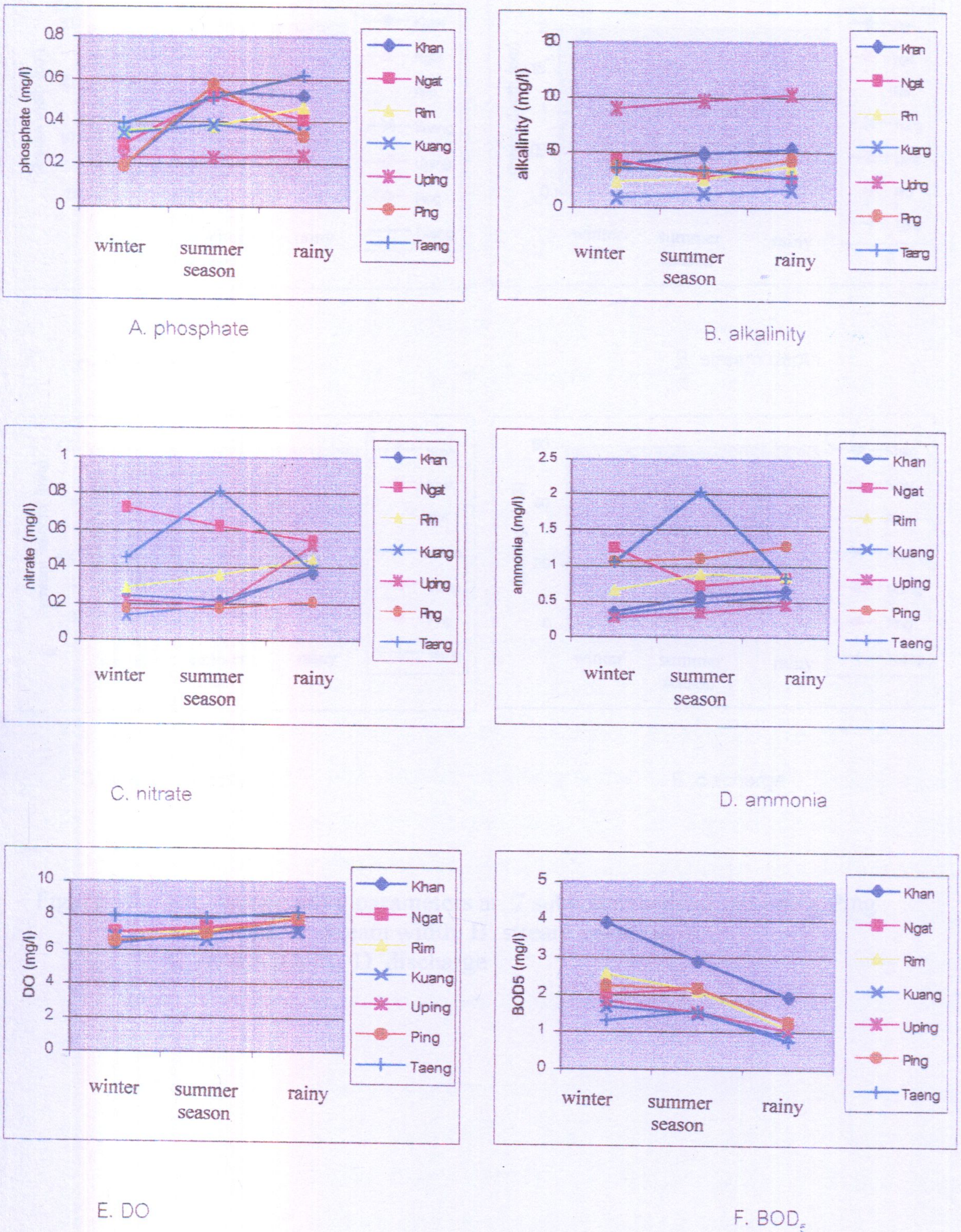


Figure 4.10 The water quality parameters at 7 subwatersheds of the upper Ping watershed A. phosphate, B. alkalinity, C. nitrate, D. ammonia, E. DO, F. BOD_5

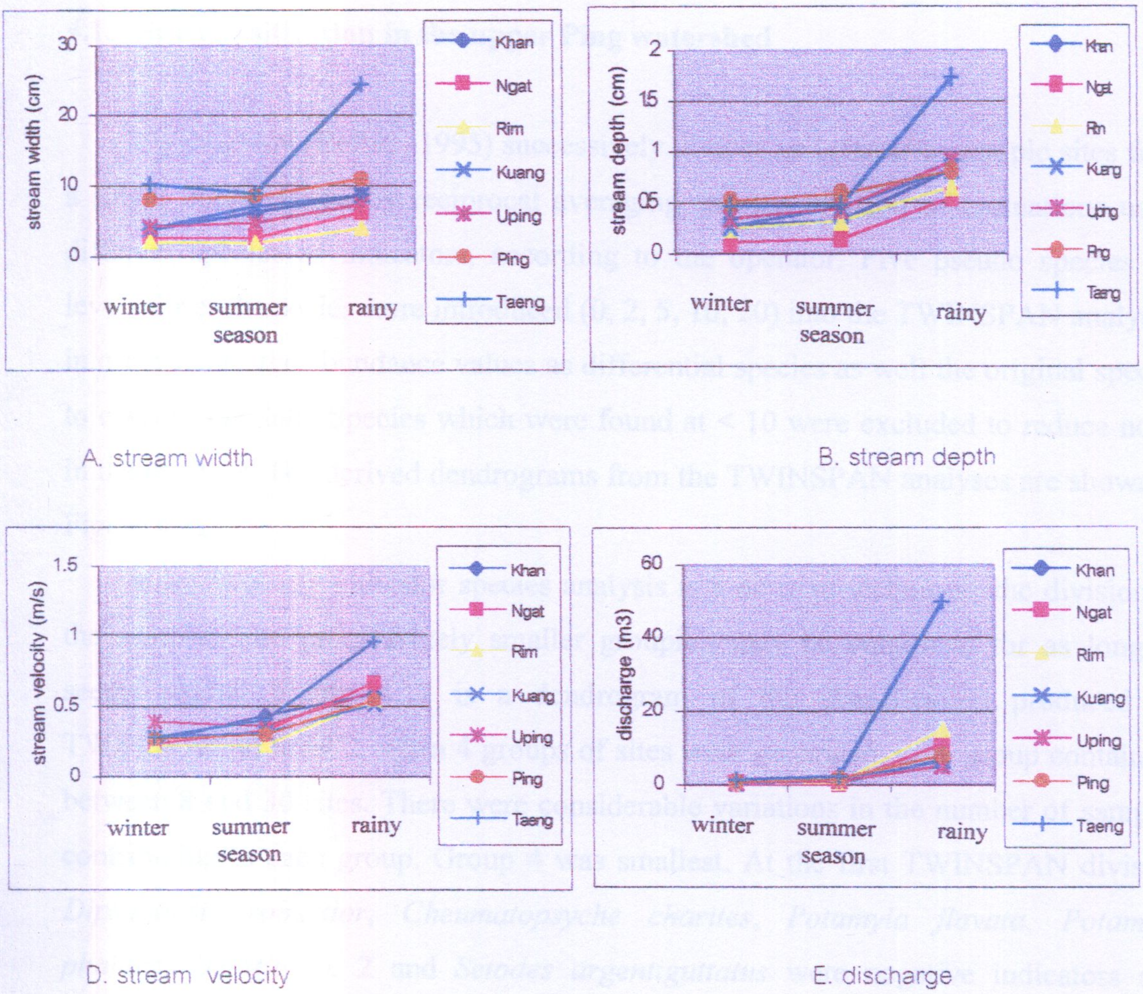


Figure 4.11 The water quality parameters at 7 subwatersheds of the upper Ping watershed A. stream width, B. stream velocity, C. stream depth, D. discharge

4.1.3 Site classification in the upper Ping watershed

TWINSPAN (Belbin, 1995) successively divides and classifies sample sites from a single initial cluster by reciprocal averaging and the division of ordinations using different species as indicators, according to the operator. Five pseudo species cut levels for each species were introduced (0, 2, 5, 10, 20) into the TWINSPAN analyses, in order to use the abundance values as differential species as well the original species to classify the data. Species which were found at < 10 were excluded to reduce noise in the analysis. The derived dendrograms from the TWINSPAN analyses are shown in Figure 4.12.

Since two-way indicator species analysis is a divisive technique, the division of the samples into progressively smaller grouping may be continued for as long as seems useful. Figure 4.12 is a dendrogram of the classification produced by TWINSPAN to level 2, when 4 groups of sites were generated, each group containing between 8 and 30 sites. There were considerable variations in the number of samples contributing to each group. Group 4 was smallest. At the first TWINSPAN division *Dipsodopsis robustior*, *Cheumatopsyche charites*, *Potamyia flavata*, *Potamyia phaidra*, *Oecetis* sp. 2 and *Setodes argentiguttatus* were negative indicators and *Goerodes doligung* was a positive indicator. For the second division *Ecnomus mammus*, *Dipsodopsis robustior,* and *Leptocerus chiangmaiensis* were indicators that separated group 1 from group 2. In the third division, *Rhyacophila suthepensis* and *Macrostemum fastosum* were positive indicators. *Chimara khamuorum*, *Cheumatopsyche globosa*, *Hydropsyche camillus*, *Macrostemum midas,* and *Goera uniformis* were negative indicators.

The number of species per site were not significantly different in four sites group (Table 4.3), but the number of individual per site were significant. Group 1 and group 2 were significantly different from Group 3 and Group 4. However within groups differences were great because of high variations (Table 4.4 and Figures 4.13). This appeared to be the result of a few of species occurring at most sites, while a lot of species had widespread, but patchy distributions. Only 22.22 % of species that similar between Group 1 and Group 4 because there were great differences in environments, viz. altitude, soil and slope that made differences in species between each group.

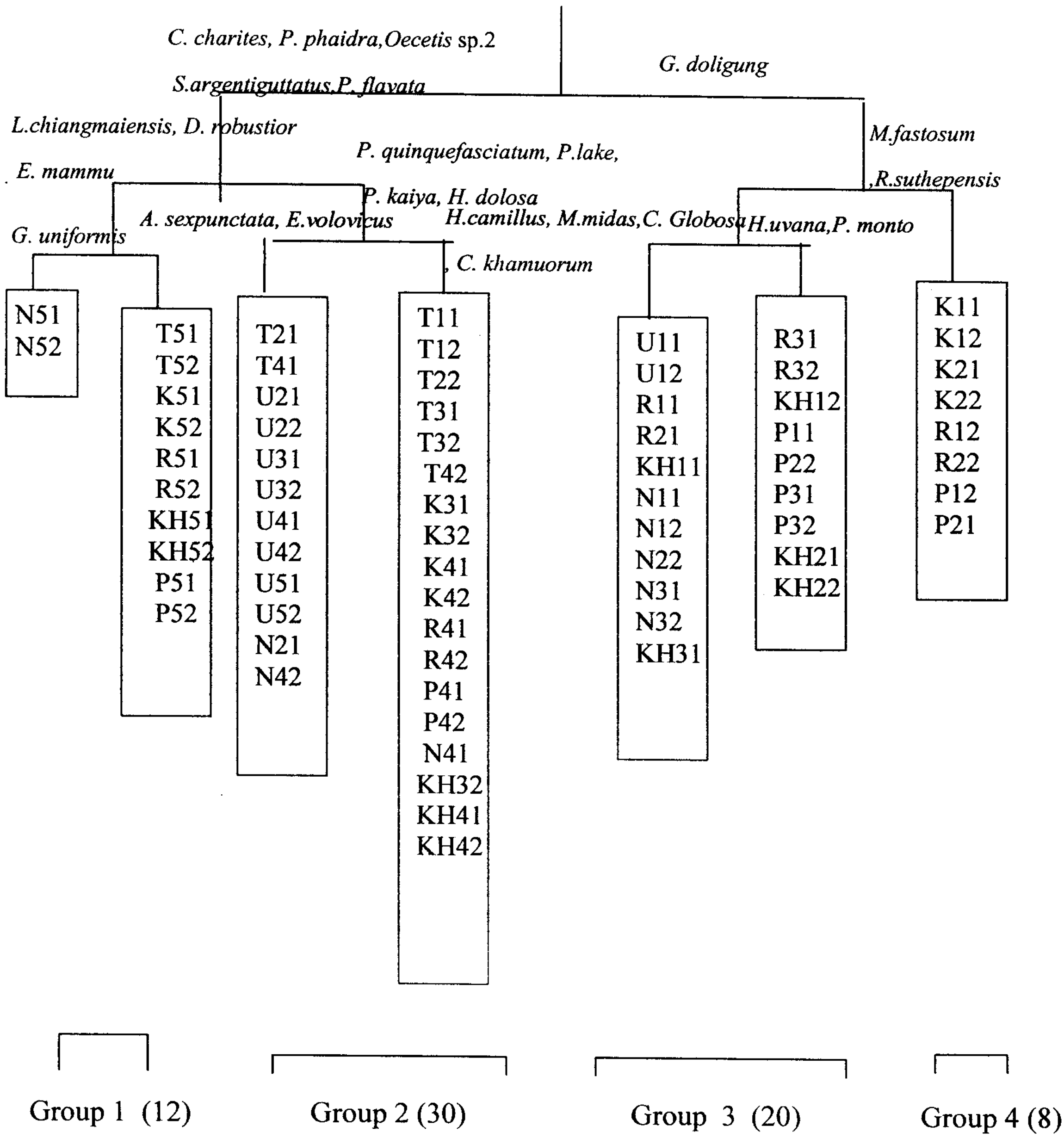


Figure 4.12 TWINSPAN classification of 70 sites in the upper Ping watershed. The number of sites in each group is indicated beside each group number.

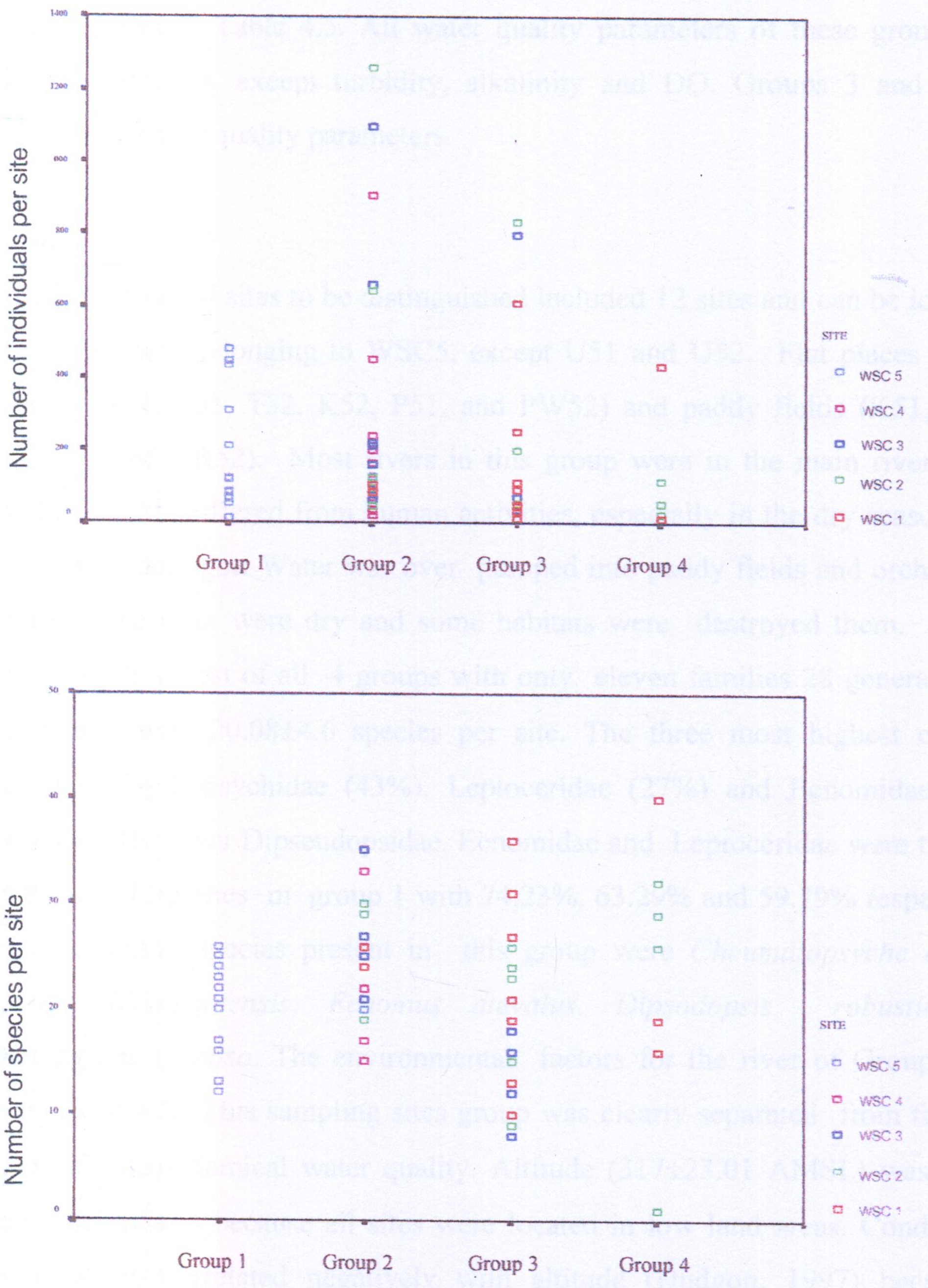


Figure 4.13. a) The number of individual recorded at each site, arranged by TWINSPAN site groups.

b) The number of species recorded at each site, arranged by TWINSPAN site groups.

The watershed class distribution (Table 4.4) of the sites in these four groups suggests that there is a strong spatial signal in the observed groupings.

The significant water quality parameters were statistically tested on the four site groups are shown in Table 4.5. All water quality parameters of these groups were significantly different, except turbidity, alkalinity and DO. Groups 3 and 4 were similar in many water quality parameters.

Group 1

The first group of sites to be distinguished included 12 sites and can be identified as Group 1, most belonging to WSC5, except U51 and U52. Flat places were in urban areas (R51, T51, T52, K52, P51, and PW52) and paddy fields (K51, KH51, KH52, NR51 and NR52). Most rivers in this group were in the main river, which wide and deep. All suffered from human activities, especially in the dry season when the water was shortages. Water was over pumped into paddy fields and orchards so some part of the river were dry and some habitats were destroyed them. Species richness was the lowest of all 4 groups with only eleven families 28 genera and 71 species overall with 20.08±4.6 species per site. The three most highest common families were Hydropsychidae (43%), Leptoceridae (27%) and Ecnomidae (16%) (Figure 4.14). However Dipseudopsidae, Ecnomidae and Leptoceridae were the most frequently found families in group 1 with 74.23%, 63.29% and 59.79% respectively. The more common species present in this group were *Cheumatopsyche cognita*, *Leptocerus chiangmaiensis*, *Ecnomus atevalus*, *Dipsodopsis robustior* and *Cheumatopsyche globosa*. The environmental factors for the river of Group 1 are shown in Table 4.5. This sampling sites group was clearly separated from the other groups by physico-chemical water quality. Altitude (317±23.01 AMSL) was lowest than the other groups because all sites were located in low land areas. Conductivity was high which correlated negatively with altitude (Dudgon, 1997) because of increasing concentration of major ions downstream. However it is lower than Group 2 because of the dilution of main water flow by tributaries and run off. The effects from urban areas and agriculture had a strong influence on river chemistry, especially

Table 4.3 Number of species per and individual per sites compared with one-way ANOVA and Kruskal-Wallis tests

	No. of species per site	No. of individuals per sites
Group 1	20.08 ±4.6	86±144.68[a]
Group 2	23.40±4.98	168±258.3[a]
Group 3	20.65±7.94	250±328.28[b]
Group 4	22.37±12.01	201±170.94[b]
Statistical val	$\chi^2_{3,.05}$ = 10.345	$F_{3,69}$ = . 907

Table 4.4 Watershed distribution of sites in four groups from TWINSPAN classification of Trichoptera community structure

Watershed Classes (WSC)	Group1 (12 sites)	Group2 (30 sites)	Group3 (20 sites)	Group4 (8 sites)
WSC1	0	2	8	4
WSC2	0	6	5	4
WSC3	0	7	7	0
WSC4	0	13	0	0
WSC5	12	2	0	0

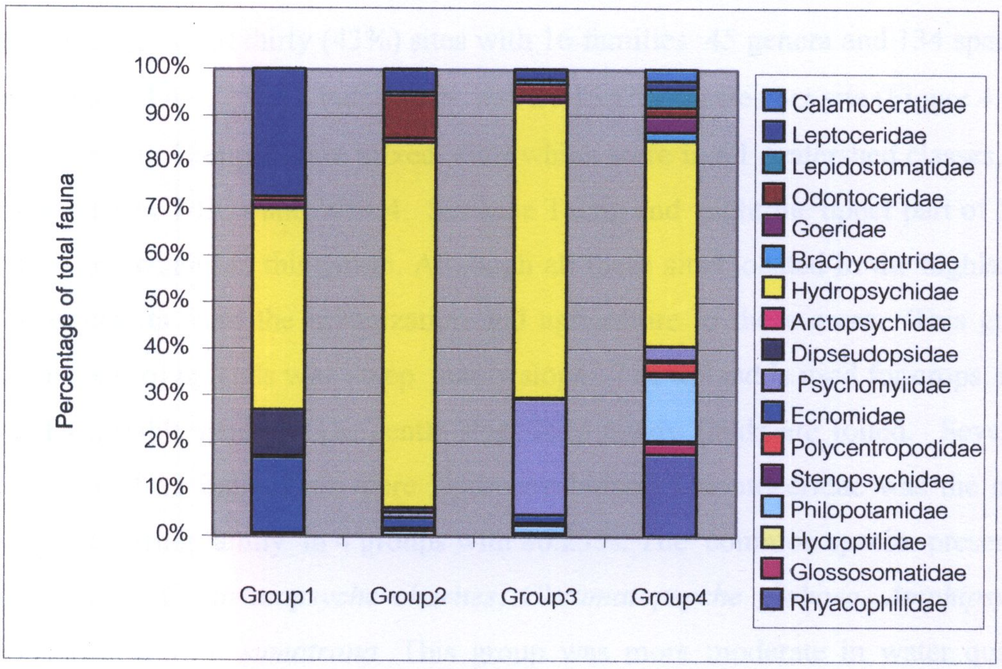


Figure 4.14 Relative abundances of Trichoptera species

nutrients (Ometo *et al.*, 2000), lowest in dissolved oxygen (6.25±0.69 mg/l), highest in ammonia (0.56±0.24mg/l), nitrates (1.04±0.31mg/l) and phosphates (0.47±0.14 mg/l) (Figure 4.15-4.20). Most of the sampleing sites were in the main river which deep and wide so high discharge was high but variable because of the effect from human activity (Figures 4.15-4.20).

Group 2

Group 2 contained thirty (43%) sites with 16 families 45 genera and 134 species. Group 2 had 168.45± 258.37 individuals and 21.15±7.4 species per site (Figure 4.13). The sites forming Group 2 were mixed sites which were in all watershed classes, but tend to be sites in WSC3 and WSC4. Six Mae Taeng and eight the upper part of Mae Ping sites are located in this group. Although all these sites located in the highlands, there were effects from the urbanization and agriculture in these areas. This group sites were areas of uplands with steep gently slope. The upland is used for crops, fruit trees and vegetable garden. On gentle slop, land paddy fields are found. Seventy-eight percent of all individuals were Hydropsychidae. Odontoceridae was the most frequently occurring family in 4 groups with 86.23%. The common species present in this group were *Cheumatopsyche charites*, *Cheumatopsyche globosa*, *Amphipsyche gratiosa* and *Marilia sumatrana*. This group was more moderate in water quality values than Group1 but higher in turbidity than the others because of land degradation, especially in Mae Taeng and Mae Ngat which located in upland which steep slope. There were high variations in water quality values because they consisted of sites in all seven subwatersheds and all WSC (Figures 4.15-4.20). Most of the water quality parameters did not differ significantly between Group1. Only PO_4, NO_3, and NH_3 were less significant than Group1.

Group 3

This group includes sites in WSC1, 2 and 3. All these sites were on hillsides and usually at high altitude with steep to very steep slopes. In this group most of the area had forest. Some sites, R11, P31, P32, N31, N32, U11, and U12, had hill- tribe groups with the shifting cultivation. Some sites were in cultivated areas with vegetable and fruit orchards. The physico-chemical water quality of this sites group were effected by this situation. Water quality was not different significantly from Group 4 (Table 4.5). Conductivity (231.048±104.0, μS/cm), TDS (115.39± 52.24, mg/l), alkalinity (48.0±37.58 mg/l) and pH (7.9190±.4519) were higher than in the other groups, but the other variables were low. The twenty sites with 16 families 44 genera and 140 species were recorded. There were 250.73±328.28 individuals and 24.20± 4.9 species per site (Table 4.3). The dominant families were Hydropsychidae (63%) and Psychomyiidae (25%) (Figure 4.14). The common species present in this group were *Cheumatopsyche charites*, *Psychomyia kaiya* and *Pseudoleptonema quinquefasciatum*.

Group 4

Only 8 sites were in Group 4 . These sites were specific and different from the other sites groups. Five sites, viz. K11, K12, K22, R12 and R22 were small and narrow streams. One site, K21, was in the main Kuang river which is narrow and shallow. The last two sites were narrow waterfalls with fast velocity in rainy season. The physico-chemical water qualities of these sampling sites were clearly low in conductivity, TDS, pH, nitrates, phosphates, alkalinity and turbidity. Nitrate value was lowest in this group (0.59±0.22 mg/l) because of low nitrate leach. Group 4 located in headwater with bountiful forest, which could be store up nitrate so in tropical forest could be complete in nutrient cycle. Only little values of nitrates would be lost from this system. Altitude and velocity are higher than in the other groups (Table 4.5) because most of these groups were located on hillsides and head water which had low impact from human activities. Temperature was lower in the other groups because of more vegetation and forest canopy the same as Sangpradub *et al.* (1997) found out that the air and water temperatures were also influenced by the magnitude of surrounding forest. Water at all sites flowed all year round with little varies in seasons because the source area was still surrounded by trees with little disturbance. All plants usually provide food, shelter and produce oxygen, which adds to the DO of water so Trichoptera species were abundant. There were 201.25±170.94 individuals and 20.08± 4.6 species per site (Table 4.3). The three most abundant families were Hydropsychidae (78%), Odontoceridae (9%) and Leptoceridae (5%).

Table 4.5 Comparison of the mean environmental variables for 4 group sites from TWINSPAN analysis

	GROUP				
	1	2	3	4	
Air temperature (°C)	24.44 ± 0.91^{a}	23.10 ± 0.95^{a}	21.49 ± 1.07^{b}	21.00 ± 0.43^{b}	$\chi^2_{3,0.05} = 43.87$
Water temperature (°C)	23.85 ± 1.15^{a}	22.52 ± 0.80^{a}	20.90 ± 1.31^{b}	20.58 ± 0.63^{b}	$F_{3,69} = 29.00$
pH	7.49 ± 0.15^{a}	7.89 ± 0.41^{b}	7.92 ± 0.45^{b}	7.36 ± 0.45^{a}	$F_{3,69} = 6.74$
Conductivity (µs/cm)	184.35 ± 75.67	227.08 ± 115.41	231.05 ± 104.26	61.33 ± 110.51^{a}	$F_{3,69} = 17.24$
TDS (mg/L)	91.31 ± 36.25	113.00 ± 59.28	115.39 ± 52.24	30.96 ± 18.74^{a}	$F_{3,69} = 17.14$
Phosphate (mg/l)	0.47 ± 0.14^{a}	0.36 ± 0.12	0.39 ± 0.16^{ab}	0.32 ± 0.01^{b}	$\chi^2_{3,0.05} = 6.83$
Nitrate (mg/l)	1.04 ± 0.31	0.83 ± 0.42^{a}	0.74 ± 0.47^{b}	0.59 ± 0.22	$\chi^2_{3,0.05} = 7.07$
Ammonia (mg/l)	0.56 ± 0.25^{a}	0.36 ± 0.18	0.31 ± 0.26	0.22 ± 0.01	$F_{3,69} = 15.07$
Turbidity (FTU)	86.33 ± 72.09	75.69 ± 67.01	64.01 ± 63.30	24.37 ± 0.90	$F_{3,69} = 10.50$
Alkalinity (mg/L)	35.40 ± 12.47	47.10 ± 31.25	48.00 ± 37.58	7.02 ± 7.37	$F_{3,69} = 16.48$
DO (mg/L)	6.52 ± 0.69	7.45 ± 0.72	7.51 ± 0.39	7.93 ± 0.60	$F_{3,69} = 11.44$
BOD_5 (mg/L)	3.50 ± 3.04	1.80 ± 0.86	1.21 ± 0.45^{a}	1.16 ± 0.36^{a}	$F_{3,69} = 27.38$
Width (m)	14.13 ± 12.61^{b}	7.29 ± 6.10^{b}	$3.51 \pm 3..94^{a}$	2.11 ± 1.20^{a}	$F_{3,69} = 19.31$
Depth (m)	1.17 ± 0.67	0.56 ± 0.34	0.23 ± 0.15^{a}	0.21 ± 0.09^{a}	$F_{3,69} = 30.15$
Velocity (m/sec)	0.35 ± 0.29^{b}	0.40 ± 0.17^{b}	0.43 ± 0.17^{ab}	0.56 ± 0.12^{a}	$F_{3,69} = 10.00$
Discharge (m3/sec)	7.55 ± 7.63	5.29 ± 8.70	1.19 ± 3.20^{a}	0.39 ± 0.41^{a}	$F_{3,69} = 18.25$
Altitude	317.00 ± 23.01^{b}	421.67 ± 85.91^{b}	679.00 ± 202.82^{a}	802.50 ± 28.71^{a}	$F_{3,69} = 47.11$

Note : A difference letter in the same horizontal row indicates significantly difference $P<0.05$
statistical value; F- value by ANOVA , χ^2 value by Kruskall – Wallis test

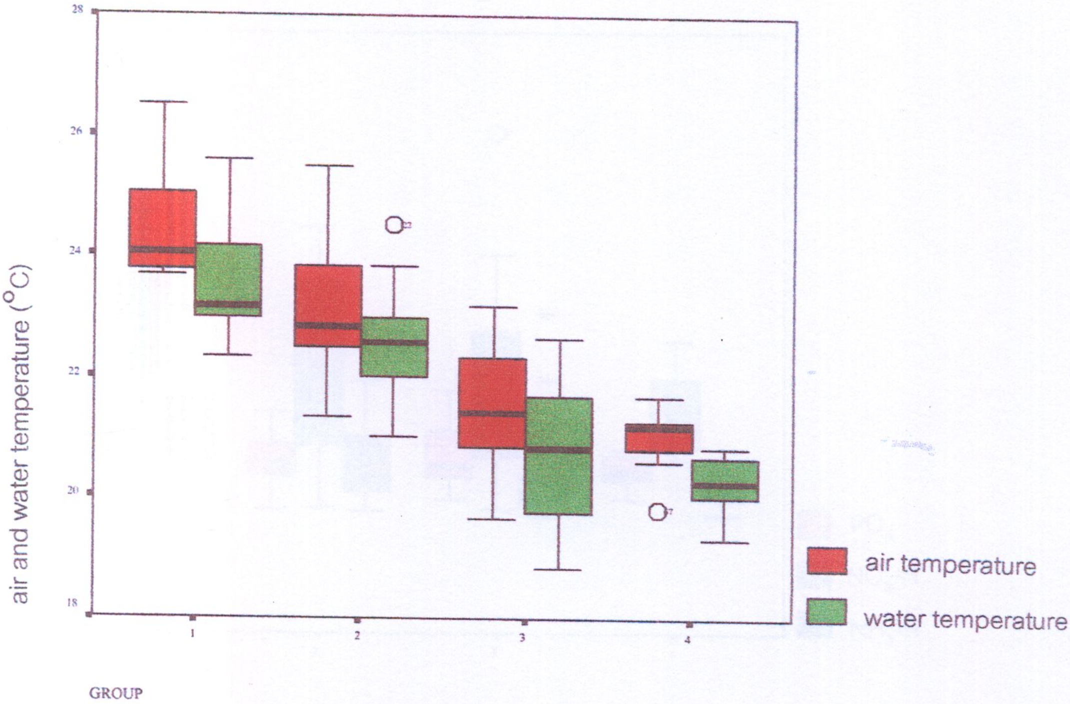


Figure 4.15 Boxplot of air and water temperature values in each TWINSPAN group

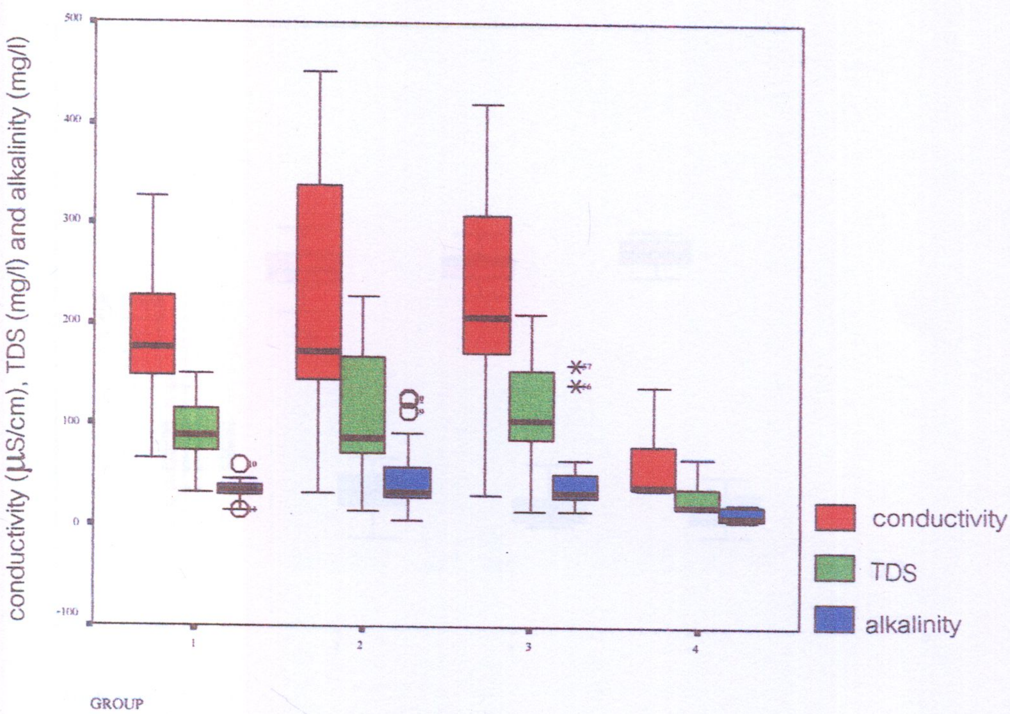


Figure 4.16 Boxplot of conductivity, TDS and alkalinity values in each TWINSPAN group

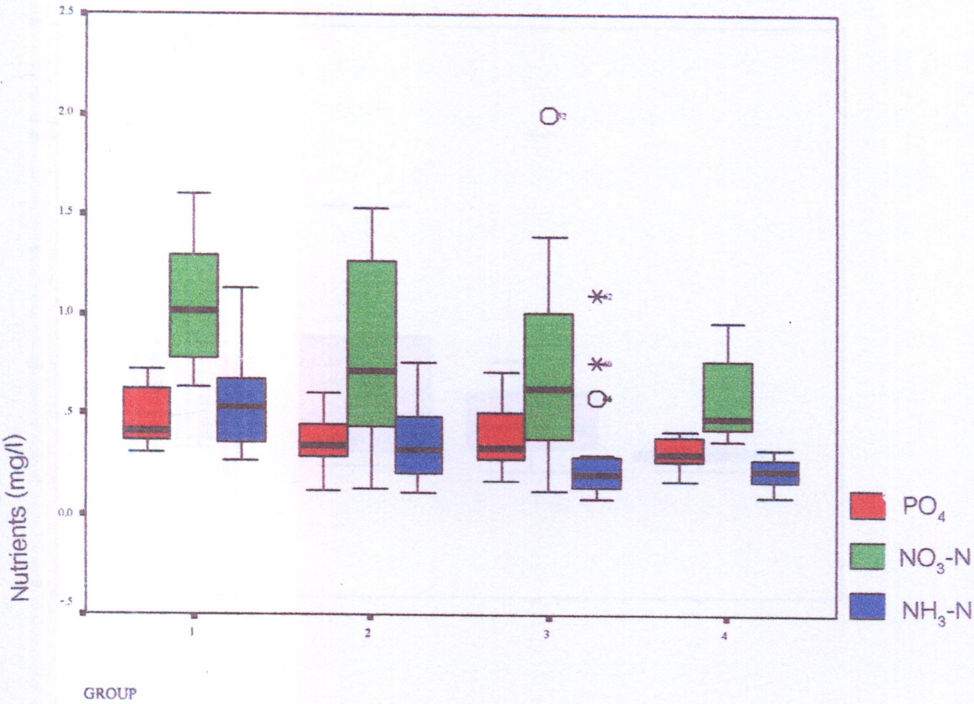


Figure 4.17 Boxplot of nutrient, PO_4, NO_3-N and NH_3-N values in each TWINSPAN group

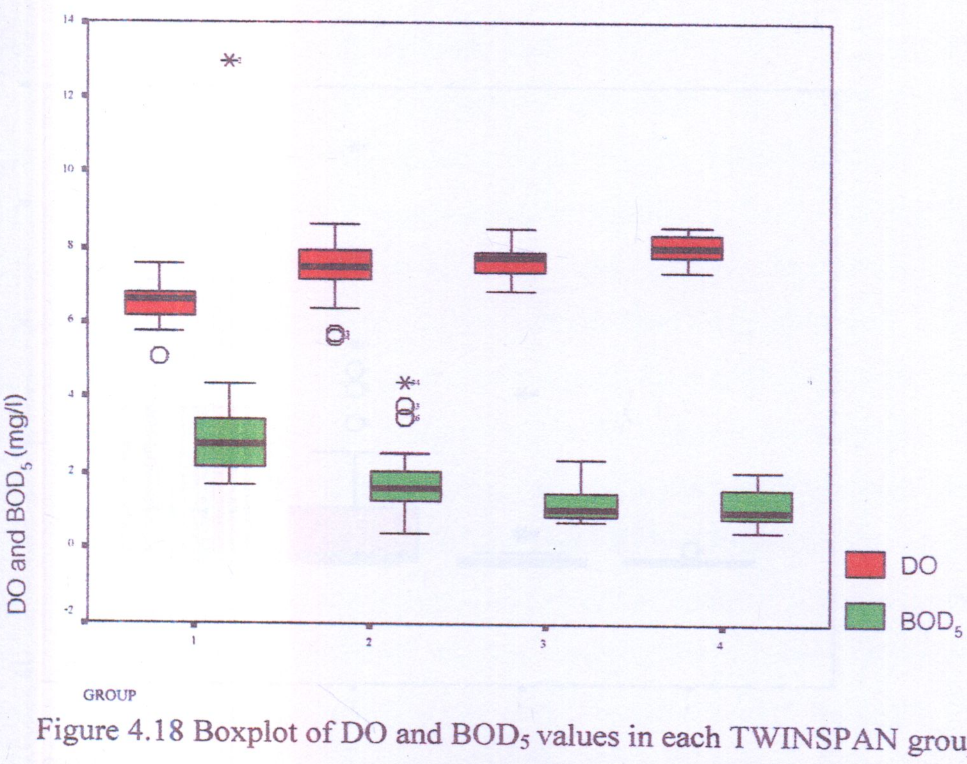


Figure 4.18 Boxplot of DO and BOD_5 values in each TWINSPAN group

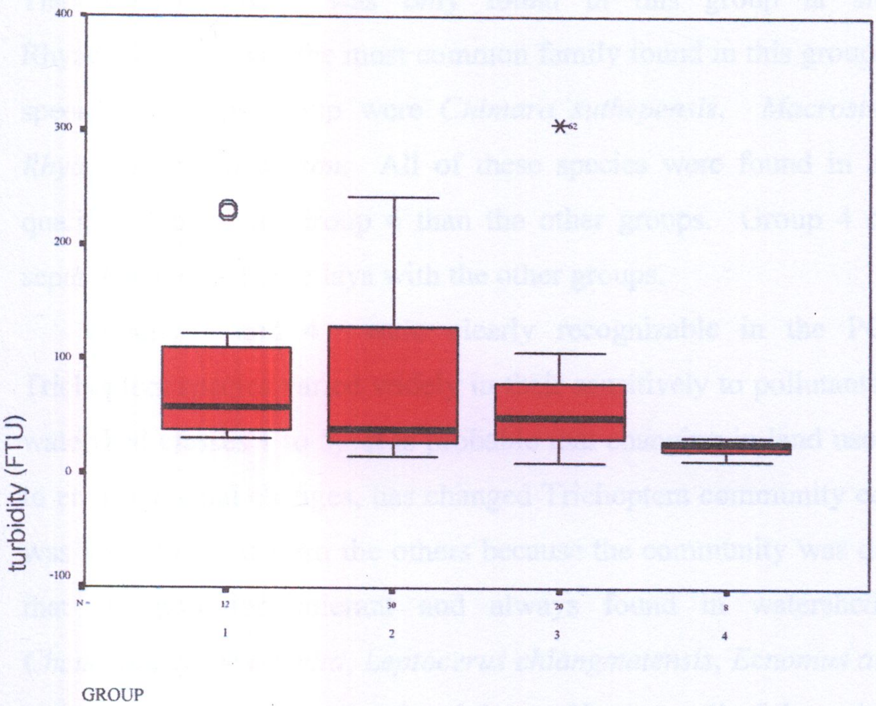


Figure 4.19 Boxplot of turbidity values in each TWINSPAN group

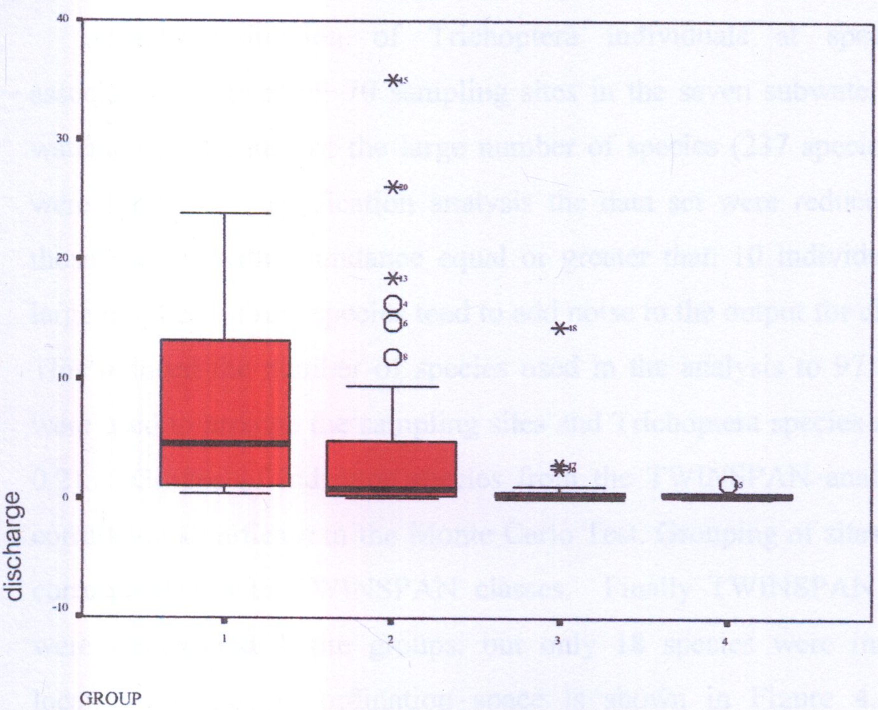


Figure 4.20 Boxplot of discharge values in each TWINSPAN group

The Brachycentridae was only found in this group at sites P21 and P12. Rhyacophilidae was the most common family found in this group. The more common species in this group were *Chimara suthepensis*, *Macrostemum fastosum* and *Rhyacophila petersorum*. All of these species were found in areas of good water quality, as point in Group 4 than the other groups. Group 4 could not be clearly separated and had over lays with the other groups.

Groups 1 and 4 were clearly recognizable in the PCA and ordination. Trichoptera species varied widely in their sensitively to pollutants, which varied from watershed classes 1 to 5. It is probable that changing in land use type, which has led to environmental changes, has changed Trichoptera community composition. Group 1 was very different form the others because the community was dominated by species that are pollution tolerant and always found in watershed class 5 such as *Cheumatopsyche cognita*, *Leptocerus chiangmaiensis*, *Ecnomus atevalus*, *Dipsodopsis robustior* and *Cheumatopsyche globosa*. However all of these 4 TWINSPAN groups were not really separated from each other because there were a lot of changing and mixing in land use patterns, especially in Groups 2 and 3

Ordination in upper Ping watershed

HMDS ordination of Trichoptera individuals at species level revealed associations with at all 70 sampling sites in the seven subwatersheds of upper Ping watershed. Because of the large number of species (237 species, Appendix A) that were found for classification analysis the data set were reduced by including only those species with abundance equal or greater than 10 individuals. This is because large numbers of rare species tend to add noise to the output for classification analysis. This reduced the number of species used in the analysis to 97 species. Three axes were used to arrange the sampling sites and Trichoptera species associations (stress< 0.2). Groups of indicator species from the TWINSPAN analysis also had strong correlation significant in the Monte Carlo Test. Grouping of sites was apparent which corresponded with TWINSPAN classes. Finally TWINSPAN classes and HMDS were represented 4 site groups, but only 18 species were indicator species. The location of sites in ordination space is shown in Figure 4.21 and the relative contribution of the species to the ordination vectors had been determined by principal axis correlation. Those species which contributed most to the pattern of site distribution are indicated by arrow in Figure 4.22. The direction of the arrow indicated the direction of the loading and the length of the arrow the importance of the species.

Group site with low scores on axis 3 are located on the left of the plot (Group 1) are dominated by *Cheumatoppsyche cognita*, *Dipsodopsis robustior*, *Cheumatopsyche globosa*, *Leptocerus chiangmaiensis*, *Ecnomus mammus*, *Ecnomus atevalus* and *Setodes Argentiguttatus*. Group 2 is in the middle of the pot. While *Cheumatoppsyche charties*, *Potamyia phaidra*, *Amphipsyche gratiosa*, *Psychomyia lak* ,*Ecnomus robustior*, *Dipsodopsis benardi*, *Potamyia panakeia* and *Pseudoleptonema quinquefasciatum* are found at many sites, they are most abundant at those sites scoring low on axis 3. The sites forming Group 3 are score high on axes 3 and 2, located in the upper part of the plot. *Macrostemum midas* and *Hydropsyche uvana* are indicator species in this group. Only 8 sites are in Group 4, and are located on the right part of the pot. *Rhyacophila suthepensis* and *Macrostemum fastosum* are indicators in this group.

The correlation for the physic-chemical variables that were significant as indicated by Monte Carlo randomization are listed in Table 4.6. The corresponding vectors indicating direction of maximum correlation are shown on Figure 4.23. Twelve variables were correlated with ordination. It is probably best to consider only those correlations with $p<0.05$ as significant. Thus, elevation, TDS, conductivity, turbidity, water and air temperatures clearly had the highest correlation ($r>0.8$).

The large area were the problem for a good representative because of many areas with different in some characteristic, so many studies attempting to identify the factor influencing macroinvertebraqte communities have been spatially extensive, compare sites that many differ in various attributes across many catchment. Examine factors affecting macroinvertebrate communities within small geographical areas or even within the same catchment can overcome such problems (Clenagham *et al*., 1998). The upper Ping watershed was good representative for these areas although it consisted of seven subwatersheds, because they were all in the upper Ping watershed and difference in some details with local situations.

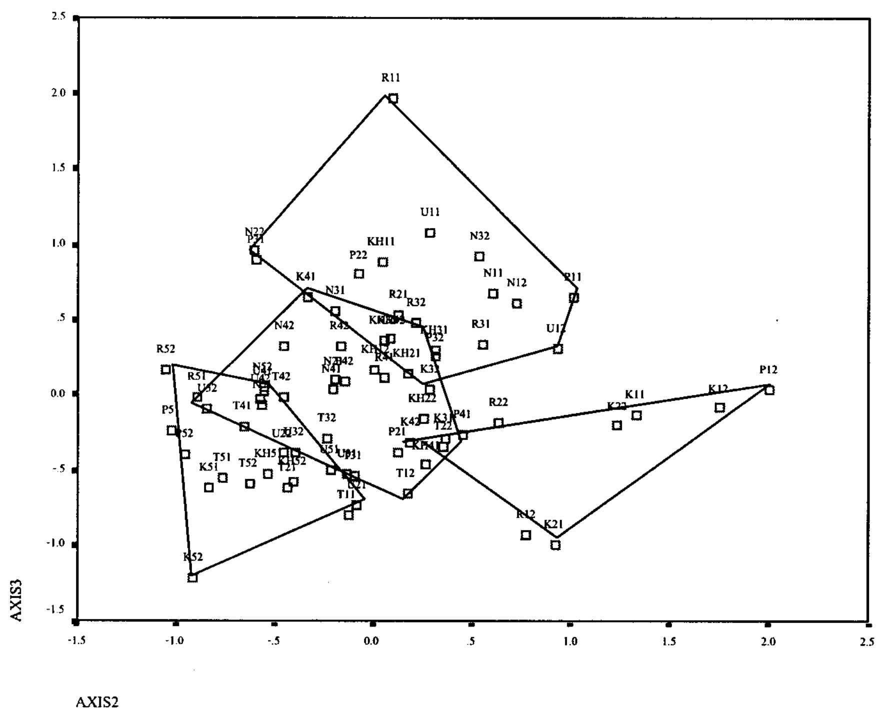


Figure 4. 21 Site ordination based on Trichoptera species in the upper Ping watershed.

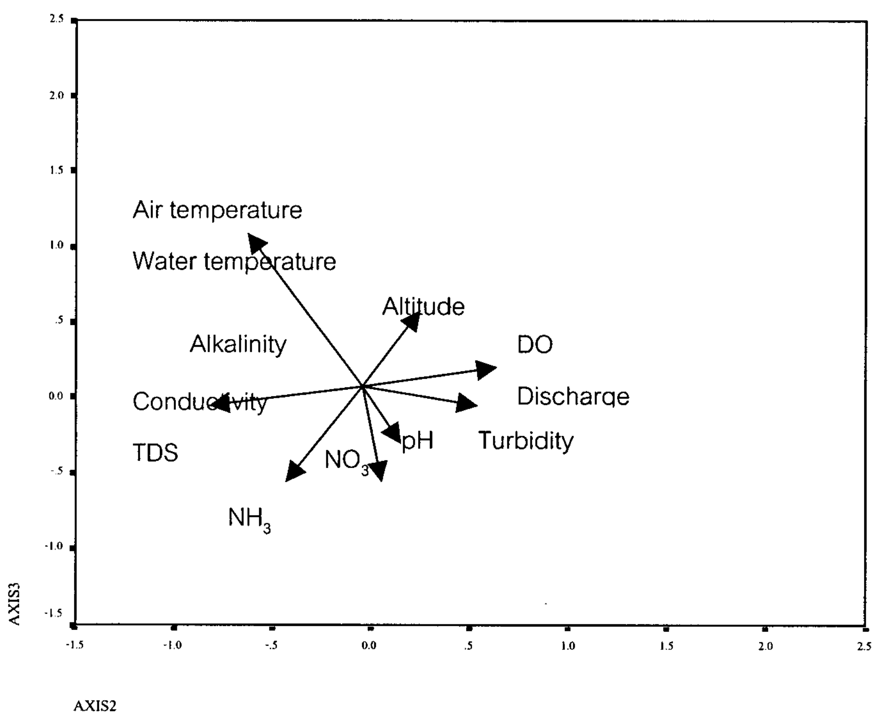


Figure 4. 22 Water quality group ordination based on site in the upper Ping watershed.

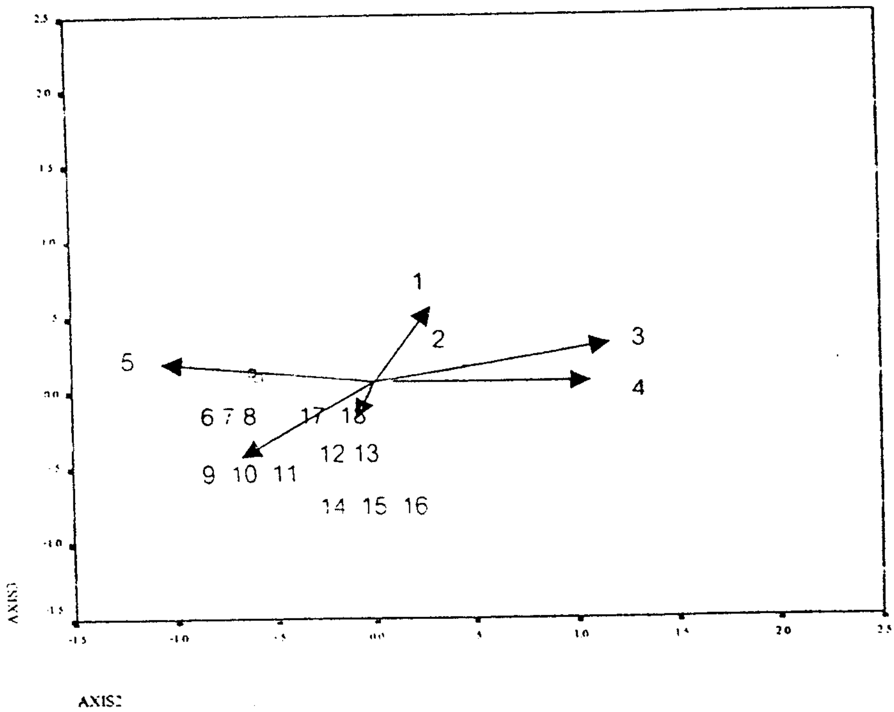


Figure 4.23 Trichoptera species ordination in the upper Ping watershed

1= *M. midas*, 2=*H. uvana*, 3=*R. suthepensis*, 4=*M. fastosum*, 5=*C. globosa*,
6= *C. cognita*, 7=*S. argentiguttayus*, 8=*L. chiangmaiensis*, 9=*E. Mammus*, 10=*E.atevalus*,
11= *D. robustior*, 12=*E. robustior*, 13=*P.panakeia*,
14=*P. phaida*, 15=*A.gratiosa*, 16=*D.benardi*, 17=*C.charites*,
18= P.*quinquefasciatum*

Table 4.6 Correlation of species with vector analysis from SSH

Code	Trichoptera species	r	Code	Trichoptera species	r
I	*C. charites*	.8163	X	*R. suthepensis*	.5560
II	*C. cognita*	.7306	XI	*E. atevalua*	.5542
III	*M. fastosum*	.7000	XII	*E. mammus*	.5440
IV	*P. phaida*	.6605	XIII	*E. robustior*	.5132
V	*D. robustior*	.6296	IVX	*H. uvana*	.5123
VI	*C. globosa*	.6017	XV	*D. benardi*	.5117
VII	*M. midas*	.5944	XVI	*S. argentiguttatus*	.5008
VIII	*L. chiangmaiensis*	.5598	XVII	*P. panakeia*	.5037
IX	*A. gratiosa*	.5598	XVIII	*P. quinquefasciatum*	.5005

Mae Taeng sites classification

Classification of Trichoptera assemblages resulted in 3 terminal site-groups at TWINSPAN level 2 (Figure 4.24). Gp1, 2, 3 contain 4, 3 and 3 sites, respectively. At the first TWINSPAN division T11, T12 and T22 were separated from the other groups. *Goera redsat* was positive indicator species for these sites groups. At the second level *Cheumatopsyche charites* was an indicator species for Gp2 which separated them from Gp1. Three groups ordinations of sites which identified by the TWINSPAN analysis was shown in Figure 4.25. Eight Trichoptera species out of a total of 27 species correlated strongly to Mae Taeng watershed (r>0.7) are Hydropsychidae. viz, *Potamyia panakeia*, *Hydropsyche askalaphos*, *Cheumatopsyche globosa*, *Cheumatopsyche charites*, *Pseudoleptonema quinquefasciatum; Leptoceridae*. viz, *Setodes argentiguttatus*, *Ecnomus robustior and Geridae. viz*, *Goera redsat* (Figure 4.26). The seven environmental variables were significantly arranged in the same way in three ordination space, stress 0.22 (Figure 4.27). The environmental variables that were significantly correlated with the ordination were altitude, conductivity, TDS, dissolved oxygen, air temperature, turbidity and alkalinity.

Mae Khan sites classification

The results of the TWINSPAN analysis for 10 sites are shown in Figure 4.28. The first group of sites (Gp1) have 4 sites, KH11, KH12, KH21 and KH32. The second group (Gp2) has 4 sites, KH22, KH31 and KH42, *Pseudoleptonema quinquefasciatum* is an indicator. The third group (Gp3) has 3 sites, viz. KH41, KH51 and KH 52. Twelve Trichoptera species correlated significantly to the HMDS ordination axes The correlation coefficients of *Marilia sumatrana* (0.8731), *Pseudoleptonema quinquefasciatum* (0.8548), *Hydropsyche camillus* (0.852), *Macrostemum midas* (0.8367), *Psychomyia lak* (0.8253), *Psychomyia kaiya* (0.8236), *Cheumatopsyche charites* (0.809), *Cheumatopsyche globosa* (0.7733), *Potamyia phaidra* (0.7547), *Cheumatopsyche copia* (0.7528), *Chimarra vibena* (0.7456) and *Ecnomus puro* (0.745) represented, respectively. Water quality variables showed significant variation throughout the area and seven variables were correlated in ordination with P<0.05

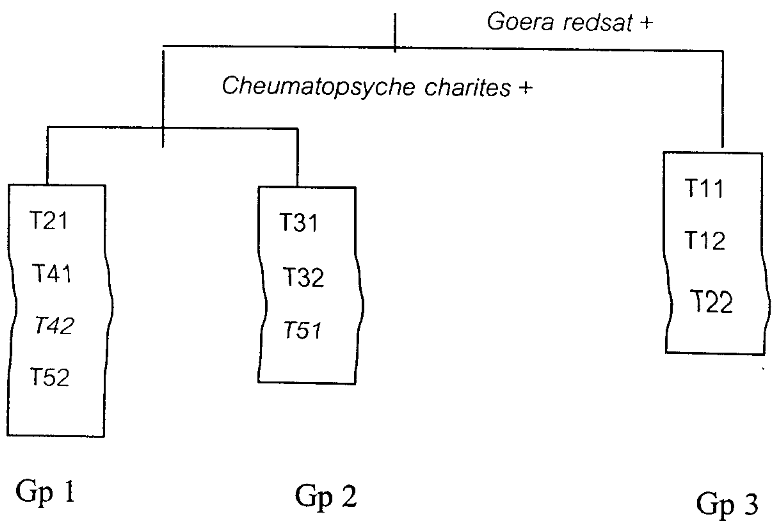


Figure 4.24 TWINSPAN classification of 10 sites in Mae Taeng watershed. Indicator species for each split are listed.

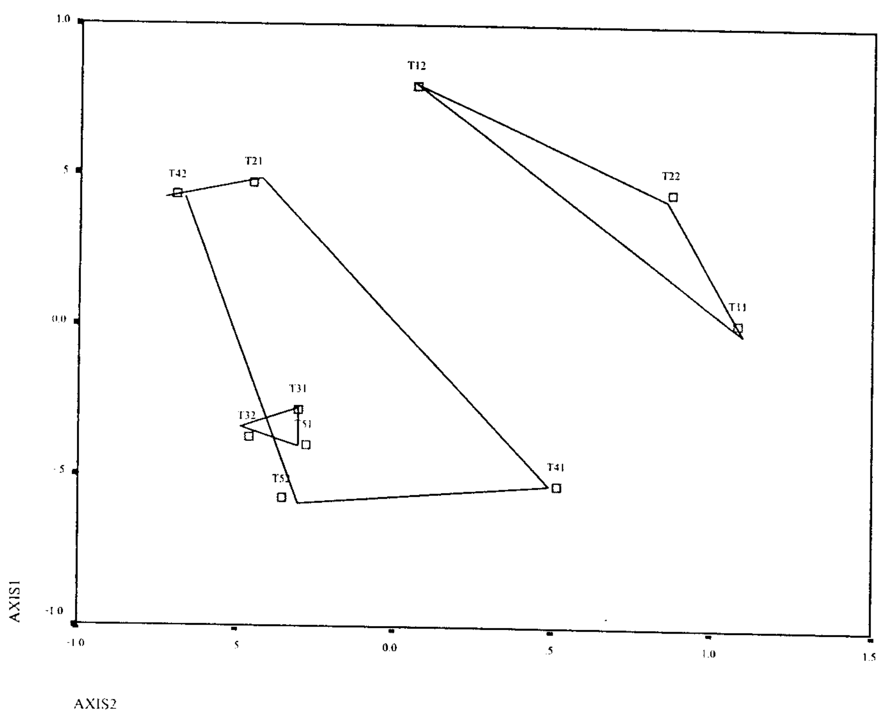


Figure 4.25 Site ordination based on Trichoptera species in Mae Taeng watershed

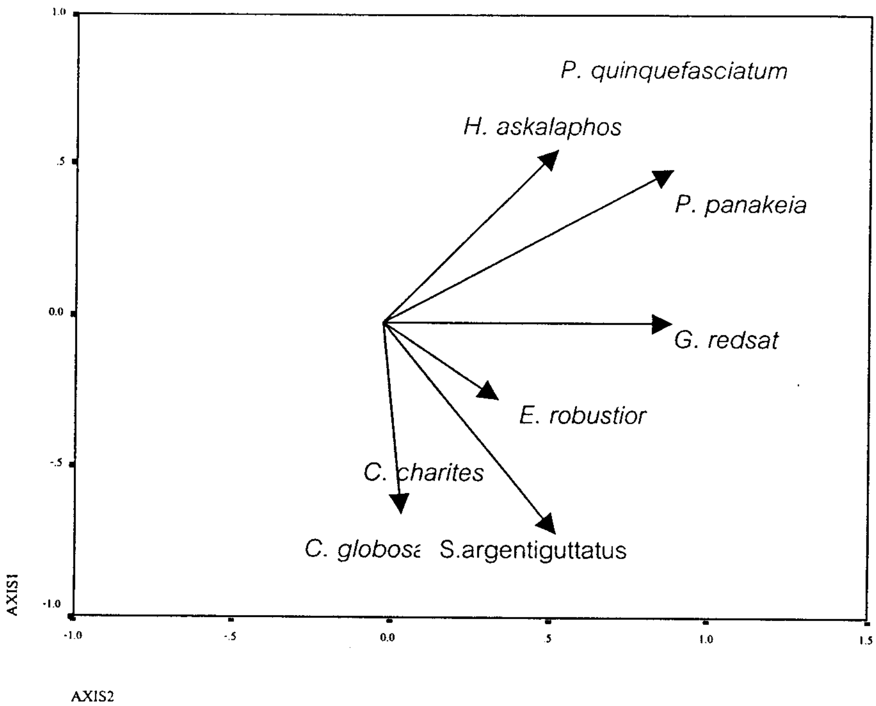


Figure 4.26 Trichoptera species ordination in Mae Taeng watershed

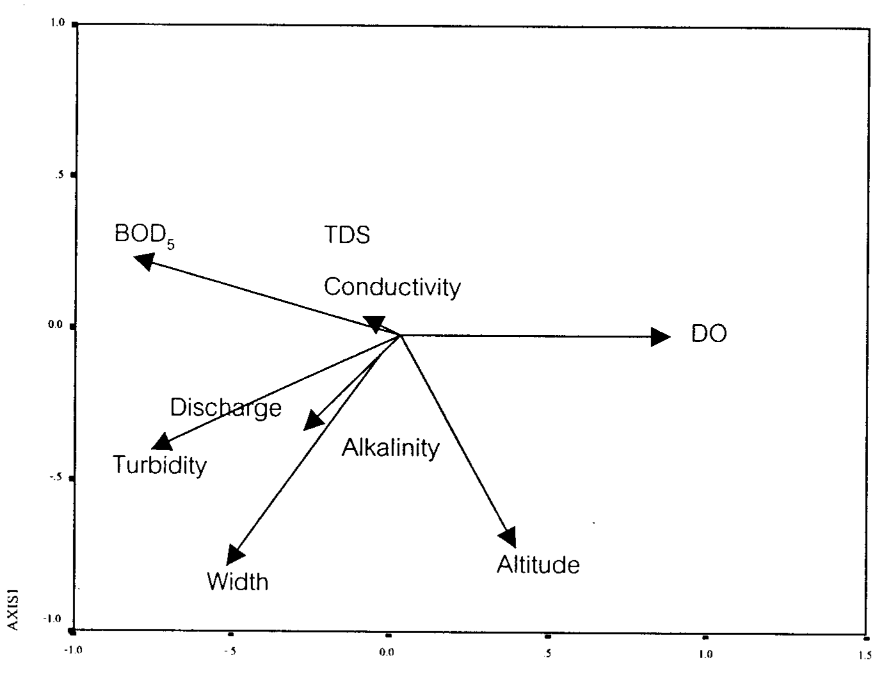


Figure 4.27 Water quality group ordination based on site in Mae Taeng watershed

Mae Khan sites classification

The results of the TWINSPAN analysis for 10 sites are shown in Figure 4.28. The first group of sites (Gp1) have 4 sites, KH11, KH12, KH21 and KH32. The second group (Gp2) has 4 sites, KH22, KH31 and KH42, *Pseudoleptonema quinquefasciatum* is an indicator. The third group (Gp3) has 3 sites, viz. KH41, KH51 and KH 52. Twelve Trichoptera species correlated significantly to the HMDS ordination axes The correlation coefficients of *Marilia sumatrana* (0.8731), *Pseudoleptonema quinquefasciatum* (0.8548), *Hydropsyche camillus* (0.852), *Macrostemum midas*(0.8367), *Psychomyia lak* (0.8253), *Psychomyia kaiya* (0.8236), *Cheumatopsyche charites* (0.809), *Cheumatopsyche globosa* (0.7733), *Potamyia phaidra* (0.7547), *Cheumatopsyche copia* (0.7528), *Chimarra vibena* (0.7456) and *Ecnomus puro* (0.745) represented, respectively. Water quality variables showed significant variation throughout the area and seven variables were correlated in ordination with $P<0.05$ being significant. Figures 4.29-4.31 show the vectors for those variables in the ordination. Seven variables were correlated with ordination with $P<0.05$ being significant.

Mae Kuang sites classification

The results of TWINSPAN classification in Mae Kuang are shown in Figure 4.32. The initial division of sites by TWINSPAN at level 1 separated K41, K51 and K52 (Gp1) from the others by *Dipsodopsis robustior.* At level 2 Gp2 (K11 and K12) separated from Gp3 (K21, K22, K31, K32 and K42) by *Cheumatopsyche charites*. Three group ordinations of sites, which identified by TWINSPAN analysis, were shown in Figure 4.33. Seven Trichoptera species correlated significantly to the sampling sites in the HMDS ordination axes. These species were *Macrostemum fastosum*, *Ecnomus atevalus*, *Ecnomus mammus*, *Dipsodopsis robustior*, Ecnomus aktaion and *Dipsodopsis doehbri*, (r =0.7381 – 0.9238). Trichoptera species data from Mae Kuang sampling sites mostly aggregated together (Figure 4.34). Three groups were clearly separate. Difference between groups were high while within-groups

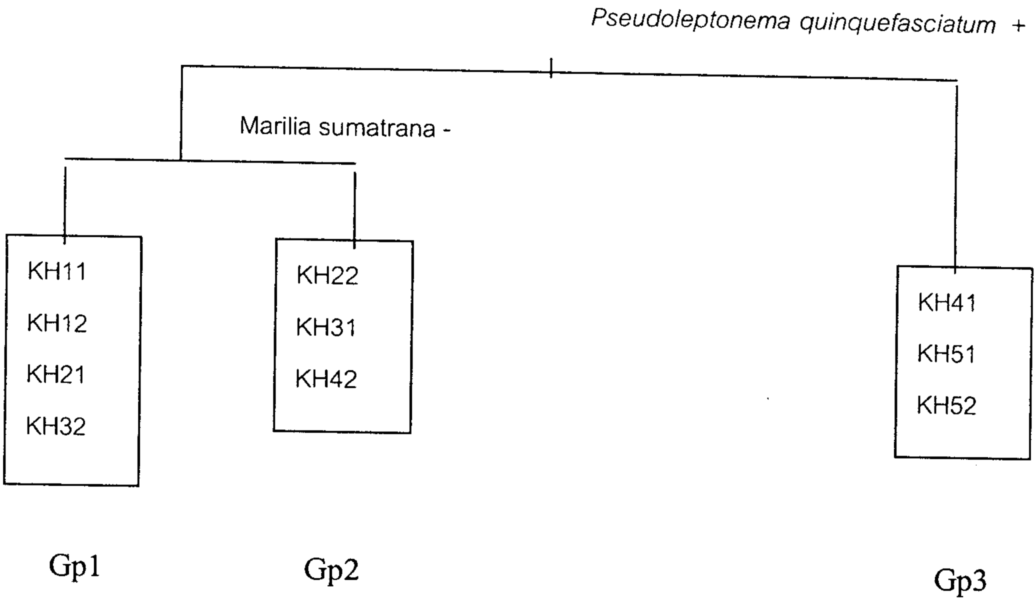


Figure 4.28 TWINSPAN classification of 10 sites in Mae Khan watershed. Indicator species for each split are listed.

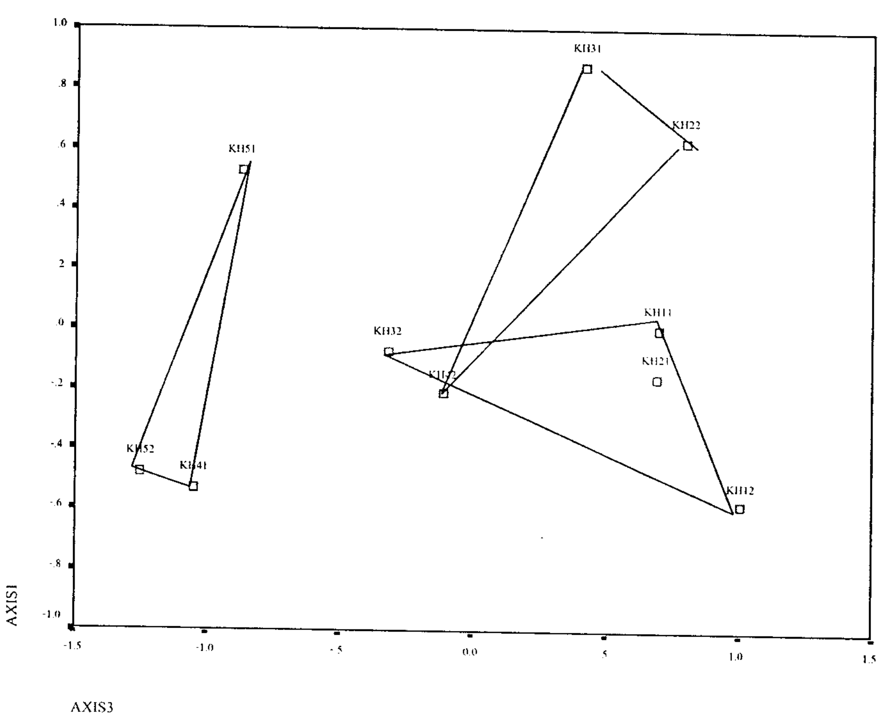


Figure 4.29 Site ordination based on Trichoptera species in Mae Khan watershed

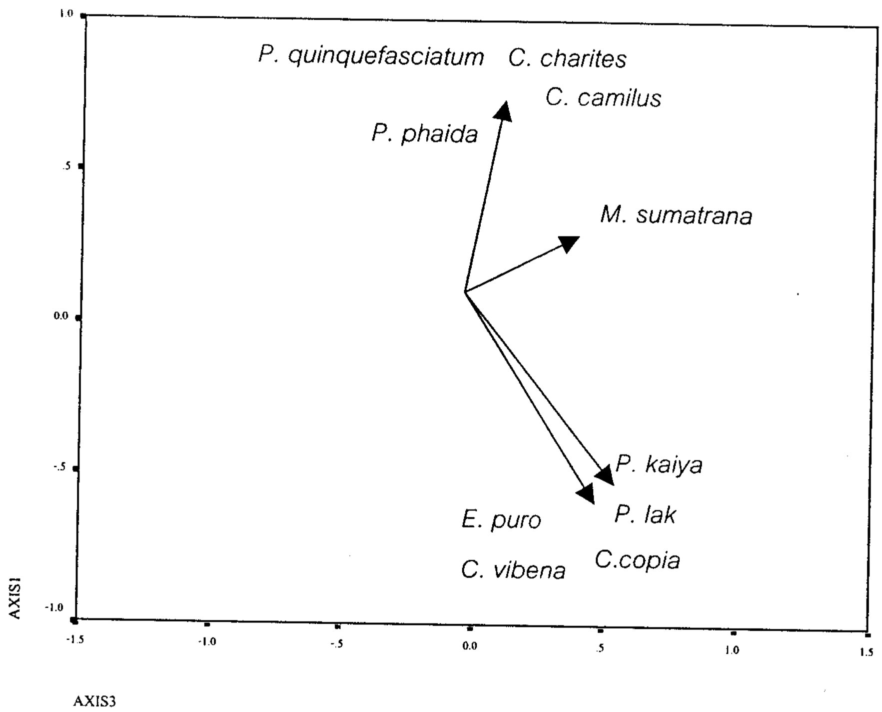


Figure 4.30 Trichoptera species ordination in Mae Khan watershed

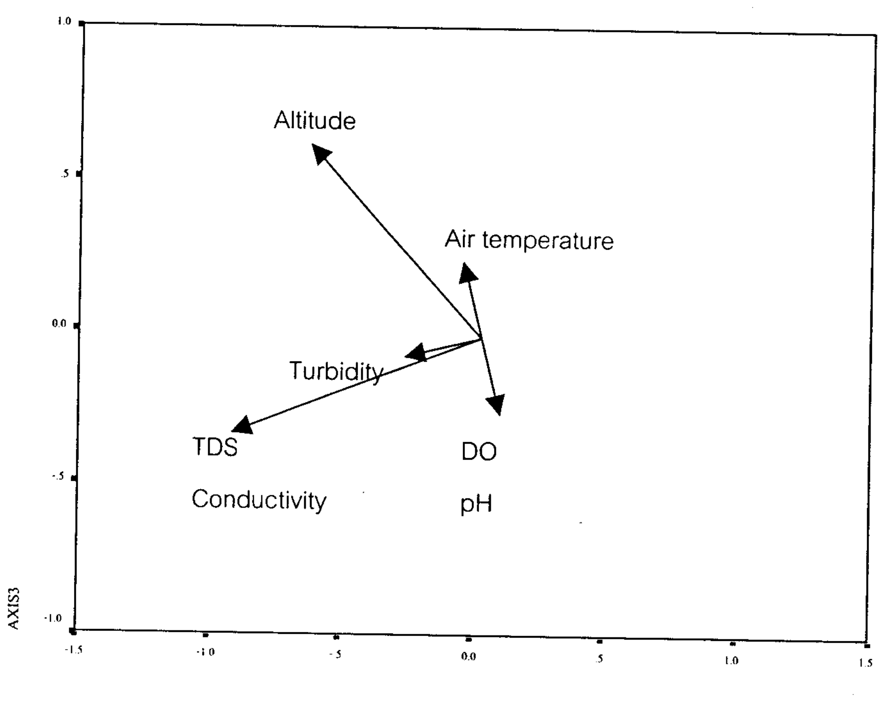


Figure 4. 31 Water quality groups ordination based on site in Mae Khan watershed

being significant. Figures 4.29-4.31 show the vectors for those variables in the ordination. Seven variables were correlated with ordination with *P*<0.05 being significant.

Mae Kuang sites classification

The results of TWINSPAN classification in Mae Kuang are shown in Figure 4.32. The initial division of sites by TWINSPAN at level 1 separated K41, K51 and K52 (Gp1) from the others by *Dipsodopsis robustior*. At level 2 Gp2 (K11 and K12) separated from Gp3 (K21, K22, K31, K32 and K42) by *Cheumatopsyche charites*. Three group ordinations of sites, which identified by TWINSPAN analysis, were shown in Figure 4.33. Seven Trichoptera species correlated significantly to the sampling sites in the HMDS ordination axes. These species were *Macrostemum fastosum*, *Ecnomus atevalus*, *Ecnomus mammus*, *Dipsodopsis robustior*, Ecnomus aktaion and *Dipsodopsis doehbri*, (r =0.7381 – 0.9238). Trichoptera species data from Mae Kuang sampling sites mostly aggregated together (Figure 4.34). Three groups were clearly separate. Difference between groups were high while within-groups difference were small. Sixteen variables were correlated with ordination with *P*<0.05 being significant (Figure 4.35).

Mae Ngat sites classification

Two- way indicator species analysis (TWINSPAN) separated Gp3; N41, N42, N51 and N52 , from those in the two other land use categories on the first division. The key species resulting in this separation were *Rhyacophila suthepensis*, *Potamyia flavata*, *Macrostemum floridum*, *Marilia sumatrana* and *Oecetis* sp.2. The second division separated in to two groups by *Cheumatopsyche globosa*. Gp1 consisted of N21, N22 and N31. Gp 2 consisted of N11, N12 and N32 (Figure 4.36). Three axes were used to arrange the sampling sites and Trichoptera species association (stress =0.07). The location of sites in ordination space is shown in Figure 4.39. Nine Trichoptera species correlated significantly (r> 0.8) to 10 sampling sites, *Cheumatopsyche globosa*, *Marilia sumatrana*, *Cheumatopsyche cognita*, *Potamyia flavata*, *Cheumatopsyche chryseis*, *Dipsodopsis robustior*, *Macrostemum floridum*, *Cheumatopsyche charites* and *Pseudoleptonema quinquefasciatum*. Seven water

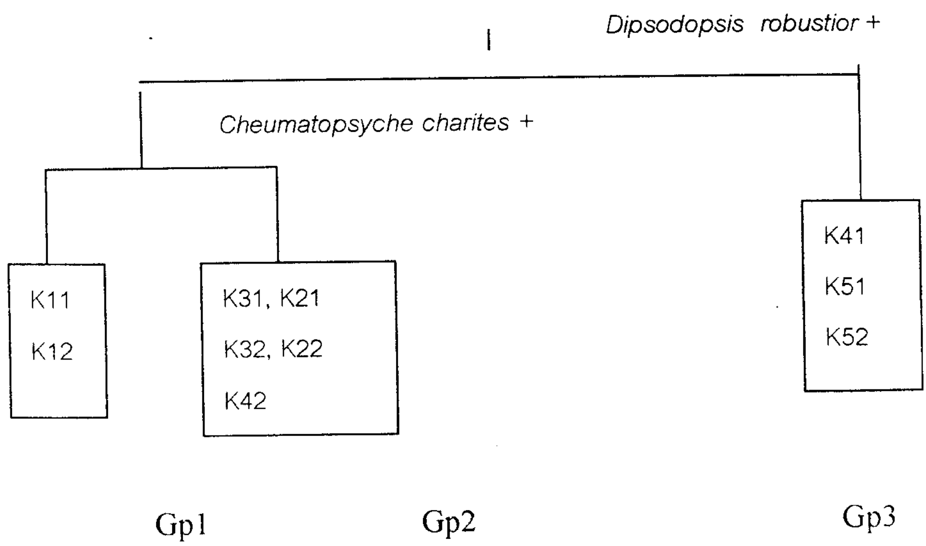


Figure 4.32 TWINSPAN classification of 10 sites in Mae Kuang watershed. Indicator species for each split are listed

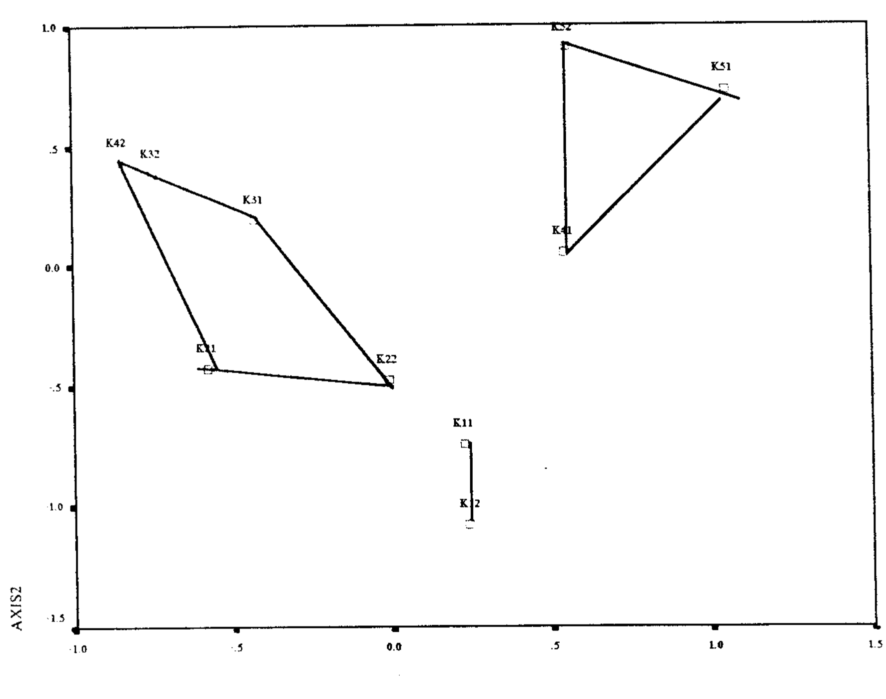


Figure 4.33 Site ordination based on Trichoptera species in Mae Kuang watershed

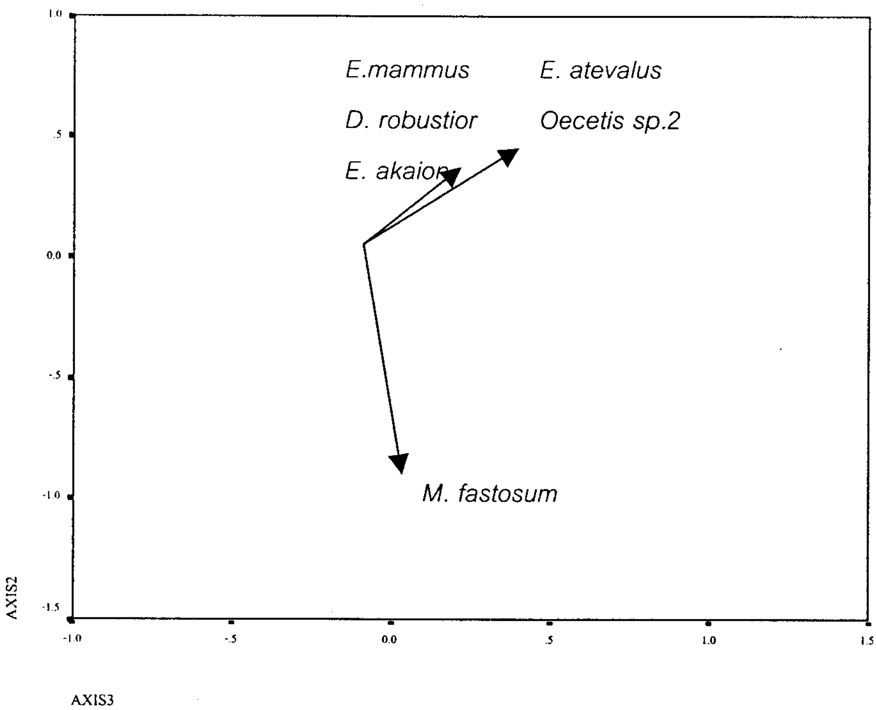


Figure 4. 34 Trichoptera species ordination in Mae Kuang watershed

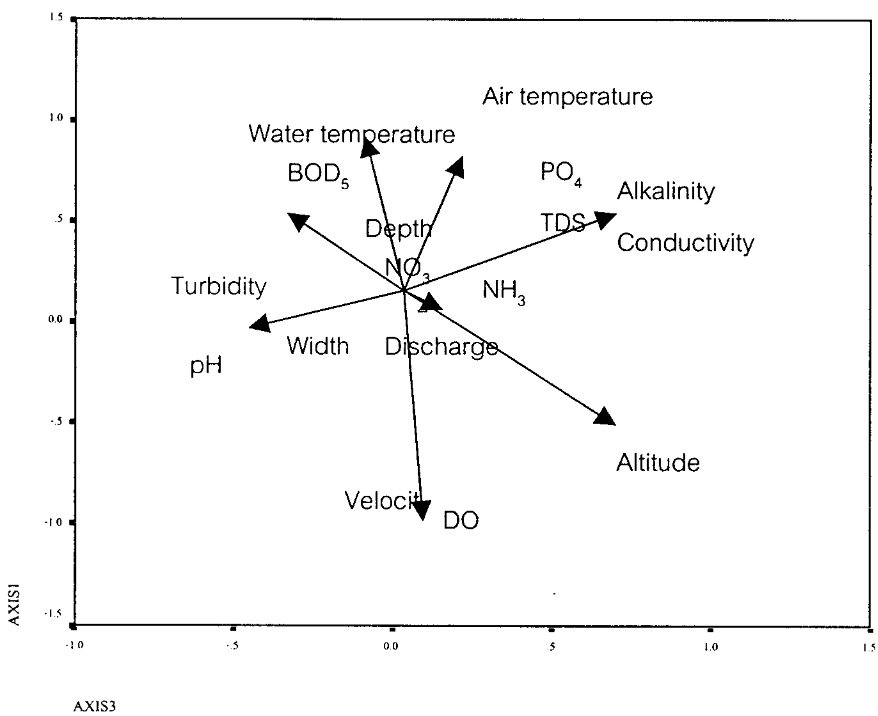


Figure 4. 35 Water quality group ordination based on site in Mae Kuang watershed

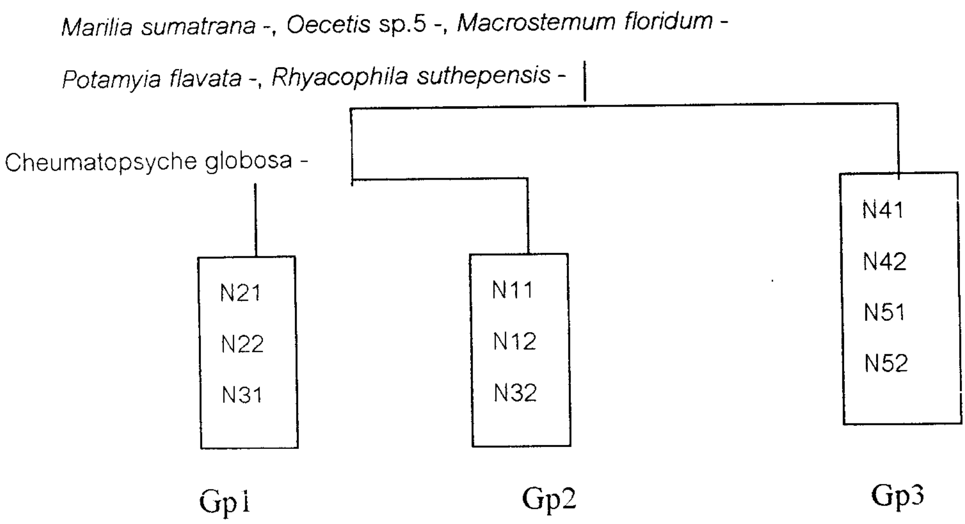


Figure 4.36 TWINSPAN classification of 10 sites in Mae Ngat watershed. Indicator species for each split are listed.

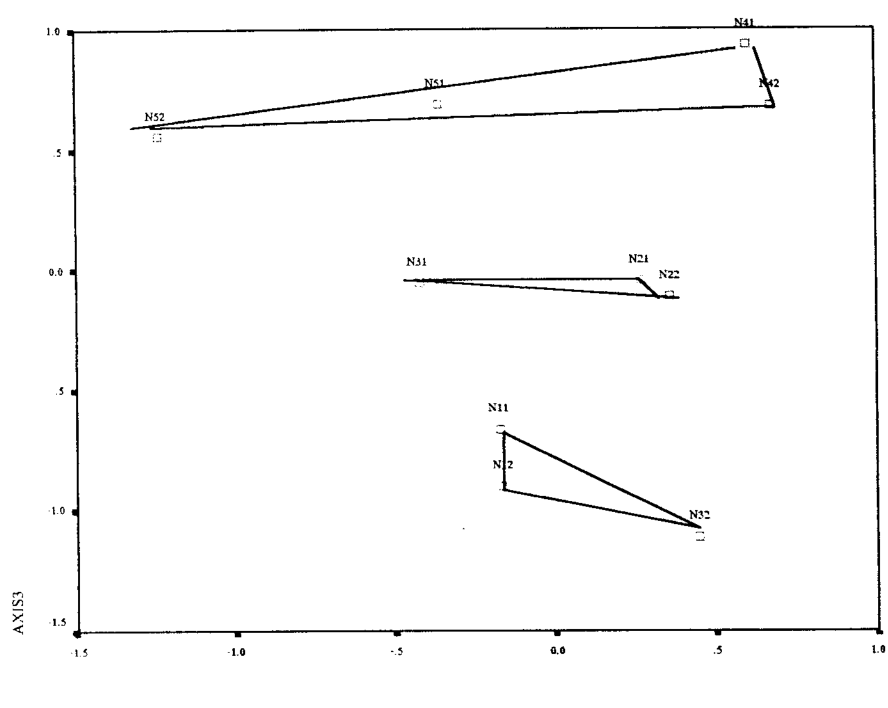


Figure 4.37 Site ordination based on Trichoptera species in Mae Ngat watershed

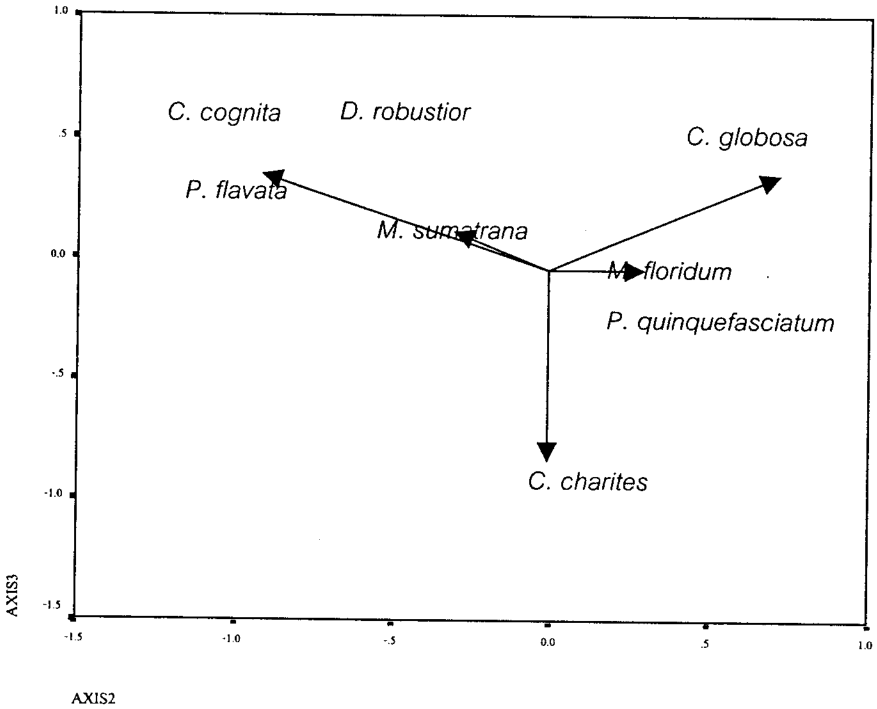


Figure 4. 38 Trichoptera species ordination in Mae Ngat watershed

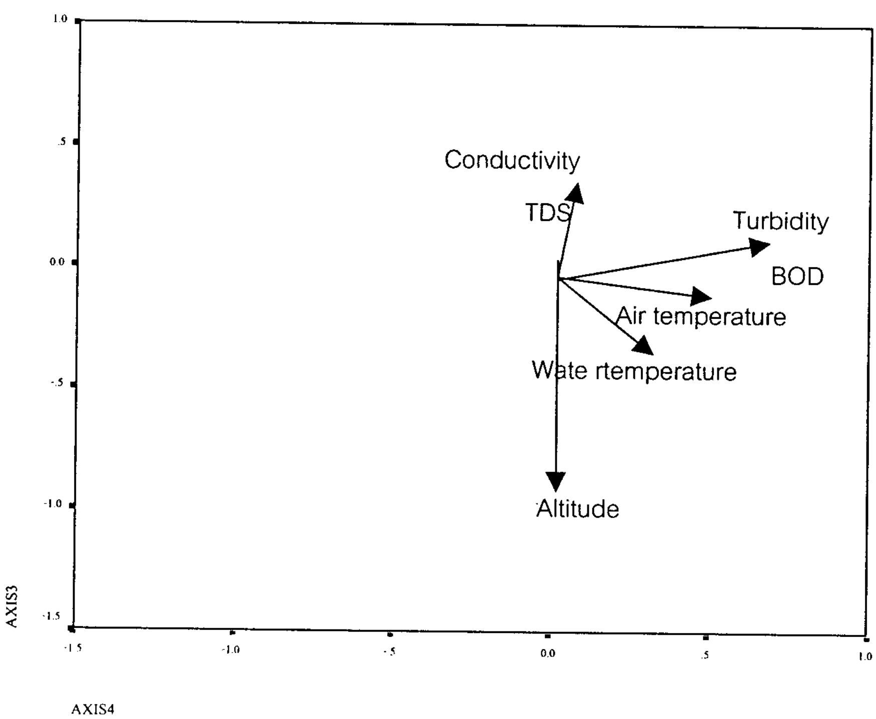


Figure 4. 39 Water quality group ordination based on site in Mae Ngat watershed

quality variables were correlated with ordination with *P*<0.05 as significant. The corresponding vectors indicating direction of correlation are shown on Figure 4.39 which projections into the four dimensions (stress=0.16).

The second part of Mae Ping watershed sites classification

Three groups of sites were generated. Figure 4.40 shows a dendrogram of the classification to level 2. At the level 1 division, the indicator species was represented by *Leptocerus chiangmaiensis* which separated Gp1 (P51 and P52) from the other groups. The remaining sites fall into two groups with *Cheumatopsyche charites* asthe indicator species. Gp1 consisted ofsites P42 and P43 while Gp2 consisted of sites P11, P12, P21, P22, P31 and P32. Three groups ordination of sites was shown in Figure 4.41. Seven Trichoptera species correlated significantly to the second part of Mae Ping watershed sites group, viz. *Rhyacophila suthepensis*, *Cheumatopsyche globosa*, *Psychomyia monto*, *Psychomyia lak*, *Psychomyia kaiya*, *Marilia sumatrana* and *Pseudoleptonema quinquefasciatum* (Figure 4.42). Eleven environmental site variables correlated significantly with the four-dimensional HMDS ordination axes (stress = 0.18) (Figure 4.43).

Mae Rim watershed sites classification

Only one level and two groups of sampling site can be classified by using *Cheumatopsyche charites* as the indicator. Gp1 had 6 sites, R11, R12, R21, R31, R41 and R42. Gp2 had 4 sites, R22, R32, R51 and R52. Dendrogram of the classification was presented in Figure 4.44. Five Trichoptera species correlated significantly to the sampling sites in HMDS ordination axes. These species were *Marilia sumatrana*, *Cheumatopsyche globosa*, *Macrostemum midas*, *Psychomyia lak* and *Psychomyia kaiya*. All these species mostly aggregated together except *Cheumatopsyche globosa*. All three groups were clearly separate. Ten environmental site variables were correlated with ordination with *P*<0.05 as significant. The four-dimensional HMDS ordination result (stress=0.23) is shown in Figures 4.45 to 4.47.

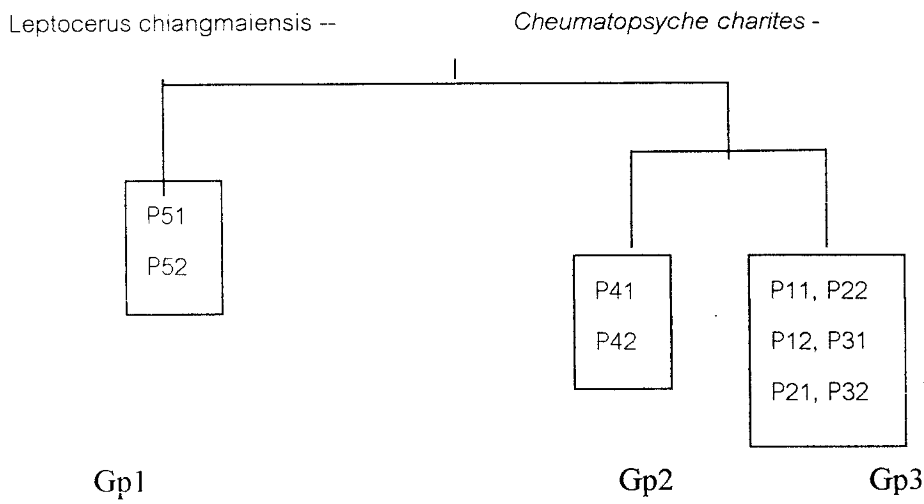


Figure 4.40 TWINSPAN classification of 10 sites in the second part of Mae Ping watershed. Indicator species for each split are listed.

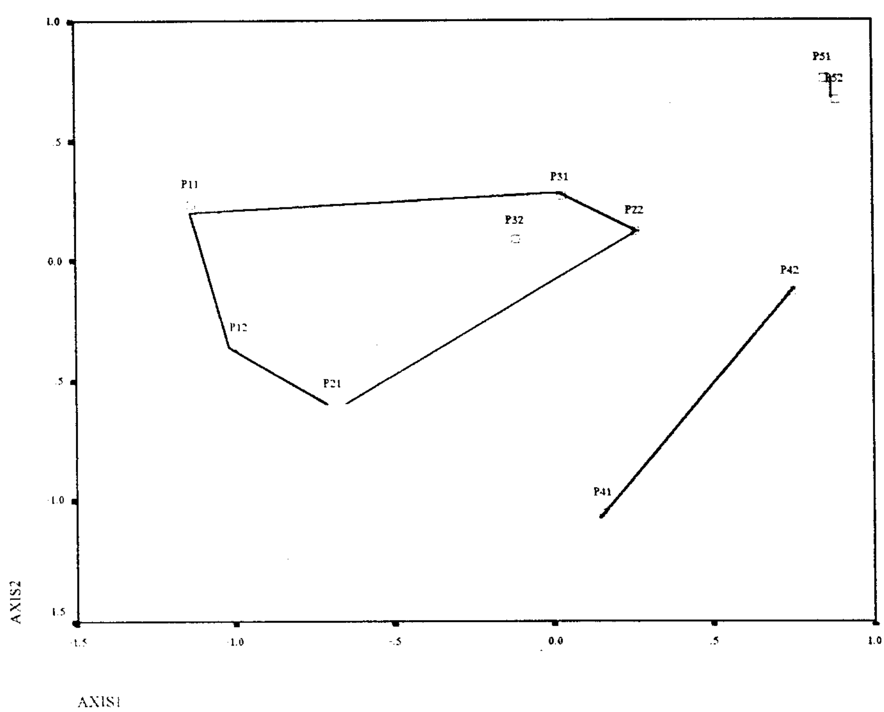


Figure 4.41 Site ordination based on Trichoptera species in the second part of Mae Ping watershed

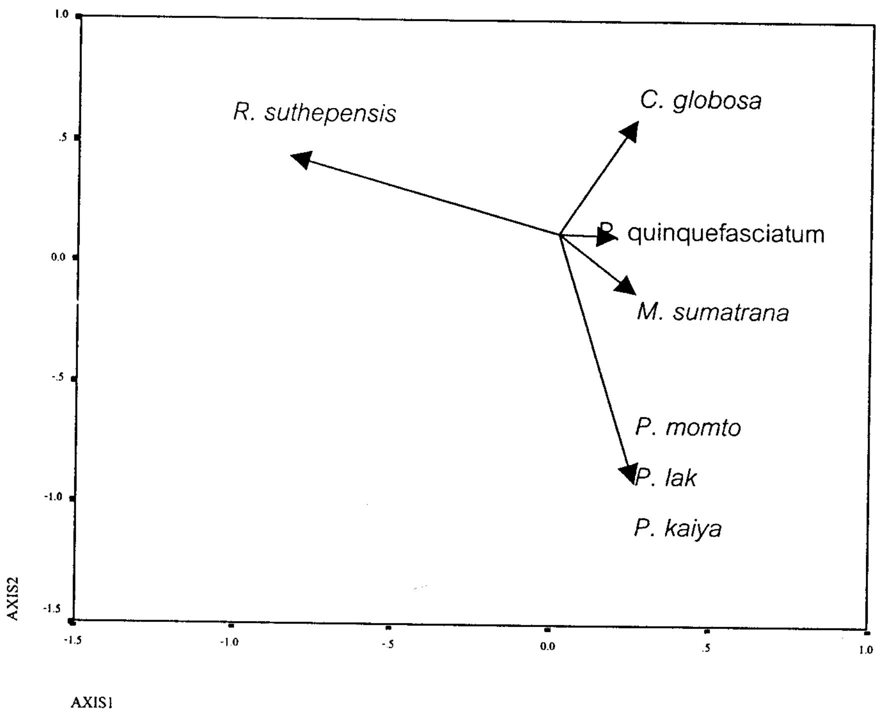


Figure 4. 42 Trichoptera species ordination in the second part of Mae Ping watershed

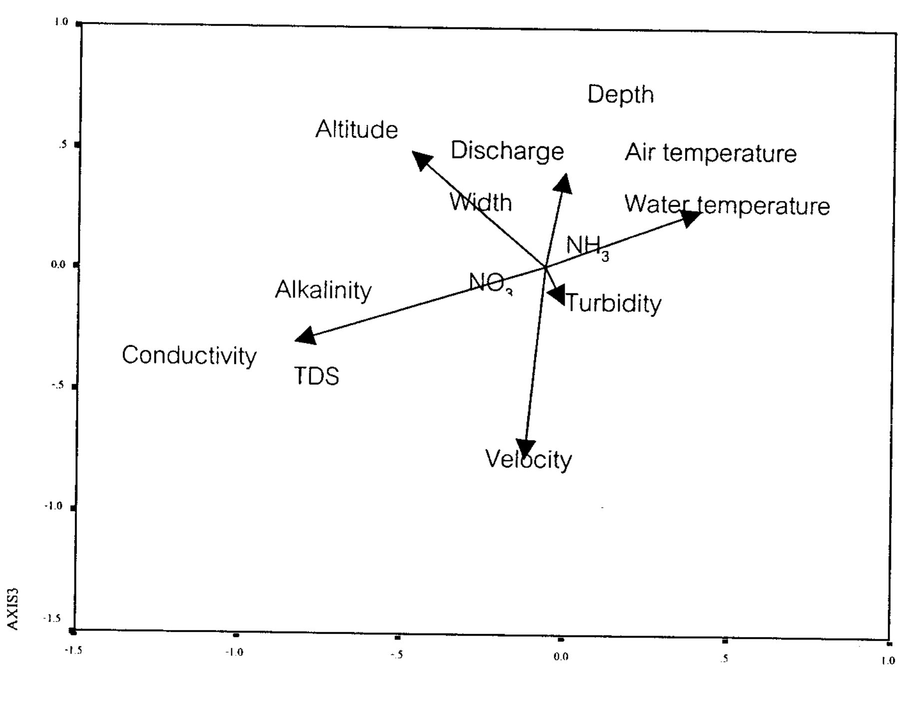


Figure 4. 43 Water quality groups ordination based on site in the second part of Mae Ping watershed

globosa, *Psychomyia monto*, *Psychomyia lak*, *Psychomyia kaiya*, *Marilia sumatrana* and *Pseudoleptonema quinquefasciatum* (Figure 4.42). Eleven environmental site variables correlated significantly with the four-dimensional HMDS ordination axes (stress = 0.18) (Figure 4.43).

Mae Rim watershed sites classification

Only one level and two groups of sampling site can be classified by using *Cheumatopsyche charites* as the indicator. Gp1 had 6 sites, R11, R12, R21, R31, R41 and R42. Gp2 had 4 sites, R22, R32, R51 and R52. Dendrogram of the classification was presented in Figure 4.44. Five Trichoptera species correlated significantly to the sampling sites in HMDS ordination axes. These species were *Marilia sumatrana, Cheumatopsyche globosa, Macrostemum midas*, *Psychomyia lak* and *Psychomyia kaiya.* All these species mostly aggregated together except *Cheumatopsyche globosa.* All three groups were clearly separate. Ten environmental site variables were correlated with ordination with $P<0.05$ as significant. The four-dimensional HMDS ordination result (stress=0.23) is shown in Figures 4.45 to 4.47.

The upper part of Mae Ping watershed sites classification

At the second level, TWINSPAN indicator species were represented by *Dipsodopsis benardi* and *Amphipsyche meridiana* at levels 1 and 2, respectively (Figure 4.48). Three groups were indicated by TWINSPAN analysis. Gp1 consisted of 2 sites in WSC1. Gp2 consisted of 4 sites in WSC 2 and 3 and Gp3 consisted of 4 sites in WSC4 and 5. Three groups can be separated but only Gp3 which sampling sites are WSC1 can be clearly separated. The location of sites in ordination space was shown in Figure 4.49. Gp1 and Gp2 were mostly aggregated together. Five Trichoptera species correlated significantly to ordination (Figure 4.50), viz. *Cheumatopsyche carna* (r=0.95), *Potamyia flavata* (r=0.89), *Hydropsyche camillus* (r=0.88), *Marilia sumatrana* (r=0.84), and *Marilia mogtiana* (r=0.80). The eleven environmental site variables correlated significantly to the HMDS ordination axes in the correlation coefficients of altitude (0.99), conductivity (0.98), air temperature

(0.95), DO (0.96), alkalinity (0.93), TDS (0.91), turbidity (0.90), water temperature (0.87), phosphates (0.86), NO_3 (0.86) and NH_3 (0.84) (Figure 4.51).

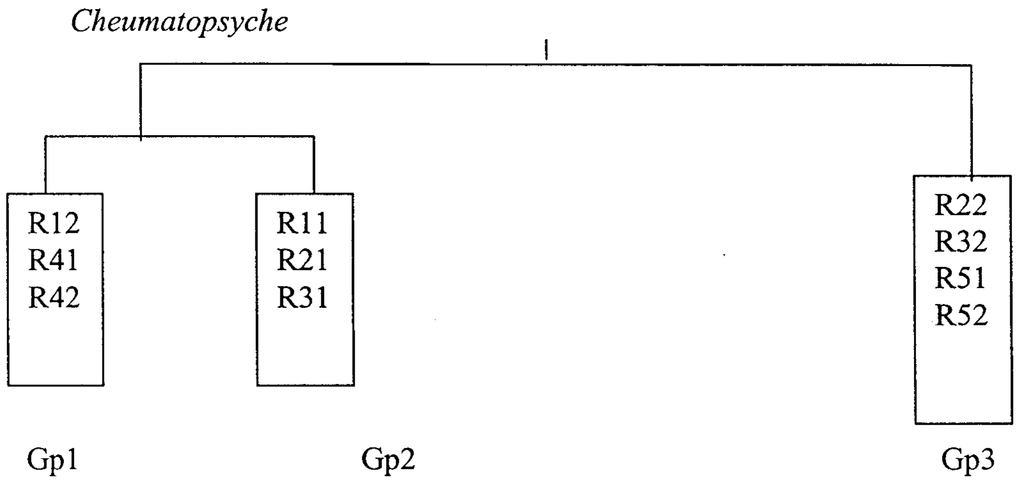


Figure 4.44 TWINSPAN classification of 10 sites in Mae Rim watershed. Indicator species for each split are listed.

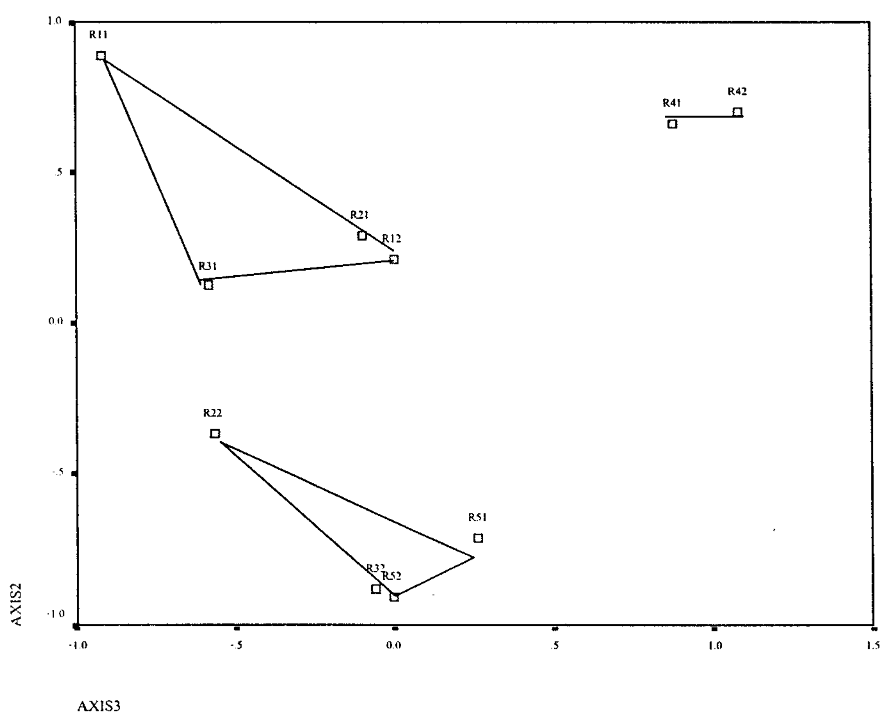


Figure 4.45 Site ordination based on Trichoptera species in Mae Rim watershed.

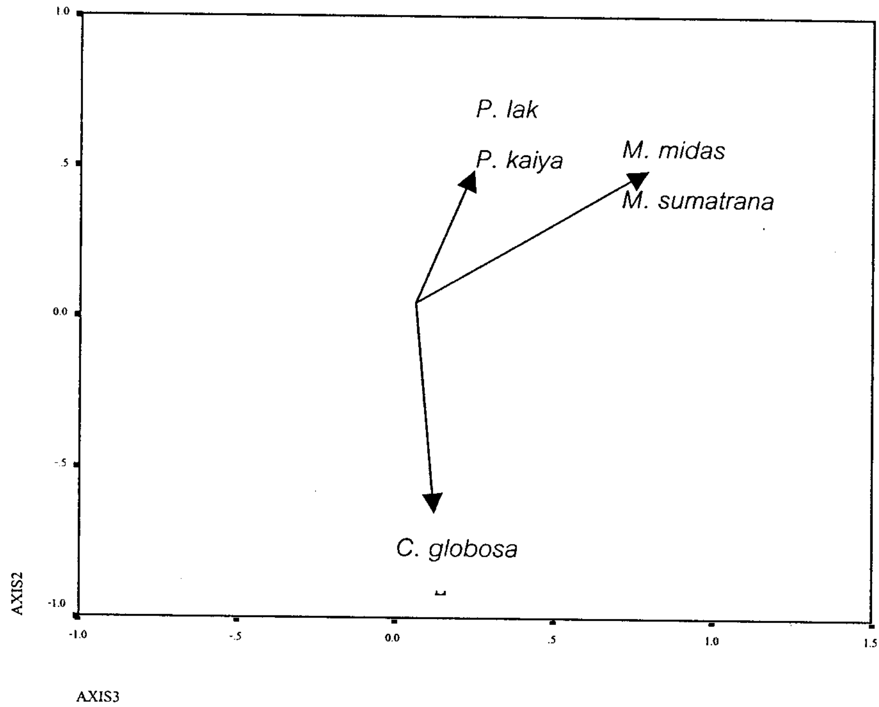


Figure 4. 46 Trichoptera species ordination in Mae Rim watershed.

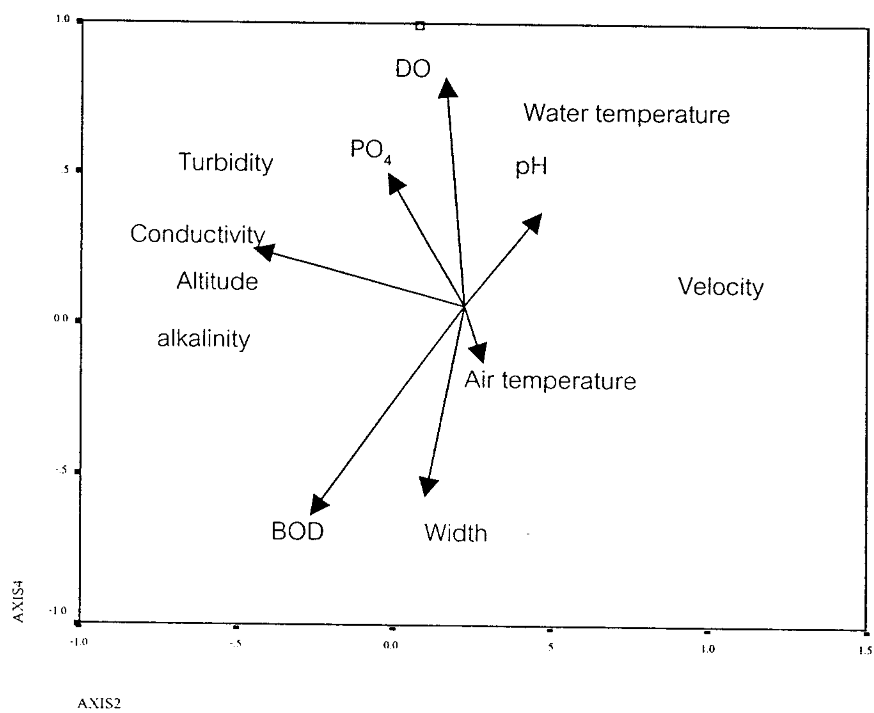


Figure 4. 47 Water quality group ordination based on site in Mae Rim watershed.

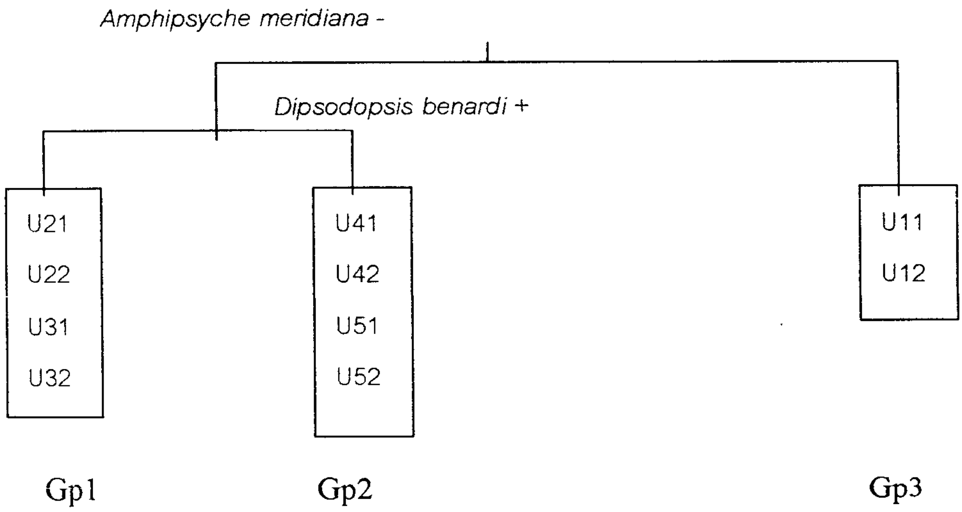


Figure 4.48 TWINSPAN classification of 10 sites in the upper part of Mae Ping watershed. Indicator species for each split are listed.

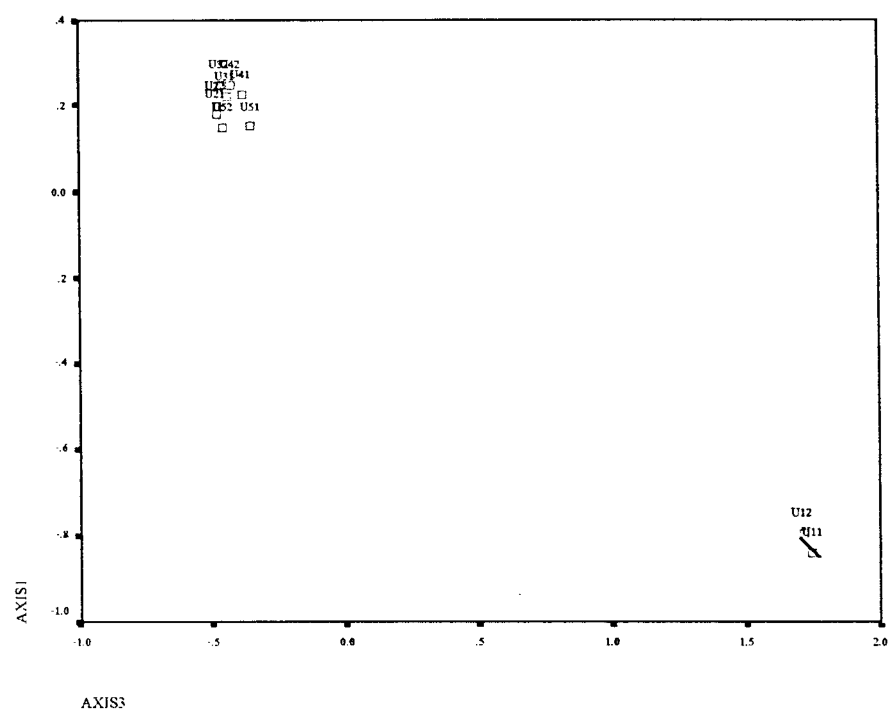


Figure 4.49 Site ordination based on Trichoptera species in the upper part of Mae Ping watershed

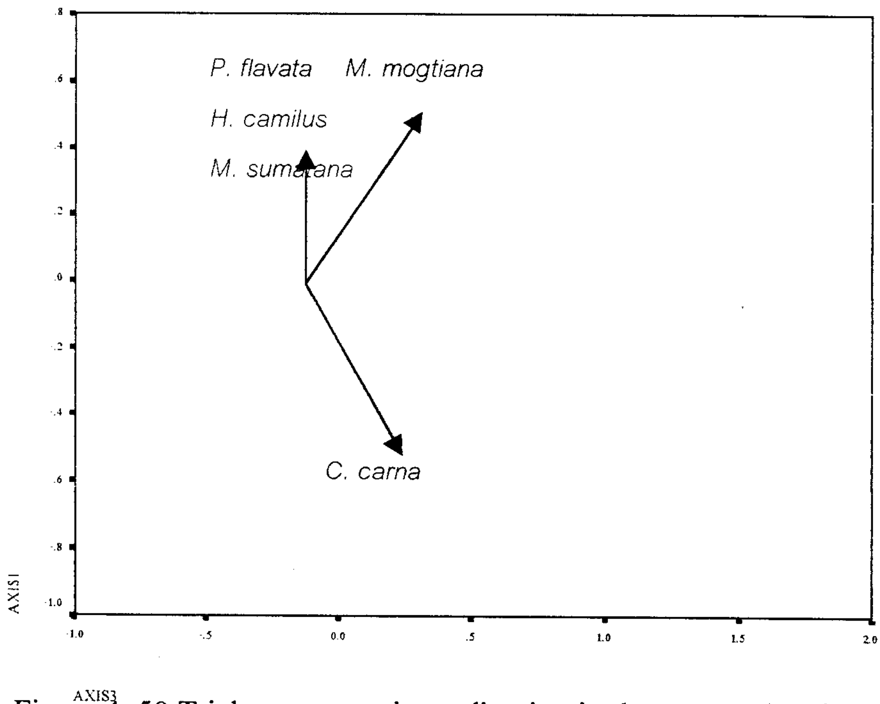


Figure 4. 50 Trichoptera species ordination in the upper part of Mae Ping watershed

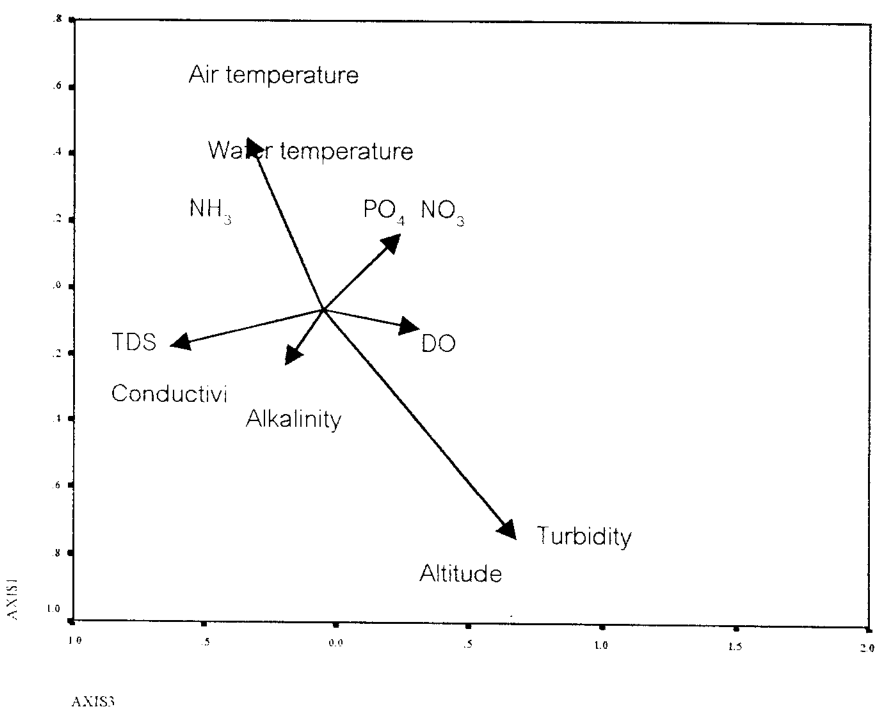


Figure 4. 51 Water quality group ordination based on site in the upper part of Mae Ping watershed

4.2 Trichoptera species diversity in Huai Jo stream

4.2.1 Community structure and distribution in Huai Jo stream

Trichoptera specimens collected were included 6 families, and 32 species (Appendix A). Sixty one percent of the specimens were distributed through Hydropsychidae (61%), Leptoceridae (34%), Psychomyiidae (4%), and Ecnomidae (1%) (Figure 4.52). The number of species and number of individuals of Trichoptera recorded at each of the sites are shown in Figure 4.53. There were relatively more species at M1 (28 species) and M1 (22 species), control sites located above the sewage plant, than M3 (14 species) and M4 (18 species). The numbers of relative individual were high in M3 (1763 specimens) and M4 (1004 specimens) while lower in M1 (1653 specimens) and M2 (1439 specimens). There was no significant difference in numbers of individuals at all sites ($\chi^2_{3,0.05}$=17.667). The number of species at M1 (11.33 ± 3.98) was especially significantly different among sites but M2 (8.83± 3.59) was not significantly different compared to M3 (4.75± 1.422) and M4 (7.58±3.34). The numbers of species at all sites in winter were significantly different from the other seasons while the number of individuals were not significantly different in each season (Table 4.6).

The species that were common to these sites include: *Amphipsyche meridiana* (37.23%), *Cheumatopsyche cognita* (23.06%), *Cheumatopsyche globosa* (14.91%) *Leptocerus chiangmaiensis* (10.77%) *Potamyia flavata* (3.51%) and *Ecnomus votticius* (3.4%), which varies among these sites and seasons.

4.2.2 Physico- chemical water quality parameters in Hui Jo stream

Huai Jo stream is in watershed class 5 of Mae Kuang, and has water quality parameters of in class 3 of the Thai Classification and Surface Water Quality Standard (NEB, 1995), except site bellows treatment plant and receives waste water is in class 4. More details are in Appendix A

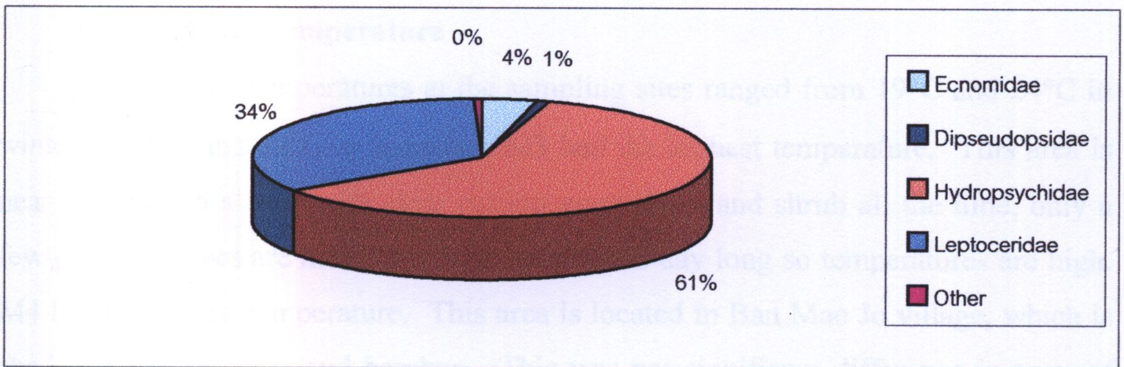


Figure 4.52 Percentage of Trichoptera individuals collected in each family during January to December 2000 in Huai jo stream.

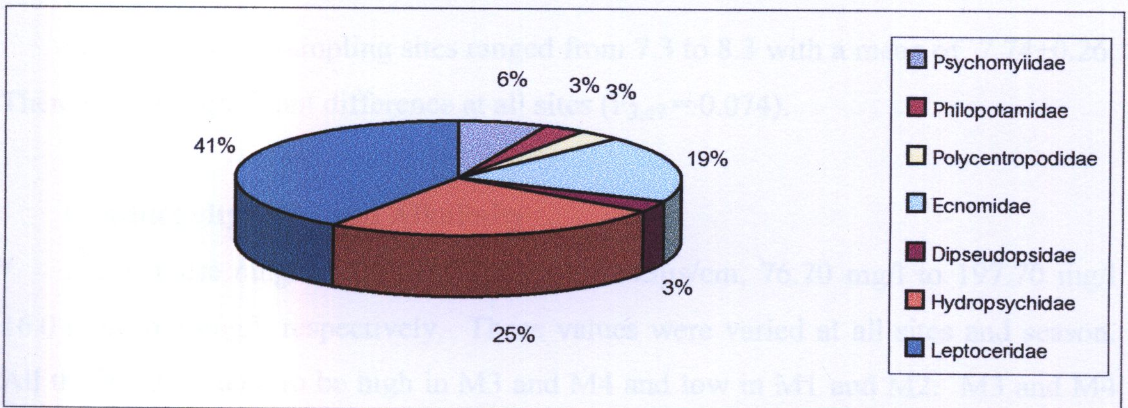


Figure 4.53 Percentage of species richness in each family collected during January to December 2000 in Huai jo stream.

Table 4.7 Number of species of Trichoptera per site and number of individuals per site recorded in each study site between January to December 2000

Study sites	No. of species/site	No. of individuals/site
M1	11.33 ± 3.98	137.58 ± 63.70
M2	8.83± 3.59[ab]	115.83± 59.97
M3	4.75± 1.422[a]	181.58±276.10
M4	7.58±3.34[b]	122.00± 114.33
	$\chi^2_{0.05}$ = 17.667	$\chi^2_{0.05}$ = 2.224,ns

Water and air Temperature

Water and air temperatures at the sampling sites ranged from 19°C and 24°C in winter to 22°C and 28°C in summer. M3 had the highest temperature. This area is near a drain and a road with clear cutting grass, bush and shrub all the time, only a few perennial trees are here. It is often shaded all day long so temperatures are high. M4 had the lowest temperature. This area is located in Ban Mae Jo village, which is shaded with fruit trees and bamboo. This was not significant difference in term of temperatures at all sites.

pH

pH levels at all sampling sites ranged from 7.3 to 8.3 with a mean of 7.74±0.26. There was no significant difference at all sites ($F_{3,47} = 0.074$).

Conductivity, TDS and Alkalinity

All of these ranged from 83.70μs/cm to 243μs/cm, 76.70 mg/l to 197.70 mg/l 16.0 mg/l to 38mg/l, respectively. These values were varied at all sites and season. All these values tend to be high in M3 and M4 and low in M1 and M2. M3 and M4 received sewage, which is high in dissolved solids, such as phosphates, chlorides and nitrates. The values for conductivity, TDS and alkalinity at the sampling sites viz. M1, M2, M3 and M4 were 156.67±40.41μs/cm, 78.38± 20.43 Mg/l and 22.33±4.81 mg/l; 160.08±45.24μs/cm, 80.40±22.27mg/l and 23.17±5.75g/l; 170.57±41.23μs/cm, 85.38±20.75 mg/l and 26.08±7.59 mg/l; 174.56±40.18 μs/cm, 87.41±20.14 mg/l and 24.67±6.42. mg/l ,respectively. There was not significant difference between sites with conductivity and TDS. Alkalinity in M4 was significantly different from the other sites in winter and rainy ($F_{3,4}=1.529$, $P<0.05$; $F_{3,4}= 0.136$, $P<0.05$).

Nutrients

Nutrients were higher in M3 than at the other sites, phosphate = 0.4283±0.26 mg/l, nitrate = 0.9667±0.1969 mg/l and ammonia = 0.8983 ± 0.6380mg/l, especially in winter and summer. This was due to more eutrophic conditions from a sewage drainage canal that flowed adjacent to the stream. The canal enriched the lower part of stream enriched with organic waste matter, especially phosphates and filth. There was very little difference in the nutrient level at M1 (PO_4 = 0.3117±0.11 mg/l, NO_3 = 0.9667±0.33 mg/l and NH_3 = 0.4458 ± 0. 08mg/l,), M2 (PO_4 = 0.3208±0.29 mg/l, NO_3 = 0.9167±0.22 mg/l and NH_3 = 0.4200 ± 0. 08mg/l. M3 was significant different from the other sites in nitrates ($\chi^2_{3,0.05}$± 2.22) and ammonia ($\chi^2_{3,0.05}$± 15.56).

DO

M4 was lowest in DO (6.62±1.14mg\l) compared to the other sites, ranging from 4.40 mg/l in winter to 7.80 mg/l in rainy season, because it is below treatment and past through Mae Jo village before merging with Mae Kal river (a Mae Kuang River tributary). The urban wastes flow into this stream. M3 was not low in DO although it had just received the water from the drain. There is a big pond and aeration from the concrete dike before the water effluence from the university. Although DO in M1 (7.47 ±0.62mg\l) and M2 (7.42±0.65 mg/l) were higher than DO in M3 (6.95± 1.08mg\l) and M4 (6.62±1.14mg\l). There was no significant difference between sites with DO ($\chi^2_{3,0.05}$± 6.239).

Turbidity

Turbidity was higher at M1 (101 ± 124.19) and M2 (87.83±97.33) than M3 (78.41±40.49) and M4 (80.25±67.47), especially in the rainy season. In July turbidity was highest at 487 FTU in M1 and 389 FTU in M2. This first reason was it just beginning in rainy season and around this area is the flower garden and paddy field. The second reason was study activity for clearing and cutting the grass, bush and shrub for by new study before a new academic year. By these reasons, there was erosion and runoff into the stream with high in turbidity but at M3 and M4 was not so high only 184 and 285 FTU were found at M3 and M4. M3 and M4 were lower than M1 and M4 because there was a pond to storage the water before water effluence from the university. However there was not significant difference between sites with turbidity level ($\chi^2_{3,0.05}$ = 6.239).

Table 4.8 Comparison of the mean environmental variables for along Huai Jo stream

Water parameter	M1	M2	M3	M4	Statistics
water temperature (°C)	22.08±1.84	22.12 ±1.83	22.29 ± 1.99	21.8 ± 2.13	$F_{3,47}$ = .126,ns
Air temperature (°C)	24.22 ± 2.21	24.12 ± 2.1	24.4 ± 2.1	24.35 ± 2.18	$F_{3,47}$ = 0.044,ns
pH	7.73 ± .227	7.72 ±.29	7.74 ±.34	7.78 ± .33	$F_{3,47}$ = 0.074,ns
Conductivity (µs/cm)	156.67 ± 40.41	160.08 ± 45.23	170.56 ± 41.23	174.56 ± 40.18	$F_{3,47}$ = 0.492,ns
TDS (mg/L)	78.38 ±20.43	80.40 ± 22.27	85.38 ± 20.74	87.40 ± 20.14	$F_{3,47}$ = 0.486,ns
PO4 (PPM)	.311 ±0.13	0.32 ± 0.24	0.43 ± 0.26	0.39 ± 0.22	$\chi_{3,0.05}$ =2.248
NO3 – N (PPM)	0.97 ± 0.34	0.92 ± 0.23	0.97 ± 0.19[a]	0.99 ± 0.21	$\chi_{3,0.05}$=2.218
NH3 – N (PPM)	0.45 ± 0.02	0.42 ± 0.02	0.89 ± 0.64[a]	0.75 ± 0.77	$X^2_{3,0.05}$ = 15.56
Turbidity (FTU)	101.25 ±124	87.83 ± 97.39	78.41 ± 40.49	80.25 ± 67.47	$X^2_{3,0.05}$ = .675
Alkalinity (mg/L)	22.33 ± 4.81	23.17 ±5.73	26.08 ± 2.19	24.67 ± 6.42	$F_{3,47}$ = 0.850
DO (mg/L)	7.48 ± 0.62	7.42 ± 0.65	6.9 ± 1.08	6.62 ± 1.15	$X^2_{3,0.05}$ = 6.239
BOD_5 (mg/L)	2.19 ± 2.73	2.31 ± 2.97	5.96 ± 4.23[a]	3.36 ± 2.68	$X^2_{3,0.05}$ = 11.802
Width (m)	3.41 ± .59	3.44 ± .55	3.01 ±.59	3.65 ± .77	$X^2_{3,0.05}$ = 2.484,ns
Depth (m)	.16 ± 0.07[a]	.27 ± 0.13	0.36 ± 0.12	0.21 ± 0.08[b]	$F_{3,47}$ = 2.12,ns
Velocity (m/sec)	0.32 ± 0.12	0.31 ± 0.11	0.28 ± 0.09	0.28 ± 0.11	$X^2_{3,0.05}$ =1.775ns

Note: A difference letter in the same horizontal row indicates significantly difference P<0.05

- statistical value; F- value by ANOVA , χ^2 value by Kruskall – Wallis test
- NS mean not significant

BOD_5

BOD_5 was highest at M3 (5.97 ±4.23 mg/l) and lowest at M1 (2.11±2.77 mg/l). Sites M3 was significantly difference from the other sites ($\chi^2_{3,0.05}$ =11.802).

Depth, width and velocity

M3 and M4 were different in depth from M1 and M2. Site M3 was deepest, ranging from 0.30 m in winter to 0.73 m in rainy season. Width and velocity were not significantly different.

4.2.3 Site Classification in Huai Jo stream

Two way indicator species analysis (TWINSPAN) can be separated the 4 sites into groups by using five pseudo species cut levels for each species which pseudo species cut levels (0,2,5,10,20). Dendrograms from the TWINSPAN analyses are shown in Figure 4.54. Two big groups of sites were generated at 3 level. The first division of the classification separated all M3 sites samples from the other sampling occasion (Figure 4.55). This indicated that the Trichoptera community at this site differed from those at the other sites throughout this study. From Figures 4.56-4.57, show three axes which were used to arrange the sampling sites and Trichoptera species association (stress =0.07). Seven species indicators were correlated with ordination, ($p<0.05$ as significant), viz. *Amphipsyche meridiana*(r=0.864), *Cheumatopsyche cognita* (r=0.902), *Cheumatopsyche globosa*(r=0.840), *Potamyia flavata*(r=0.849), *Leptocerus chiangmaiensis* (r=0.9) and *Leptocerus dirghachuka* (r=0.740) *Leptocerus lumpunensis* (r=0.762). *Amphipsyche meridiana* was the only one species that was significant and had correlation with M3 ordination. The other species were significant and correlated with M1 and M2.

Water qualities in all four sites along Huai Jo stream were not were not significantly different from each other, except with BOD_5 and NH_4-N (Table 4.8). The level of BOD_5 was reduced from 2.19±2.73 to 5.96±4.3 mg/l and that of NH_4-N from 0.45±0.02 to 0.89±0.64 mg/l. This change is reflected in a decrease in the number of the other species and an increase in *Amphipsyche meridiana*, which is the most dominant species, thought out this area. When we plot only species significant abundance on a graph. There is a difference in the abundance of seven species indicators, which varies in three seasons. From the results *Amphipsyche meridiana* had the highest abundance at M3 in each season (Figure 4.58) which has high correlation significance ($P< 0.05$) with NO_3, turbidity, alkalinity, air temperature and correlated significantly with PO_4 at $P<0.05$. *Cheumatopsyche cognita* was varied in seasonal also, but was more abundant at M1 and M2 than at M3 and M4 and had high correlation significance with turbidity and NO_3-N and NH_4-N. The other species occurred in every season, but were more abundant in summer and the rainy season than in winter, especially at M1 and M2. M3 and M4 had less abundance and richness than M1 and M2.

Twelve environmental variables were significantly arranged in the same way in three ordination spaces (stress 0.22, Figures 4.56). The environmental variables that were significantly correlated with the ordination were conductivity, TDS, dissolved oxygen, air temperature, water temperature, turbidity, alkalinity, depth, width, BOD_5, velocity, and pH.

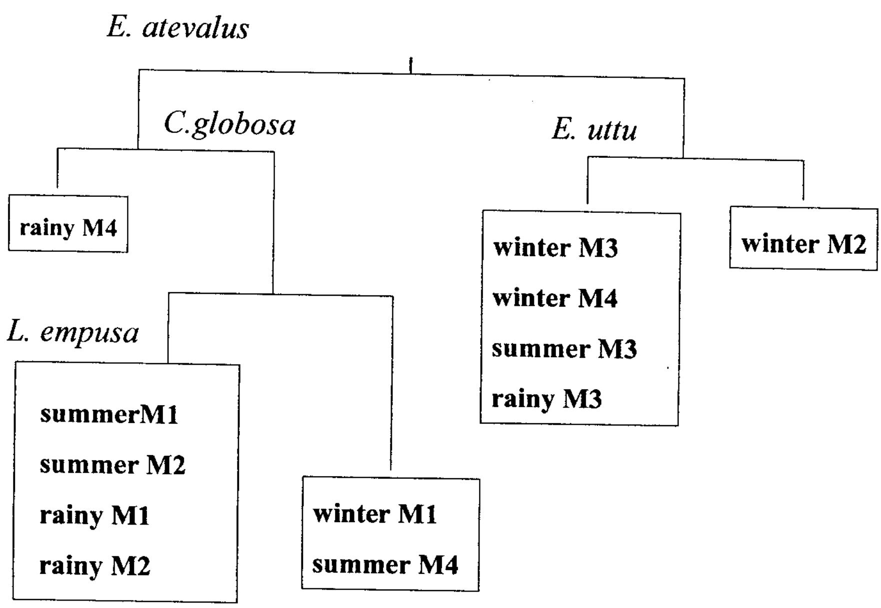


Figure 4.54 TWINSPAN classification of Huai Jo stream

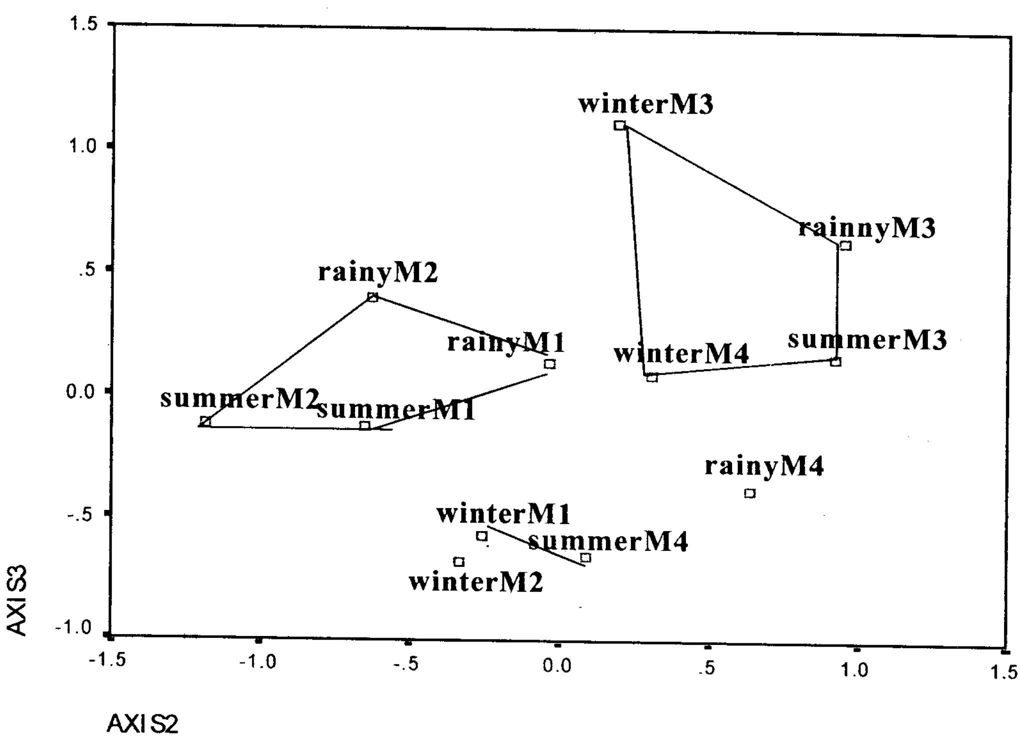


Figure 4.55 HMDS ordination of Huai Jo stream

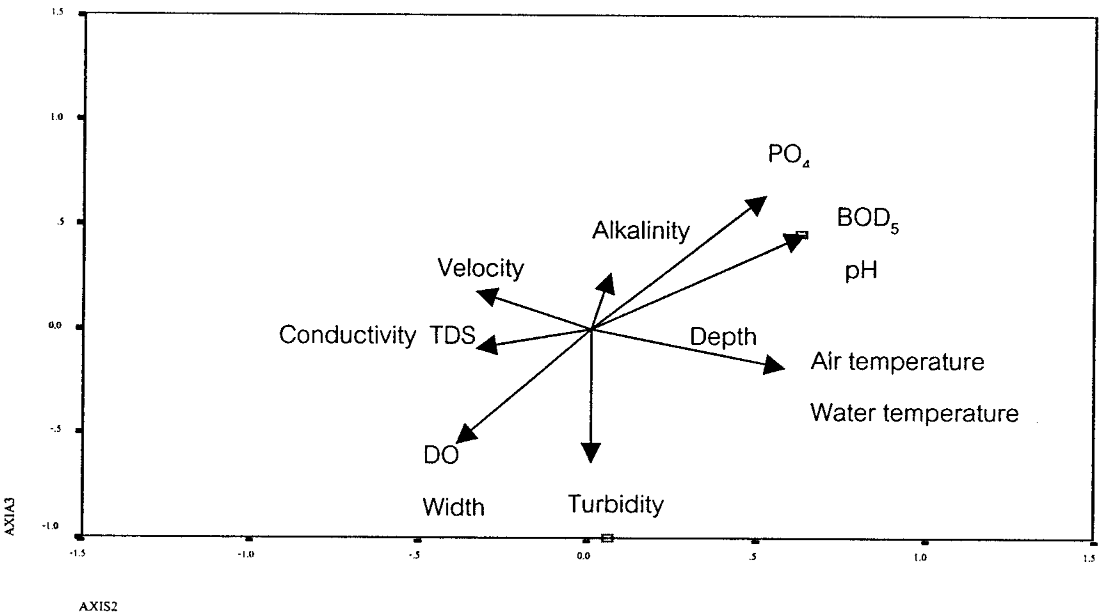


Figure 4.56 HMDS ordination of water quality at Huai Jo steam

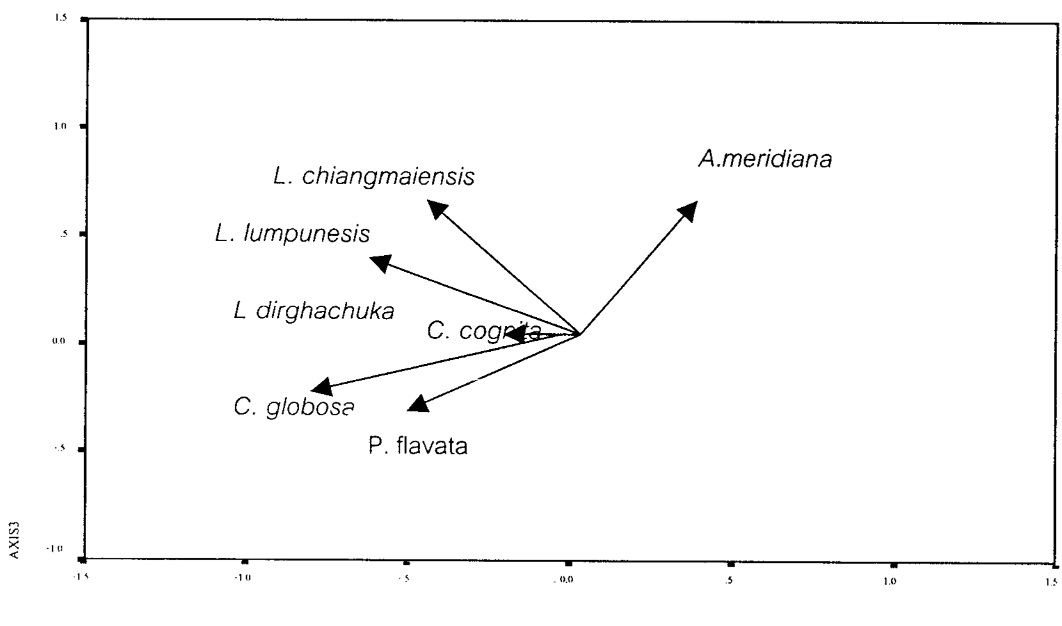


Figure 4.57 HMDS ordination of Trichoptera indicator species at Huai Jo stream

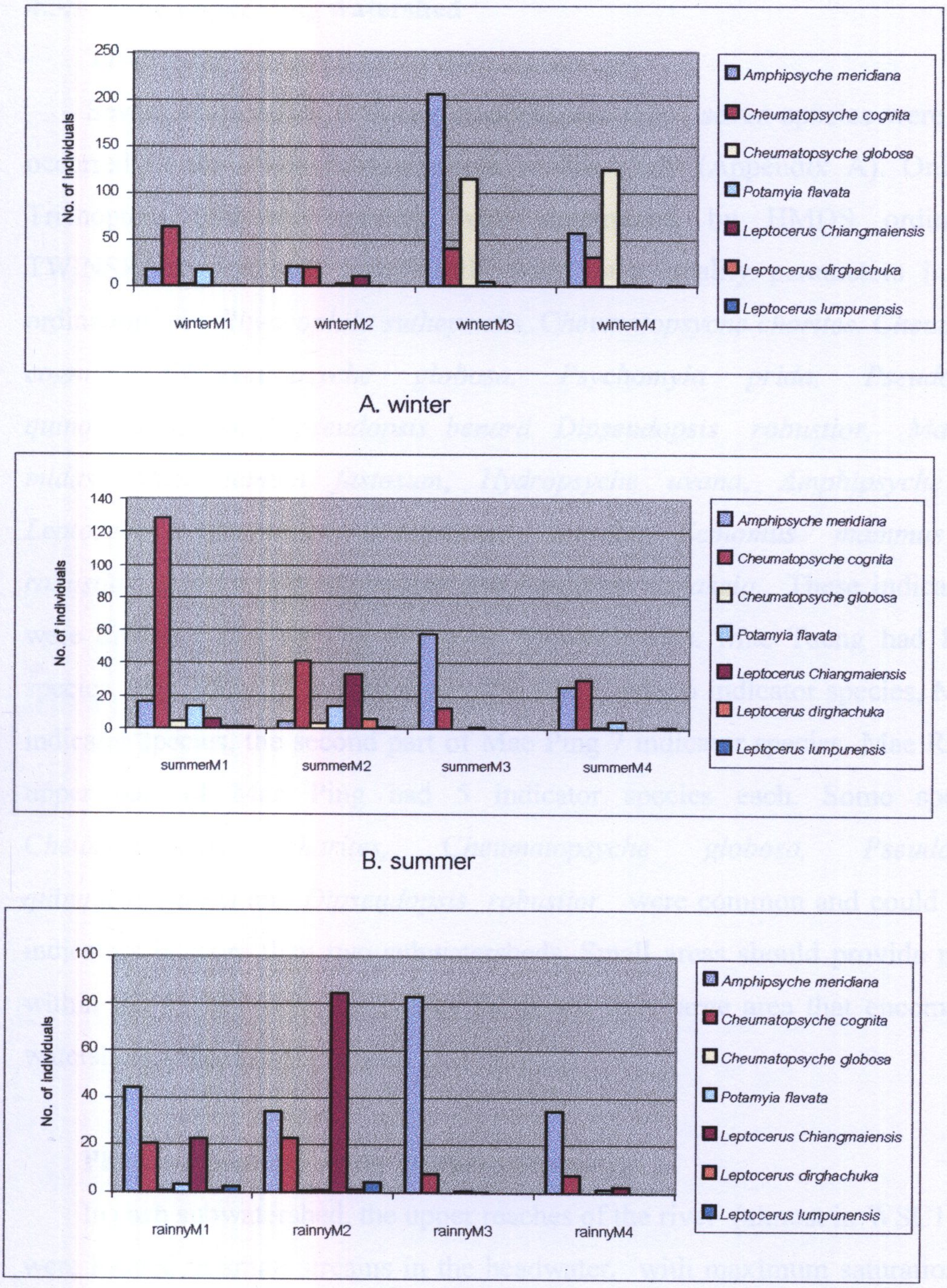


Figure 4.5 **Trichptera significance species and their abundance in each season.**
A. winter B. summer C. rainy season

4.3 Trichoptera species and their relation to water quality parameters

4.3.1 The upper Ping watershed

Trichoptera structure and distribution

Seventeen families with two hundred and thirty seven species were found and occurred in the seven subwatersheds in this study (Appendix A). Only eighteen Trichoptera indicator species, were determined by HMDS ordination and TWINSPAN correlated significantly with water quality parameters in the same ordination, viz. *Rhyacophila suthepensis, Cheumatopsyche charites, Cheumatopsyche cognita, Cheumatopsyche globosa, Psychomyia prida, Pseudoleptonema quinquefasciatum, Dipseudopsis benard, Dipseudopsis robustior, Macrostemum midas, Macrostemum fastosum, Hydropsyche uvana, Amphipsyche gratiosa, Leptocerus chiangmaiensis, Ecmomus atevalus, Ecmomus mammus Ecmomus robustior, Setodes argentiguttatus and Potamyia panakeia.* These indicator species were different and vary in all seven subwatersheds. Mae Taeng had 8 indicator species, Mae Khan 12 indicator species, Mae Kuang 6 indicator species, Mae Ngat 9 indicator species, the second part of Mae Ping 7 indicator species, Mae Rim and the upper part of Mae Ping had 5 indicator species each. Some species, viz. *Cheumatopsyche charites, Cheumatopsyche globosa, Pseudoleptonema quinquefasciatum* and *Dipseudopsis robustior,* were common and could be used as indicators in more than two subwatersheds. Small areas should provide more detail within the limited area which they are based than large area that encompass many watersheds (Marchant, 1999).

Physico-chemical water quality parameters

In each subwatershed, the upper reaches of the river (almost in WSC1 to WSC2) were located in small streams in the headwater, with maximum saturation levels of dissolved oxygen, minimal organic load, and low levels of BOD_5 which intervention by man was minimal, showed a diversified benthic fauna with a predominance of Trichoptera. The lower sites on each subwatershed were located in main streams (WSC 3 to WSC5). The diversity of Trichoptera and species richness declined as a result of the increase in organic pollution from discharge of domestic and industrials wastes. The average air and water temperatures in the upper Ping watershed were 22.6 ±1.49 °C and 22.05± 1.51 °C, respectively. Mae Rim watershed had the lowest temperature, while the upper part of Mae Ping had the highest. Mae Taeng (181.33 ± 40.22 FTU) was highest in turbidity and the second part of Mae Ping (22.30±10.48 FTU) was the lowest. Mae Taeng had high turbidity from soil erosion and surface runoff because of the shifting cultivation by hill tribes. The average DO level at all sites ranged from 4.95 to 8.4 mg/l with a mean of 7.42±0.76 mg/l. It was the lowest in Mae Khan watershed. BOD_5 ranged from 3.11±3.70 mg/l in Mae Khan to 1.12 ± 0.48 mg/l in Mae Taeng. All BOD_5 levels in these areas were of the Thai standard class 2 (BOD≥1.5mg/l), except Mae Khan which was in Class 3 (NEB, 1995. Nitrates were low in every subwatersheds, but ammonia levels were high at Mae Ngat (0.63± 0.27 mg/l) and Mae Taeng (0.56±0.01mg/l). From the study the water quality in the upper Ping watershed is still in the Thai standard criteria. These species also correlated significantly to the water quality parameter variables by HMDS ordination. The correlation of 18 indicator species found in all seven 7 subwatersheds and water quality variables were tested by bivariate (Pearson correlation coefficients).

Sensitive and tolerant groups of indicator species

The results of PCC and HMDS ordination 4 groups of sites were generated based on Trichoptera species while the watersheds had 5 classes. Although the environment was changed from forest and headwater in Group 4 to mixing land use in Group 3, 2 and urbanization and agriculture in Group 1, but habitats and environmental surroundings in the middle of watershed classes (2, 3 and 4) were not clearly difference from each other. From the study only Group 1 and Group 4 were clearly different from each other. The number of species declined from 22.37±12.01 in Group 4 to Group 3 and 1, respectively, except Group 2 the number of species were highest (23.40±4.95). Group 2 was ecotone from changing highland to lowland, which consisted of many types of habitat so there was species highest (Kay *et al.*, 1999). However from the study the number of species were correlated with percent of canopy that the same as Cleanghan *et a*l. (1998) that found macroinvertebrate diversity and evenness trends to increase primarily with increases in the amount of deciduous cover of the stream. This may be because most macroinvertebrate species tolerate some shading, but since few famous a heavy degree of shading. However, relatively shaded sites under agricultural influence (such as Ban Mae Ram Noi (R41), Ban Lao Saen Tong (KH42) and Ban Om Long (KH32)) had low Trichoptera diversity, suggesting that effected of shading on invertebrate diversity and evenness may only be obvious at relatively oligotrophic sites (Cleanghan *et a*l., 1998). Intensive agricultural land use produces modifications, which reduce the variety of species richness (Dance and Hynes, 1980). Richness of aquatic insects decreases with increasing urbanization (Jones and Clark, 1987) because of organic residual loading (Navia *et al*., 1997).

The indicator species for Group 1 were *Cheumatopsyche cognita, Cheumatopsyche globosa, Dipseudopsis robustior,* Leptocerus *chiangmaiensis, Ecmomus atevalus, Ecmomus mammus, Setodes argentiguttatus and Potamyia flavata.* The indicator species for Group 2 were *Cheumatopsyche charites, Psychomyia prida, Pseudoleptonema quinquefasciatum, Dipseudopsis benardi, Amphipsyche gratiosa, Ecmomus robustior, Setodes argentiguttatus and Potamyi panakdi.* The indicator species for Group 3 were *Macrostemum midas Hydropsyche uvana* and *Potamyia flavata.* The indicator species for Group 4 were *Rhyacophila suthepensis* and *Macrostemum fastosum.*

There was a clear tendency for levels of nitrate, ammonia, phosphates, BOD_5 turbidity, air and water temperatures to increase with distance downstream. The results of PCC and HMDS ordination are summarized in Table 4.9 for species having a high correlation in the ordination. Positive and negative correlation based on Pearson product moment correlation coefficients between species data and environmental variables are given in Table 4.9. *Cheumatopsyche cognita was* negative with DO and positive with BOD_5. *Ecnomus mammus* was negative with DO. *Leptocerus chiangmaiensis* was positive with NO_3, NH_3 and alkalinity. *Cheumatopsyche charite was* positive to pH. These species were more tolerant to organic pollution and can survive in polluted water. *Rhyacophila suthepensis* was positive with DO and altitude, but negative with BOD_5. *Macrostemum midas was* positive with DO while *Macrostemum fastisum was* negative with conductivity and

Table 4. 9 Pearson product moment correlation between indicator species and environmental variables in the upper Ping watershed

Species name	Air Temp	Water Temp	pH	Con	TDS	PO_4	NO_3	NH_3	Turbidity	Alkalinity	DO	BOD_5	Width	Depth	Velocity	Discharge	Altitude
C. charites			+														
C. cognita	++	++									-	+	+	++	++	+	+
M. fastosum				-	-												
P. phaida																	
D. robustior																	
C. globosa	+																
M. midas											+						
L. chiangmaien	++	++					+	+		+			++	++		+	
A. gratiosa	+	+												+			+
R.suthepensis											+	-					
E. atevalua	++	++											++	++			
E. mammus	++	++									-		++	++			
E. robustior			+						+		++						
H. uvana	-	-					+	-									
D. benardi	++	+											++	++			
S. argentiguttat																	
P. panakeia						+			+		+						
P. quinquefasci																	

Note : ++ = positive significantly correlated at $P < 0.01$; -- = negative significantly correlated at $P < 0.01$
\+ = positive significantly correlated at $P < 0.05$; - = negative significantly correlated at $P < 0.05$

TDS. *Hydropsyche uvana* was negative with temperature and NH3, but positive with NO_3. All these species lived in clean water, and were in Groups 3 and 4 which are located in highlands with temperatures cooler. Ten species of Rhyacophilidae were found in this study with only 225 specimens. All of them were found in the highlands, and were never found in urban rivers polluted with raw sewage. The remaining species were found in the lower parts of the river with high BOD_5 and nutrients. These species correlated significantly with ordination in Groups 1 and 2.

For the results, it should be noted that 64.11% of the indicator species belong to Hydropsyche, which ranked very differently to pollution from highly tolerance polluted to less pollute. The Hydropsychidae family were very different ranking of some species on the organic pollution gradient (Dohet, 2002). For these reasons, the species-level identifications are necessary in ascertaining water quality tolerances. For accurate ecological predictions, species-level identifications have to be made (DeMoor, 1999). However the certain taxonomic to the species levels are time-consumering so selected species on indicator species were used.

4.3.2 Huat Jo stream (draining a sewage plant)

Trichoptera structure and distribution

Trichopteras specimens collected included 6 families and 32 species. Seven indicators species were correlated with ordination, ($P<0.05$ as significant), viz. *Amphipsyche meridiana, Cheumatopsyche cognita, Cheumatopsyche globosa, Potamyia flavata, Leptocerus chiangmaiensis, Leptocerus dirghachuka* and *Leptocerus lumpunensis*in. These were common species and varied among these sites and seasons. M1 and M2, which were the control sites, were high in species richness with 28 and 22 species. M3, which was polluted with sewage, was low in species richness, with only 14 species found during this study. Eighteen species were found in M4, which was non-recovery from the sewage. In accordance, Reddy & Rao (1991) reported that domestic sewage pollution reduced the number of taxa and indicated that better water quality when species richness increased (Yasuno, 1991).

Physico-chemical water quality parameterrs

Nutrients were high in this area. M1, PO_4 = 0.3117±0.11 mg/l, NO_3 = 0.9667± 0.33 mg/l and NH_3 = 0.4458 ± 0.08 mg/l. M2, PO4 = 0.3208±0.29 mg/l, NO_3 = 0.9167±0.22 mg/l and NH_3 = 0.4200 ± 0. 08mg/l. M3, PO_4 = 0.4283±0.26 mg/l, NO_3 = 0.9667±0.1969 mg/l and NH_3 = 0.8983 ± 0. 6380 mg/l. M4, PO4 = 0.39± 0.22 mg/l, NO_3 = 0.99±0.21mg/l and NH_3 = 0.75 ± 0. 77 mg/l. Nutrient levels in this area are high but still criteria in the Thai standard. BOD_5 levels in this area were in class 3 of the Thai standard (BOD≥2.0 mg/l), only M3 was in class 4. The other water quality parameters were moderate in values. The species were also correlated significantly to these water quality parameter variables by HMDS ordination. Seven indicator species were correlated. Thirteen water quality parameters were correlated with ordination ($P<0.05$ as significant).

Sensitive and tolerant groups of indicator species

The results of PCC and HMDS ordination together with the correlation based on Pearson analysis between species data and environmental variables indicated that tolerant indicator species were *Cheumatopsyche cognate, Ecnomus mammus Leptocerus chiangmaiensiss,* C*heumatopsyche globosa,, Potamyia panakeia and Amphipsyche meridiana.* Sensitive indicator species included: *Riyacophila suthepensis, Macrostemum midas, Macrostemum fastosum* and *Hydropsyche uvana Amphipsyche meridiana* was the only species that had significant correlation with M3 which receives water directly from the drainage, *Amphipsyche meridiana* was negative with NO_3 and positive with nitrates, turbidity and alkalinity. It is tolerant to domestic waste. *Amphipsyche meridiana* was a tolerant species that can be used as indicator species in Ping river (Chaibu, 2000) and appeared only after the post-flooding period (Inmoung, 1998). Correlation based on Pearson product moment correlation coefficients between species data and environmental variables are given in Table 4.10. *Cheumatopsyche cognita* was positive in correlation with temperature, NO_3, NH_3, turbidity but had negative correlation with DO. *Cheumatopsyche globosa* had positive correlation with temperature and negative correlation with pH and conductivity. *Leptocerus chiangmaiensis* had positive correlation with velocity and negative correlation with alkalinity, conductivity and TDS. *Leptocerus lumpunensis* has positive correlation with velocity and negative correlation with pH. *Potamyia flavata* had positive correlation with BOD_5. *Leptocerus dirghachuka* had no significance with water quality parameters.

Table 4.10 Pearson product moment correlation between indicator species and environmental variables in Huai Jo stream

Species name	Air Temp	Water Temp	pH	Con	TDS	PO_4	NO_3	NH_3	Turbidity	Alkalinity	DO	BOD_5	Velocity
A. meridiana	+					+	++		++	++			
C. cognita							+	+	+		-		
C. globosa	+	+	-	-									
P. flavata												+	
L. chiangmaiensis				--	--					--			+
L.dirghachuka													
L. lumuensis			-										+

Note : ++ = positive significantly correlated at $P< 0.01$; -- = negative significantly correlated at $P< 0.01$
+ = positive significantly correlated at $P< 0.05$; - = negative significantly correlated at $P< 0.05$

4.4 New species

25 species were new during this study. Five species were described already, one species was Calamoceridae, *Anisocentropus erichthnios* Malicky and Cheunbarn 2001, and four species were Leptoceridae, *Leptocerus dryade* Malicky and Cheunbarn 2001, *Adicella larentia* Malicky and Cheunbarn 2002, *Ceraclea hera* Malicky and Cheunbarn 2002 and one paratype was *Ceraclea idaia* Malicky and Chaibu 2002, (Figure IV 4.59 to IV 4.63). Twenty species are probably new. Eighteen species were in Leptoceridae (Adicella 5 species, Leptocerus 3 species, Ceraclea 5 species, Triaenodes 1 species, Setodes 3 species), Hydropsyche (Cheumatopsyche 1 species) and unknown 2 species), Male genitalia drawings are shown in Figure1 to 20 (Appendix B)

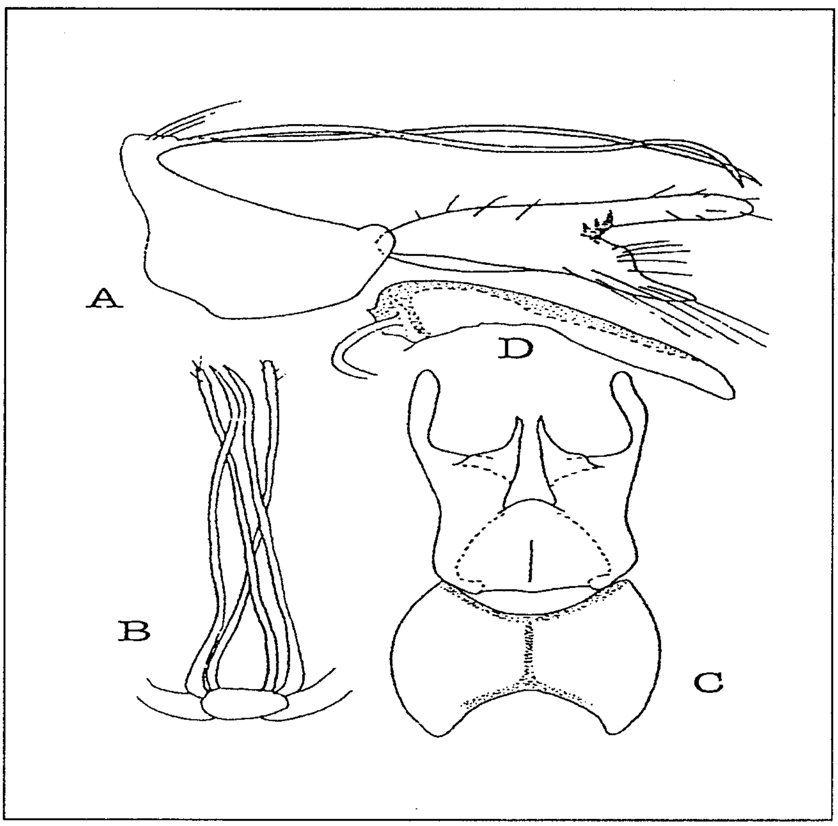


Figure 4.59 Male genitalia of *Leptocerus gryade* Malicky and Cheunbarn 2001
A. genitalia, lateral view B. ventral view C. adeagus, lateral view
D. adeagus, lateral view

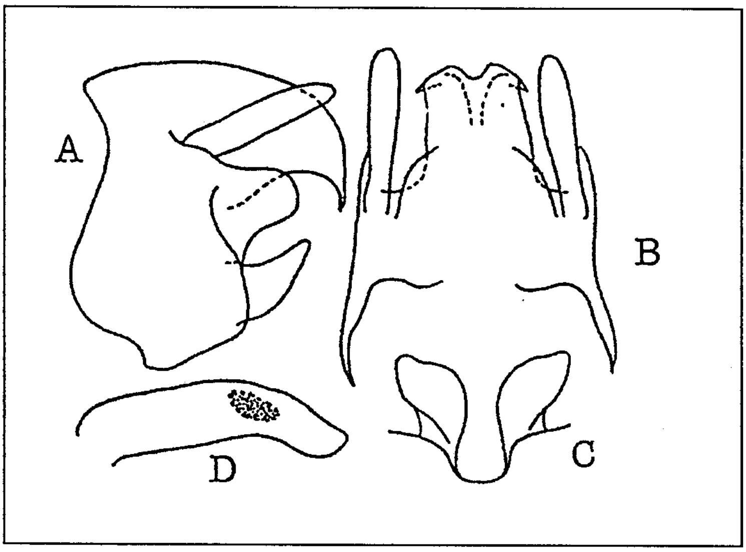


Figure 4.60 Male genitalia of *Anisocentropus erichthnios* Malicky and Cheunbarn 2001 A. genitalia, lateral view B. dorsal view C. ventral view D. adeagus, lateral view

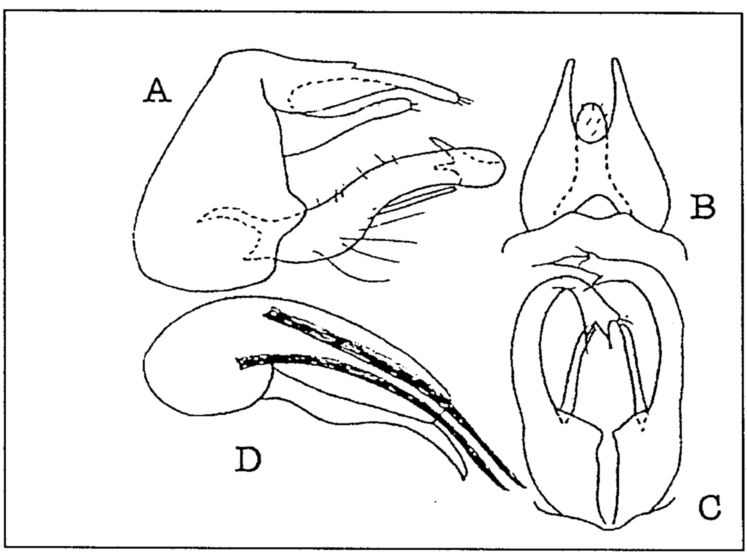


Figure 4.61 Male genitalia of *Ceraclea hera* Malicky and Cheunbarn 2002 genitalia, lateral view B. dorsal view C. ventral view D. adeagus, lateral view

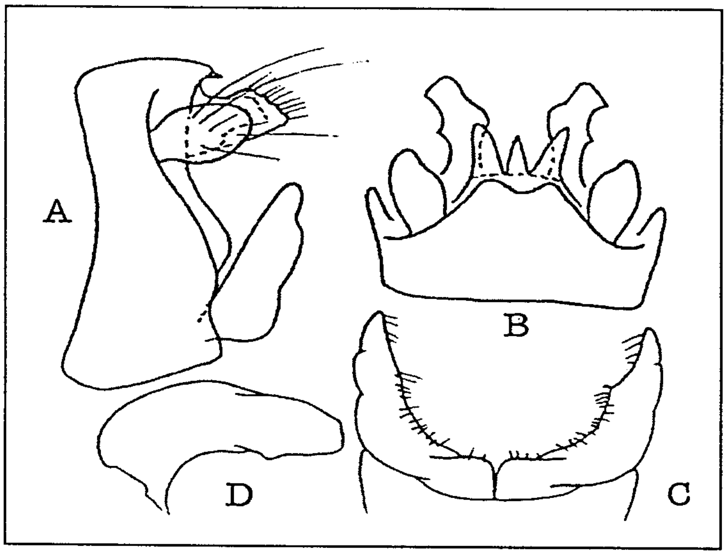


Figure 4.62 Male genitalia of *Adicella larentia* Malicky and Cheunbarn 2002 A. genitalia, lateral view B. dorsal view C. ventral view D. adeagus, lateral view

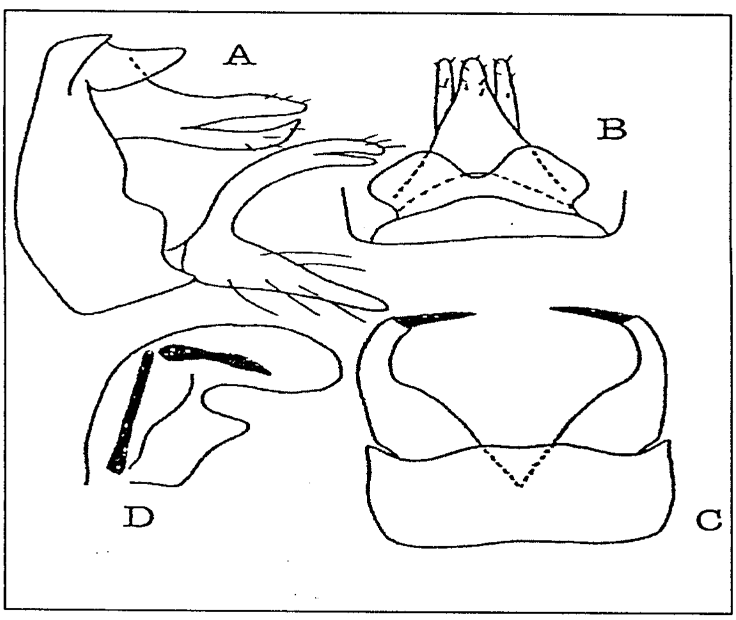


Figure 4.63 Male genitalia of *Ceraclea idaia* Malicky and Chaibu 200 A. genitalia, lateral view B. dorsal view C. ventral view

CHAPTER 5
CONCLUSIONS

1. Trichoptera have high diversity in the upper Ping watershed. Total 40914 male Trichoptera specimens were collected during January to December 2000. Seventy families, 54 genera and 237 species were identified in this study. Most of them were Hydropsychidae (67%) along with Psychomyiidae (7%), Leptoceridae (8%), Odontoceridae (6%) and Ecnomidae (5%). *Cheumatopsyche charites* was the most frequent species found, representing 24.46 % of the specimens collected, followed by *Cheumatopsyche globosa* (11.72%) *and Amphipsyche gratiosa* (7.48%). Differences in species compositions and abundances were found in each subwatershed depending on habitat preferences associated with environmental conditions at each site. The water quality parameters in the 7 subwatersheds were significanly different from each other ($P< 0.05$). Most of the water quality parameters were in Thai Classification and Surface Water class 2, except Mae Khan watershed which was in class 3

2. Land uses were seriously changed in all watershed classes because inappropriate in land use and very distrusted by human. Only four group sites were generated within five groups of watershed classes with clearly mixed classes in each group site. Group 1 was the only group that consisted of only 1 class in watershed class 5, which are the urban area and paddy fields. Group 2 has the highest land use change, which consisted of all watershed classes. Group 3 has moderate land use change, which consisted of watershed classes 1, 2 and 3. All of these sites were in the hillside, usually in the high elevations with steep to very steep slopes and therefore high in environmental degeneration. Group 4 was least in land use changing which consisted of watershed classes 1 and 2. Most of them were located in National Park or headwater.

3. Six families and 32 species were found in Huai Jo stream, which received polluted from a sewage plant. Hydropsychidae (61%), Leptoceridae (34%), Psychomyiidae (4%), and Ecnomidae (1%) that varied among these sites and seasons. The control sites were high in species richness. The polluted sites with sewage were

low in species richness. Species richness increased as the pollution was diluted in the recovery from the sewage. The water parameters were in Thai Classification and Surface Water class 3, except sites with received wastewater from treatment, which were in class 4.

4. Tolerant indicator species that are always found in urban and polluted sites, especially in watershed classes 4 and 5 were *Cheumatopsyche cognita, Ecnomus mammus, Leptocerus chiangmaiensis, Cheumatopsyche globosa, Potamyia panakeia* and *Amphipsyche meridiana*. *Amphipsyche meridiana* can be used as an indicator for domestic waste pollution. Sensitive indicator species that are always found in forested sites, especially in watershed classes 1 and 2 were *Macrostemum midas, Macrostemum fastosum, Hydropsyche uvana, Rhyacophila suthepensis* and *Hydropsyche uvana.*

5. Trichoptera community can be used as biomonitoring and helps us understand the real situation in each watershed class. These informations are important for maintaining land use quality for the future.

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Table 1 Check list of Trichoptera found in Mae Taeng watershed

A. winter

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Glossosomatidae										
Glossosoma elvisso				2				6		
Philopotamidae										
Chimara akkaorum				1						
Chimara joliveti		1								
Chimara khamuorum	1			1	1					
Chimara suadulla				1						
Polycentopodidae										
Polyplectropus menna					1					
Ecnomidae										
Ecnomus cincibilus									1	1
Ecnomus mammus										1
Ecnomus robustior						1				
Ecnomus volovicus			1		2					
Psychomyiidae										
Psychomyia intorachit					7	14				
Psychomyia kaiya		1		1		9				
Psychomyia lak	4	43		4	20	11				
Psychomyia monto						1				
Psychomyia samanaka						1				
Dipseudopsidae										
Hyalopsyche parsula		1	1		1		1			
Arctopswychidae										
Maesaipsyche prichapanyai	1		1	2						
Hydropsychidae										
Cheumatopsyche charites	1	7	1		15	44	1	26	2	5
Cheumatopsyche chryseis					1					
Cheumatopsyche cognita						1	2		6	1
Cheumatopsyche criseyde						1				
Cheumatopsyche dhanikari					1	2				
Cheumatopsyche globosa					3	2			1	
Hydropsyche askalaphos				3	1	1				
Hydropsyche atropos				1						
Hydropsyche camillus	1				1		2			
Hydropsyche dolosa	1				4		8			
Hydropsyche biareus	1		3	2						
Potamyia alleni								4		
Potamyia flavata			2		1	3	3	1	3	1
Potamyia panakeia	2	2	1							
Potamyia phaidra				4		5				
Amphipsyche gratiosa			14		25		8	1	2	
Macrostemum floridum					1					2
Aethaloptera sexpunctata									1	
Goeridae										
Goera matuilla		1		2		1				
Goera redsai	2	1								
Goera uniformis			1							
Lepidostomatidae										
Goerodes doligung					1					

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Leptoceridae										
Oecetis sp.2		1	1		4	3		1		
Setodes argentiguttatus					1	13				
Setodes fluvialis									2	
Setodes sp.2		1			1			1		
Polyplectropus aiolos		3								
Ecnous pagei			1							
Calamoceratidae										
Anisocentropus erichthonios						1				

B. summer

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Polycentopodidae										
Polyplectropus admin	5									
Ecnomidae										
Ecnomus cincibilus									1	
Ecnomus mammus										1
Ecnomus robustior	8	2	4	1	8	5	23	1		
Ecnomus volovicus			5		7		21			1
Paduniella semarangensis									2	
Psychomyiidae										
Psychomyia kaiya	1				3					
Dipseudopsidae										
Dipsodopsis benardi	4	5	22	1			7	4		
Dipsodopsis robustior									1	1
Arctopsychidae										
Hyalopsyche parsula	1	1			1		1		1	
Maesaipsyche prichapanyai	2									
Maesaipsyche stengeli				1		1				
Hydropsychidae										
Cheumatopsyche carmentis					1		3			
Cheumatopsyche charites	37	77	107	43	390	277	976	89	42	38
Cheumatopsyche caieta							3			
Cheumatopsyche cognita					1		19		20	31
Cheumatopsyche globosa		1	10		21	20	59	1	7	8
Hydropsyche askalaphos	32	9	2	13						
Hydropsyche camillus								1		
Hydropsyche dolosa			2				1		1	1
Hydropsyche truncatus				1						
Hydatomanicus klanklini	1									
Potamyia alleni	2			1			7		2	1
Potamyia baenzigeri	3									
Potamyia flavata						1	5		5	2
Potamyia panakeia	49	17	6	67						
Potamyia phaidra	34	15	4	7	8	2	1	8	7	4
Amphipsyche gratiosa		21	37	22	28	14	66	2	7	2
Amphipsyche meridiana	20									
Macrostemum fastosum		2		1						

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Macrostemum floridum						1				
Macrostemum midas		1		1			1	1		
Pseudoleptonema quinquefasci	12	7		18	1	1			1	
Goeridae										
Goera redsat	26			5						
Goera uniformis			2	2		10	3	5		
Odontoceridae										
Marilia sumatrana						3		2		
Dinarthrum pratetaiensis				1						
Leptoceridae										
Leptocerus chiangmaiensis										3
Leptocerus dirghachuka									6	
Leptocerus lampunensis									2	2
Leptocerus lanzenbergeri									2	
Oecetis tripunctata						5				4
Oecetis sp.2			9			10	4	1	3	11
Oecetis sp.10							1			
Oecetis sp.12							1			
Setodes argentiguttatus				1	4		20		3	4
Setodes fluvialis						1			1	3
Calamoceratidae										
Ganomena fuscipenne						1	1			

C. rainy season

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Philopotamidae										
Chimara akkaorum				1						
Chimara joliveti		1								
Chimara khamuorum	1			1	1					
Chimara suadulla				1						
Polycentopodidae										
Polyplectropus menna					1					
Ecnomidae										
Ecnous paget			1							
Ecnomus cincibilus									1	1
Ecnomus mammus										1
Ecnomus robustior						1				
Ecnomus volovicus			1		2					
Psychomyiidae										
Psychomyia intorachit					7	14				
Psychomyia kaiya		1		1		9				
Psychomyia lak	4	43		4	20	11				
Psychomyia monto						1				
Psychomyia samanaka						1				
Dipsoeudopsidae										
Hyalopsyche parsula		1	1		1		1			
Arctopsychidae										
Maesaipsyche prichapanyai	1		1	2						
Hydropsychidae										

	T11	T12	T21	T22	T31	T32	T41	T42	T51	T51
Cheumatopsyche charites	1	7	1		15	44	1	26	2	5
Cheumatopsyche chryseis					1					
Cheumatopsyche cognita						1	2		6	1
Cheumatopsyche criseyde						1				
Cheumatopsyche dhanikari					1	2				
Cheumatopsyche globosa					3	2			1	
Hydropsyche askalaphos				3	1	1				
Hydropsyche atropos				1						
Hydropsyche camillus	1				1		2			
Hydropsyche dolosa	1				4		8			
Hydropsyche biareus	1		3	2						
Potamyia alleni								4		
Potamyia flavata			2		1	3	3	1	3	1
Potamyia panakeia	2	2	1							
Potamyia phaidra				4		5				
Amphipsyche gratiosa			14		25		8	1	2	
Macrostemum floridum					1					2
Aethaloptera sexpunctata									1	
Goeridae										
Goera matuilla		1		2		1				
Goera redsat	2	1								
Goera uniformis			1							
Goerodes doligung					1					
Leptoceridae										
Oecetis sp.2		1	1		4	3		1		
Setodes argentiguttatus					1	13				
Setodes fluvialis									2	
Setodes sp.2		1			1			1		
Polyplectropus aiolos		3								
Calamoceratidae										
Anisocentropus erichthonios						1				

Table 2 Check list of Trichoptera found in Mae Khan watershed

A. winter

	KH11	KH12	KH21	K22	KH31	KH32	KH41	KH42	KH51	KH52
Philopotamidae										
Chimara khamuorum			1							
Ecnomidae										
Ecnous quordaiopaget										1
Ecnomus tolito			1		3					
Psychomyiidae										
Psychomyia lak				1						
Psychomyia monto		5								
Dipseudopsidae										
Maesaipsyche prichapanyai		1	2							
Hydropsychidae										
Cheumatopsyche charites	1	2		2	39			1		
Cheumatopsyche chrysothemis					1					
Cheumatopsyche cognita	3		1		5				6	4
Cheumatopsyche copia		3	2							
Cheumatopsyche dhanikari								1		
Cheumatopsyche globosa		2			21	3	1	1		1
Hydropsyche appendiculalis			1							
Hydropsyche atropos	1	1	1							
Hydropsyche camillus	1	1			1					
Hydropsyche truncatus		1								
Potamyia flavata			3		5				8	2
Potamyia phaidra					1					
Macrostemum fastosum		1								
Macrostemum floridum				1	19				2	
Pseudoleptonema quinquefasciatum					1					
Goeridae										
Goera mandana			1							
Goera uniformis					1					
Odontoceridae										
Marilia sumatrana		2	4							
Lepidostomatidae										
Goerodes doligung			1							
Leptoceridae										
Triplectides sp.1		1								
Oecetis sp.2					2					
Setodes argentiguttatus					6	1				
Triaenodes sp.1			1							

B. summer (April-June 2000)

	KH11	KH12	KH21	KH22	KH31	KH32	KH41	KH42	KH51	KH52
Philopotamidae										
Agapetus halong						1				
Philopotamidae										
Chimara akkaorum					2	38		3		
Chimara khamuorum						22	7			
Chimara uppita						4				
Chimarra vibena		45								

	KH11	KH12	KH21	KH22	KH31	KH32	KH41	KH42	KH51	KH52
Triplectides sp.1						3				
Leptocerus chiangmaiensis									12	1
Leptocerus dirghachuka	1			6					4	
Leptocerus lampunensis									6	
Leptocerus posticus			1							
Oecetis empusa		6								
Oecetis tripunctata			5	3		2				
Oecetis sp.2	1		1		32	2	1	45	19	
Oecetis sp.20						1				
Setodes argentiguttatus	1	3		6	88				12	
Setodes fluvialis		3	1						8	
Triaenodes sp.1									1	

C. rainy season

	KH11	KH12	KH21	K22	KH31	KH32	KH41	KH42	KH51	KH52
Philopotamidae										
Potamyia alleni					2					
Ecnomidae										
Ecnomus lotiio					2					
Ecnomus robustior	5	1		1						
Ecnomus cincibilus									3	
Ecnomus jojachin				1						
Psychomyiidae										
Psychomyia lak		1	6							
Psychomyia kaiya		1	1							
Hydropsychidae										
Cheumatopsyche cognita	1						2		93	3
Cheumatopsyche banksi	1			1			1		2	4
Cheumatopsyche globosa		1		13	92	4	1	5		1
Cheumatopsyche charites		2	3	31	24					
Cheumatopsyche caieta						3				
Macrostemum midas	1	3			10	1		11		
Hydropsyche askalaphos	2	1								
Maesaipsyche prichapanyai	6	6	1							
Potamyia phaidra		4		46	170					
Hydropsyche atropos						2				
Hydropsyche camillus				41	86	3				
Hydropsyche briareus				2	2					
Hyalopsyche parsula										1
Macrostemum floridum				6	48	2		1	1	
Amphipsyche meridiana									32	1
Potamyia flavata		1			2	1	15		7	5
Pseudoleptonema quinquefasciatum				4	2				1	
Lepidostomatidae										
Goerodes doligung					4					
Odontoceridae										
Marilia sumatrana	2		1			2				
Leptoceridae										
Leptocerus chiangmaiensis									8	
Oecetis tripunctata			1				1		6	

Oecetis sp.12			1					1		
Setodes argentiguttatus									2	

Table 3 Check list of Trichoptera found in Mae Kuang watershed

A. winter

	K11	K12	K21	K22	K31	K33	K41	K42	K51	K52
Rhycophilidae										
Rhyacophila tosagan	2			1						
Glossosomatidae										
Glossosoma elvisso	1									
Glossosoma malayanum			3							
Philopotamidae										
Chimara atara		1								
Chimara bimbilona						3				
Hydroptilidae										
Kisaura consagia				2						
Dolophilodes truncata			1							
Stenopsychidae										
Stenopsyche siamensis	1		1		7	8				
Stenopsyche haimavatika	1	1								
Psychomyiidae										
Polyplectropus admin										5
Ecnomidae										
Ecnomus alevalus									28	345
Ecnomus aktaion										98
Ecnomus mammus									1	7
Psychomyiidae										
Paduniella wangtakraiensis						1				
Lype atnia				1						
Psychomyia lak								1		
Dipsoeudopsidae										
Dipsodopsis doehbri						1				48
Hydropsychidae										
Hyalopsyche parsula									4	
Cheumatopsyche charites			1			2				
Cheumatopsyche chryseis				8						
Cheumatopsyche cognita								2	17	1
Cheumatopsyche gaia							1			
Cheumatopsyche globosa						2		1		
Cheumatopsyche schwendingeri										1
Hydropsyche arcturus	3			2						
Hydropsyche atropos		2				1				
Hydropsyche briareus	1		2	2						
Hydromanicus adrastos		1	1	3						
Hydropsyche truncatus				2						
Potamyia baenzigeri						1				
Potamyia flavata									2	
Potamyia phaidra					2	1				
Amphipsyche gratiosa						6				
Amphipsyche meridiana										1
Macrostemum floridum								1	1	
Odontoceridae										
Marilia sumatrana								1		1
Leptoceridae										
Leptocerus chiangmaiensis										1

	K11	K12	K21	K22	K31	K33	K41	K42	K51	K52
Leptocerus dirghachuka									2	
Leptocerus posticus				1						
Oecetis tripunctata						1			2	4
Oecetis sp.2									1	
Oecetis sp.5										5
Oecetis sp.12									12	46
Oecetis sp.12									1	
Setodes argentiguttatus									140	
Setodes sp.2									2	
Triaenodes sp.1						1				
Calamoceratidae										
Anisocentropus brevipennis				1						
Ganomena extensum		1								

B. summer

	KR11	KR12	KR21	KR22	KR31	KR32	KR41	KR42	KR51	KR52
Rhycophilidae										
Rhyacophila inaequalis				1						
Rhyacophila suthepensis	1	1		3						
Rhyacophila tosagan		1								
Glossosomatidae										
Glossosoma elvisso	2	2	1	1						
Philopotamidae										
Chimara akkaorum						5				
Chimara bimblona			4	1	3	1				
Chimara chiangmaiensis						55				
Chimara monorum				3						
Chimara noebia		1								
Chimara khamuorum					15					
Chimara shiva		1								
Chimara spinifera	1									
Chimara yaorum							1			
Chimara uppila						5				
Hydroptilidae										
Kisaura consagia				3						
Stenopsychidae										
Stenopsyche siamensis	2				6	14				
Polycentopodidae										
Nyctiophylax curtius										11
Polyplectropus admin	1	1	3	1		8				
Ecnomidae										
Ecnomus alevalus									132	128
Ecnomus cincibilus						1				
Ecnomus mammus									9	50
Ecnomus puro					2	1		4		
Psychomyiidae										
Paduniella sampati										12
Psychomyia kaiya					1					
Psychomyia lak			7							
Psychomyia mithila			1							
Dipsoeudopsidae										
Dipsodopsis robustior							1		2	320

	KR11	KR12	KR21	KR22	KR31	KR32	KR41	KR42	KR51	KR52
Dipsodopsis varians					1	5		3		
Hyalopsyche parsula									16	
Hydropsychidae										
Cheumatopsyche banksi									1	
Cheumatopsyche charites			2		10	128		180		
Cheumatopsyche chryseis				2						
Cheumatopsyche caieta							2	2	14	
Cheumatopsyche cressida			3					1		
Cheumatopsyche dhanikari						1	3			
Cheumatopsyche globosa					5	6	3	2	3	
Hydropsyche atropos			1							
Hydropsyche bootes			1							
Hydropsyche briareus			1							
Hydropsyche camillus						1				
Hydropsyche carva							1			
Hydropsyche dolosa										1
Hydromanicus adrastos				1						
Hydropsyche truncatus	1	1	1	2						
Potamyia alleni									1	
Potamyia flavata							2	1	2	
Potamyia phaidra						4				
Amphipsyche gratiosa						1				
Amphipsyche meridiana									12	
Macrostemum fastosum	10	15	2	4				3		
Macrostemum floridum					8		3			
Macrostemum indistinctum						33				
Macrostemum midas					1	11	2	1		
Pseudoleptonema quinquefasciatum						8				
Trichomacronema tamdao							7			
Goeridae										
Goera redsomar		1	11	2	2	6				
Gorra solicar			1	1	8	27		14		
Odontoceridae										
Marilia sumatrana			1	1	2	7		82		
Lepidostomatidae										
Dinarthrum pratetaiensis		1		1						
Dinarthrum tungyawensis	2									
Goerodes doligung	1	2		2		11				
Hydropsyche abiud			1							
Leptoceridae										
Leptocerus chiangmaiensis										5
Leptocerus dirghachuka							2			
Leptocerus inthanonensis			1							
Oecetis empusa							2			
Oecetis tripunctata						1		3		
Oecetis sp.5					2	13		2		12
Calamoceratidae										
Setodes argentiguttatus									12	
Anisocentropus brevipennis							8			
Ganonema fuscipenne				2	3	1				

C. rainy season

	K11	K12	K21	K22	K31	K33	K41	K42	K51	K52
Rhycophilidae										
Himalopsyche acharai		1		1						
Rhyacophila petersorum				1						
Rhyacophila suthepensis		1								
Glossosomatidae										
Glossosoma elvisso	1		10							
Glossosoma malayanum				1						
Ugandatrichia honga			2		12	3				
Philopotamidae										
Chimara bimblitona					13					
Chimara deva							5			
Chimara lannaensis			1							
Chimara shiva		1								
Chimara spinifera	1									
Stenopsychidae										
Stenopsyche siamensis			1		16	3				
Nyctiophylax maath								1	7	2
Polycentropodidae										
Pseudoneur eclipsis abia					1					
Pseudoneureclipsis usia					1					
Ecnomidae										
Ecnomus atevalus									13	43
Ecnomus aktaion									1	
Ecnomus cincibilus										3
Ecnomus jojachin							2	1		
Ecnomus mammus									1	7
Ecnomus robustior							1			
Psychomyiidae										2
Psychomyiidae										
Paduniella sampati								2		
Paduniella wanglakraiensis								1		
Psychomyiidae										
Lype atnia		1								
Psychomyia kaiya			3		2	1				
Psychomyia lak			5		2	1				
Psychomyia monto				1						
Dipsoeudopsidae										
Dipsodopsis benardi								7		
Dipsodopsis robustior									9	184
Dipsodopsis varians					1	1				
Phylocentropus orientalis							2	1		
Hyalopsyche parsula							6		6	
Hydropsychidae										
Cheumatopsyche banksi									6	
Cheumatopsyche charites			5	1	22	66				1
Cheumatopsyche chryseis				1						
Cheumatopsyche chrysothemis							1	357		
Cheumatopsyche cognita									13	1
Cheumatopsyche copia							2	2		
Cheumatopsyche cressida					1					
Cheumatopsyche globosa					2	1				
Cheumatopsyche schwendingeri							3	5		
Hydropsyche adonis	1									

	K11	K12	K21	K22	K31	K33	K41	K42	K51	K52
Hydropsyche atropos	2		3	2						
Hydropsyche briareus			69		5	1				
Hydromanicus adrastos								2		
Hydropsyche truncatus				1						
Potamyia baenzigeri					1					
Potamyia phaidra					1			4		
Amphipsyche gratiosa					2	4				
Amphipsyche meridiana								10		
Macrostemum dohrni								3		
Macrostemum fastosum		2		3						
Macrostemum floridum	7		1	3	3	1			2	
Macrostemum indistinctum							1	17		
Macrostemum midas					1	3				
Pseudoleptonema quinquefasciatum					76	2				
Goeridae									417	
Goera schmidi			1	1						
Odontoceridae										
Marilia aerope								1		
Marilia sumatrana					5					
Lepidostomatidae										
Dinarthrum martius			1							
Leptoceridae										
Leptocerus chiangmaiensis		1							3	
Leptocerus lampunensis							1			
Oecetis tripunctata					1	1			1	
Oecetis sp.2						2				
Oecetis sp.12								1		
Setodes argentiguttatus					3				30	
Setodes sp.2							1	1		
Calamoceratidae										
Ganomena fuscipenne			12		13	3				

Table 4 Check list of Trichoptera found in Mae Ngat watershed

A. winter

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Rhycophilidae										
Agapetus halong	1		1							
Stenopsychidae										
Nyctiophylax maath				2						
Polycentopodidae										
Polyplectropus menna									2	
Ecnomidae										
Ecnomus cincibilus										3
Ecnomus jojachin									1	
Ecnomus puro									1	
Ecnomus lotiio									2	
Ecnomus venimar			1							
Ecnomus volovicus								1		
Psychomyiidae										
Lype atnia			1			2				
Psychomyia samanaka								3		
Hydropsychidae										
Cheumatopsyche banksi										1
Cheumatopsyche carna	2				1	1				
Cheumatopsyche chryseis	13	1				9				
Cheumatopsyche cognita			2					4	3	
Cheumatopsyche criseyde			4							
Cheumatopsyche dhanikari							3			
Cheumatopsyche gaia			1							
Cheumatopsyche globosa	4	1	17	12			5	82	11	1
Hydropsyche bacchus	2				1					
Hydropsyche camillus	30	18	13		5	2	3	2	1	6
Hydropsyche dolosa	19	9	4		3		1			
Hydromanicus adrastos		1								
Hydropsyche clitumnus		1								
Hydropsyche pallipenne	1									
Hydatomanicus klanklini	1	1								
Hydromanicus serubabel	9					1				
Polamyia flavata			4		1	1		1	9	5
Macrostemum fastosum							3			
Macrostemum floridum								3	5	
Macrostemum indistinctum					1					
Macrostemum midas									1	
Goeridae										
Goera uniformis	1				1		1	1		
Odontoceridae										
Marilia sumatrana	2		1			2	9	6	8	4
Lepidostomatidae										
Dinarthrum lungyawensis	7									
Goerodes doligung		1					2			
Leptoceridae										
Triplectides sp.1	3				1		2			3
Leptocerus chiangmaiensis			1						1	
Leptocerus dirghachuka								7		

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Leptocerus posticus									4	
Oecetis tripunctata									9	4
Oecetis sp.2							1		22	
Oecetis sp.12								1		
Oecetis sp.12								1		
Setodes argentiguttatus								27		
Setodes fluvialis								1	6	
Calamoceratidae										
Anisocentropus brevipennis			1							

B. summer

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Rhycophilidae										
Rhyacophila sulhepensis	1									
Agapetus chinensis					2					
Philopotamidae										
Chimara akkaorum	5	4					5			
Chimara coma	1						1			
Chimara khamuorum		3			2	5				
Kisaura sura	5				4					
Stenopsychidae										
Stenopsyche siamensis					1					
Nyctiophylax curtius					1					
Polycentopodidae			1	4						
Pseudoneur eclipsis abia	1							2		
Ecnomidae										
Ecnomus cincibilus									13	2
Ecnomus jojachin									3	
Ecnomus puro									36	
Ecnomus lotiio									2	
Ecnomus venimar	1									
Ecnomus volovicus								9	9	2
Psychomyiidae										
Psychomyia monlo	4									
Dipsoeudopsidae										
Dipsodopsis robustior									2	6
Dipsodopsis varians	2						6			
Hydropsychidae										
Cheumatopsyche charites							1			
Cheumatopsyche chryseis	13	11				7				
Cheumatopsyche chrysothemis				2						
Cheumatopsyche cognita					17		1	3	11	7
Cheumatopsyche copia			26					1		
Cheumatopsyche dhanikari							1			
Cheumatopsyche globosa			24	18	11		24	75	5	6
Hydropsyche atropos		1								
Hydropsyche camillus		2	4	8		1				6
Hydropsyche dolosa		1	1	1						3
Hydropsyche abiud	2									
Hydromanicus adrastos		1								
Hydatomanicus klanklini	1									
Hydromanicus serubabel	6						2			

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Potamyia flavata										13
Macrostemum dohrni	2									
Macrostemum floridum			5		5		15			4
Macrostemum midas	19	10		15	79	1	32	2		
Goeridae										
Gastroce evansi								2		
Goera schmidi	4				1	2				
Goera larumana	4									
Goera uniformis		2	12	10	31	4	27	4		38
Odontoceridae										
Marilia sumatrana	19	5			2		32		24	21
Lepidostomatidae										
Dinarthrum pratetaiensis	1	1								
Goerodes doligung	10				8	3	16			
Leptoceridae										
Triplectides sp.1							5			
Triplectides sp.2			4							
Leptocerus chiangmaiensis		1						7		
Leptocerus dirghachuka	16						3	7	4	
Leptocerus lampunensis								1		
Leptocerus posticus					1					
Oecetis empusa	3									
Oecetis tripunctata										1
Oecetis sp.2							2		21	
Setodes argentiguttatus					1			22	1	
Setodes endymion					2					
Setodes fluvialis								2		
Trichosetodes pellectus					1			2		
Calamoceratidae										
Anisocentropus pan				4						
Polyplectropus aiolos	2									

C. rainy season

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Philopotamidae										
Chimara akkaorum										1
Chimara pipake		1	3							
Stenopsychidae										
Nyctiophylax curtius				4						
Ecnomidae										
Ecnomus puro							6		3	2
Ecnomus lotiio									4	
Ecnomus volovicus								1		
Dipseudopsidae										
Dipsodopsis robustior									10	22
Dipsodopsis varians							8			15
Hydropsychidae										
Cheumatopsyche banksi					1				1	2
Cheumatopsyche chryseis	3	2			6	27				
Cheumatopsyche chrysothemis				2	1	2				
Cheumatopsyche cognita			2		1			3	3	51

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
Cheumatopsyche cocles						4				
Cheumatopsyche cressida	13	4								
Cheumatopsyche criseyde						2				
Cheumatopsyche globosa			1	5		1	1	64	1	5
Hydropsyche camillus					1					6
Hydropsyche dolosa			1							
Hydropsyche pallipenne	17	10								
Hydromanicus serubabel	8	2					1			
Potamyia alleni									1	
Potamyia flavata										5
Potamyia phaidra					2					
Macrostemum dohrni	3									
Macrostemum floridum							1	1	1	4
Macrostemum midas				1						
Goeridae										
Goera matuilla	1				1	1				
Goera uniformis			1		1	1			2	75
Odontoceridae										
Marilia sumatrana			1				2	1	2	5
Dinarthrum daidalion		1								
Leptocerus chiangmaiensis										2
Leptocerus dirghachuka							2		6	7
Leptocerus lampunensis									1	2
Oecetis tripunctata									1	1
Oecetis sp.2										11
Setodes sp.2							6			
Calamoceratidae										
Ganomena fuscipenne					1					
Polyplectropus aiolos									3	8

Table 5 Check list of Trichoptera found in the second part of Mae Ping watershed

A. winter

	P11	P12	P21	P22	P31	P32	P41	P42	P51	P52
Rhycophilidae										
Himalopsyche acharai		1								
Rhyacophila jalita	6									
Rhyacophila malayama			18							
Rhyacophila petersorum			23							
Rhyacophila suthepensis		1								
Rhyacophila scissa		1								
Rhyacophila quana		1								
Philopotamidae										
Chimara atara		1								
Chimara joliveti										5
Chimara khamuorum							1			
Chimara suthepensis		1	6							
Hydroptilidae										
Kisaura cina		1								
Kisaura consagia		1								
Polycentropodidae										
Polyplectropus menna		1								
Ecnomidae										
Ecnomus volovicus										1
Dipseudopsidae										
Dipsodopsis benardi										5
Dipsodopsis robustior									3	
Hydropsychidae										
Cheumatopsyche angusta							1		129	
Cheumatopsyche cognita				1		1		2	365	267
Cheumatopsyche cocles		4								
Cheumatopsyche copia							1			
Cheumatopsyche dhanikari				1	1	1				
Cheumatopsyche globosa	1			39	20	13	7		55	16
Hydropsyche adonis			3							
Hydropsyche askalaphos								8		
Hydropsyche arcturus		8								
Hydropsyche briareus								1		
Hydropsyche bootes			2			11				
Hydropsyche camillus	1			1				1		
Hydropsyche truncatus		2								
Hydropsyche truncatus	2						2	2		
Hydropsyche truncatus			1							
Potamyia alleni									3	7
Potamyia flavata							1	2		2
Amphipsyche meridiana									3	4
Macrostemum dohrni							1			
Macrostemum floridum									112	6
Goeridae										
Goera maluilla							1			

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Odontoceridae									
Psilotrela baureo			2						
Lepidostomatidae									
Dinarthrum pratetaiensis		2							
Dinarthrum tungyawensis	17								
Goerodes doligung				1					
Leptoceridae									
Athripsodes sp.3									2
Leptocerus chiangmaiensis									310
Oecetis tripunctata						1			
Oecetis sp.5									2
Setodes argentiguttatus									1
Calamoceratidae									
Anisocentropus pan						1			

B. summer

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Rhycophilidae									
Himalopsyche acharai		2							
Rhyacophila hippocerpica			24						
Rhyacophila inaequalis			2						
Rhyacophila petersorum		2	16						
Rhyacophila suthepensis	49	35						2	
Rhyacophila scissa		2							
Rhyacophila quana		6							
Glossosomatidae									
Agapetus halong		1							
Ugandatrichia kermuang			4						
Philopotamidae									
Chimara akkaorum		2					6		
Chimara deva				2					
Chimara monorum					1				
Chimara khamuorum	4					3	4	4	
Chimara hlinorum		2							
Chimara spinifera		1							
Chimara suadulla					5				
Chimara suthepensis		6	17						
Chimara toga			3						
Chimarra vannaesnsis								2	
Hydroptilidae									
Dolotlanes adnamai				5					
Kisaura consagia		1							
Kisaura sura		2							
Stenopsychidae									
Nyctiophylax curtius					4		6		
Polycentropodidae									
Polyplectropus admin							3		
Polyplectropus menna		1							
Pseudoneureclipsis usia		14						2	
Ecnomidae									
Ecnomus atevalus									12

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Ecnomus aktaion									
Ecnomus jojachin	1				1				
Ecnomus mammus									
Ecnomus puro							3		
Ecnomus suadrus		4							
Ecnomus tolito							4		
Ecnomus volovicus			1						
Psychomyiidae									
Paduniella sampati							1		
Psychomyia barata		1							
Psychomyia monto		4			2	6	18		
Tinodes wodgabay	1								
Dipsoeudopsidae									
Dipsodopsis robustior									8
Hydropsychidae									
Cheumatopsyche catela									
Cheumatopsyche cognita							12	2	6
Cheumatopsyche cocles	4	17							
Cheumatopsyche copia								32	
Cheumatopsyche globosa			1		16	13	139	14	
Hydropsyche adonis			1						
Hydropsyche askalaphos								4	
Hydropsyche arcturus		2	2						
Hydropsyche brontes								32	
Hydropsyche bootes			16			2			
Hydropsyche abiud		1	4						
Hydropsyche truncatus		2	2						
Hydropsyche truncatus	7					5	5	25	
Hydropsyche truncatus								1	
Hydromanicus serubabel		6							
Potamyia flavata							21		
Amphipsyche meridiana									
Macrostemum bellerophon				1					
Macrostemum fastosum		48							
Macrostemum floridum							10	5	
Macrostemum midas				2			2		
Brachycentridae									
Trichomacronema paniae		5							
Goeridae									
Goera schmidi					3				
Goera uniformis						1			
Larcasia lannaensis		4							
Odontoceridae									
Lannapsyche chantaramongkolae	2								
Marilia sumatrana	1						4		
Psilotreta baureo			6						
Lepidostomatidae									
Adinarthrella moulmina	8	6							
Dinarthrum martius				1					
Dinarthrum adidalion		4							
Dinarthrum pratetaiensis		7							
Dinarthrum tungyawensis		1							
Goerodes abrutus		4							

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Goerodes doligung				5		3	2		
Leptoceridae									
Leptocerus chiangmaiensis									226
Leptocerus lampunensis							5		
Oecetis empusa								34	
Trichosetodes pellectus							5		
Calamoceratidae									
Anisocentropus janus		1							
Ganomena extensum		3							

C. rainy season

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Rhycophilidae									
Himalopsyche acharai		1							
Rhyacophila inaequalis			2						
Rhyacophila petersorum		2	33						
Rhyacophila suthepensis		2				1			
Agapetus latus		1							
Glossosomatidae									
Chimara akkaorum							1		1
Chimara berenike		1							
Chimara chiangmaiensis							3		
Chimara hlinorum		5							
Chimara spinifera			2						
Chimara suadulla			2						
Chimara suthepensis		1	67						
Stenopsychidae		2							
Nyctiophylax maath							1		
Plectrocnemia eccingoma									6
Pseudoneureclipsis usia		3							
Ecnomidae									
Ecnomus alevalus									15
Ecnomus aklaion									13
Psychomyiidae									
Lype atnia						1			
Psychomyia lak							2		
Psychomyia monto		5							
Dipsoeudopsidae									
Dipsodopsis robustior									4
Hydropsychidae									
Cheumatopsyche angusta									11
Cheumatopsyche banksi				2					
Cheumatopsyche caiela									2
Cheumatopsyche cognita			2					2	45
Cheumatopsyche cocles		18			4				
Cheumatopsyche copia		1							
Cheumatopsyche cressida							2	4	
Cheumatopsyche dhanikari					3				
Cheumatopsyche globosa			1	6	37	6	10	1	25
Hydropsyche adonis			7						
Hydropsyche askalaphos								1	

	P11	P12	P21	P22	P31	P32	P41	P42	P51
Hydropsyche arcturus		10							
Hydropsyche briareus								142	
Hydropsyche bootes			39		1	1			
Hydropsyche camillus				1			1		
Hydropsyche abiud			2						
Hydropsyche pallipenne			3						
Hydropsyche truncatus	4		7	6	9	8		10	
Hydropsyche truncatus			2			1			
Hydatomanicus klanklini			10						
Hydromanicus serubabel		5							
Potamyia alleni									1
Potamyia flavata							1		
Macrostemum floridum						1			
Trichomacronema paniae		1							
Micrasema fortiso		1							
Goera matuilla				2					
Goera redsomar				1					
Marilia sumatrana			2			1			
Brachycentridae									
Psilotreta baureo						1			
Lepidostomatidae									
Dinarthrum daidalion		3							
Goerodes abrutus		4							
Goerodes doligung						1			
Leptoceridae									
Leptocerus chiangmaiensis									79
Calamoceratidae									
Oecetis sp.12						1			
Anisocentropus janus		2							
Ganomena extensum		1	2						

Table 6 Check list of Trichoptera found in Mae Rim watershed

A. winter

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Ecnomidae										
Ecnomus cincibilus										1
Ecnomus mammus										1
Psychomyiidae										
Psychomyia monto							1			
Hydropsychidae										
Cheumatopsyche chryseis							1			
Cheumatopsyche cognita			1				1		1	1
Cheumatopsyche dhanikari					1					
Cheumatopsyche globosa					1	28	1	1	1	1
Hydropsyche atropos	3	3		1						
Hydropsyche camillus			1							
Odontoceridae										
Marilia sumatrana		1	1	1						
Leptoceridae										
Triplectides sp.2									1	
Calamoceratidae										
Anisocentropus erichthonios				2						

B. summer

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Rhycophilidae										
Rhyacophila inaequalis					1					
Rhyacophila suthepensis					4					
Glossosomatidae										
Glossosoma elvisso				1						
Ugandatrichia honga						1				
Hydroptilidae										
Chimara akkaorum			5		3	2		1		
Chimara coma						1				
Chimara khamuorum			10		4	11		6		
Chimara shanorum	3						5			
Chimara shiva					2					
Chimara spinifera		1	2							
Dolocianes gressitti					1					
Stenopsychidae										
Nyctiophylax chiangmaiensis			1							
Nyctiophylax curtius					1					
Polycentopodidae										
Polyplectropus admin	1									
Polyplectropus admin			2							
Polyplectropus menna					1					
Pseudoneureclipsis usia			1							
Ecnomidae										
Ecnomus atevalus								1		

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Ecnomus cincibilus									4	
Ecnomus mammus									7	10
Ecnomus puro								2	2	
Ecnomus suadrus			26							
Psychomyiidae										
Psychomyia inforachit						9				
Psychomyia kaiya			7	1	1			13		
Psychomyia lak			1					4		
Psychomyia monto				1		2		1		
Dipsoeudopsidae										
Dipsodopsis robustior									1	
Phylocentropus orientalis					4					
Hyalopsyche parsula								1		
Hydropsychidae										
Cheumatopsyche charites		4								
Cheumatopsyche caiela		1								
Cheumatopsyche cognita			16		2	1		11	49	31
Cheumatopsyche cressida								1		
Cheumatopsyche dhanikari								1		
Cheumatopsyche globosa			6	9	2	59	14	67	83	110
Cheumatopsyche ningmapa				1						
Cheumatopsyche naumanni	2			10						
Hydropsyche askalaphos				1						
Hydropsyche arcturus	2									
Hydropsyche atropos	10	2		1						
Hydropsyche camillus			3							
Hydropsyche truncatus			2				5			
Potamyia flavata								5	3	
Potamyia phaidra									1	
Amphipsyche gratiosa										1
Macrostemum bellerophon					1					
Macrostemum floridum			16		11	2	1	12	1	
Goeridae	1		4		1		3	1		
Goeridae										
Goera matuilla	1				2	1	2			
Goera redsai				6						
Gorra solicar				1					1	
Goera uniformis			3				3	3		
Odontoceridae										
Marilia mogliana	16		15	1	1		44			
Marilia sumatrana		5	5					4		
Lepidostomatidae										
Dinarthrum tungyawensis					1					
Goerodes doligung			5		5	7	3	7		
Leptoceridae										
Adicella sp.2						1				
Triplectides sp.1						1			1	
Leptocerus chiangmaiensis									39	18
Leptocerus dirghachuka								28		
Leptocerus lampunensis								1		
Oecetis empusa								9		4
Oecetis tripunctata		1				1				
Oecetis villosa								23		

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Oecetis sp.10									7	
Oecetis sp.20									3	
Parasetodes bakeri									65	
Setodes endymion									6	
Calamoceratidae										
Anisocentropus janus		2								
Anisocentropus brevipennis			1		1					
Anisocentropus erichthonios				8						

C. rainy season

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Rhycophilidae										
Rhyacophila inaequalis	1									
Rhyacophila sulhepensis				1						
Philopotamidae										
Chimara akkaorum							4			
Kisaura consagia		1								
Ecnomidae										
Ecnomus alevalus										1
Ecnomus aklaion									1	
Psychomyia kaiya				1						
Hyalopsyche parsula				1						1
Cheumatopsyche banksi			8					3		
Cheumatopsyche caiela		6	1					1	2	
Cheumatopsyche cognita		1						6	15	17
Cheumatopsyche cressida							4			
Cheumatopsyche dhanikari					2			1		
Cheumatopsyche globosa				14	1	12	1	20	1	41
Hydropsyche atropos		1		4	1					
Hydropsyche briareus							8			
Hydropsyche camillus						1				
Hydropsyche dolosa										1
Hydropsyche truncatus						7				
Hydromanicus serubabel		1								
Potamyia alleni									1	
Potamyia flavata								1	1	
Potamyia phaidra				1						
Amphipsyche meridiana										1
Macrostemum bellerophon					4					
Macrostemum floridum			2	1				4	1	
Macrostemum hestia		1								
Goeridae										
Goera matuilla		5		3						
Goera uniformis										
Odontoceridae					1					
Marilia sumatrana			4							
Lepidostomatidae										
Dinarthrum pratetaiensis		1								
Goerodes doligung			1		1					
Leptoceridae										
Leptocerus chiangmaiensis									1	

	R11	R12	R21	R22	R21	R32	R41	R42	R51	R52
Leptocerus dirghachuka								2		
Leptocerus lampunensis								1	10	3
Oecetis empusa		1								
Oecetis sp.20									2	
Parasetodes bakeri								4	3	
Setodes fluvialis									1	1
Trichosetodes pellectus	2	2								

Table 7 Check list of Trichoptera found in the upper part of Mae Ping watersed

A. winter

	UP11	UP12	UP21	UP22	UP31	UP32	UP41	UP42	UP51	UP52
Philopotamidae										
Chimara chiangmaiensis	1									
Chimara lannaensis	1									
Gunungiella segsafiazga		1								
Polycentopodidae										
Polyplectropus admin			1							
Pseudoneur eclipsis abia								1		
Ecnomidae										
Ecnomus cincibilus							2	2		1
Ecnomus puro							1			
Ecnomus volovicus									2	
Dipseudopsidae										
Dipsodopsis benardi			8	10						
Dipsodopsis robustior								1		
Arctopsychidae										
Maesaipsyche prichapanyai					1					
Hydropsychidae										
Cheumatopsyche angusta									1	
Cheumatopsyche banksi			1							
Cheumatopsyche charites			8	24		6		4		8
Cheumatopsyche caiela							1			
Cheumatopsyche cognita				1	18	7	15	25	3	15
Cheumatopsyche globosa				4	1	6	26	2	6	4
Hydropsyche baimaii	3									
Hydropsyche camillus									1	1
Hydropsyche carva	1	2								
Hydropsyche dolosa			2	6		6			1	
Hydromanicus serubabel		8								
Potamyia flavata			1		2	3	4	1	3	3
Potamyia phaidra			17	138		45			1	
Amphipsyche gratiosa			18	258	50	315		1		
Amphipsyche meridiana			3	1	32	18	15	35	3	20
Macrostemum fastosum		1								
Macrostemum floridum							4			
Macrostemum midas	3	5								
Aethaloptera sexpunctata				1	1					
Goeridae										
Goera uniformis							1			
Odontoceridae										
Marilia sumatrana									1	
Lepidostomatidae										
Dinarthrum pratetaiensis			1	5						
Leptoceridae										
Leptocerus dirghachuka						3	5	2		4
Leptocerus lampunensis							2	1		
Oecetis tripunctata								3	2	
Oecetis sp.2				2			2	3		2
Oecetis sp.12			5	8						
Setodes argentiguttatus			1	4		22	15	13	1	1
Setodes fluvialis							1			

	UP11	UP12	UP21	UP22	UP31	UP32	UP41	UP42	UP51	UP52
Calamoceratidae										
Ganomena fuscipenne					1					

B.

	UP11	UP12	UP21	UP22	UP31	UP32	UP41	UP42	UP51	UP52
Rhycophilidae										
Agapetus halong	2									
Philopotamidae										
Chimara bimblona	1									
Chimara chiangmaiensis	2									
Chimara deva	4									
Chimara monorum	1									
Gunungiella jimjafiazga	3									
Polycentopodidae										
Pseudoneur eclipsis abia		8	3	6						
Ecnomidae										
Ecnomus cincibilus						8	1		1	3
Ecnomus puro				1	1		12	17	1	25
Ecnomus venimar	1	10								
Ecnomus volovicus			6	4	1	8			1	
Psychomyiidae										
Lype atnia	2									
Psychomyia kaiya		1		4						
Psychomyia lak	2									
Dipsoeudopsidae										
Dipsodopsis benardi			3	26	9	28				
Dipsodopsis robustior										1
Arctopsychidae										
Maesaipsyche prichapanyai				2	1					
Maesaipsyche stengeli										1
Hydropsychidae										
Cheumatopsyche carna		12								
Cheumatopsyche charites			696	890	318	408		24		29
Cheumatopsyche cognita						5	4	5	7	15
Cheumatopsyche criseyde					1					
Cheumatopsyche dhanikari							1			
Cheumatopsyche globosa	2		108	52	13	28	157	20		1
Cheumatopsyche phaidra			6							
Hydropsyche atropos		1								
Hydropsyche camillus					8	36	3			
Hydropsyche dolosa				10	11	48		4		
Hydropsyche clitumnus	1									
Hydromanicus serubabel	2	4								
Potamyia alleni			12					28		
Potamyia flavata			3	2	4	12				1
Potamyia phaidra				58	102	252	2	4		
Amphipsyche gratiosa			60	144	760	1076				
Amphipsyche meridiana					3	5	4	5		8
Macrostemum fastosum		2								
Macrostemum floridum			3				40			
Macrostemum midas		1				20				1

	UP11	UP12	UP21	UP22	UP31	UP32	UP41	UP42	UP51	UP52
Aethaloptera sexpunctata			0	0	0	1	7	8	5	11
Goeridae										
Goera redsomar		2								
Goera uniformis	3			6	1	1		4		1
Odontoceridae										
Marilia sumatrana			18	48	22	44	11	1502		
Lepidostomatidae										
Dinarthrum pratetaiensis		1	20	30	7	5	2	3	1	
Dinarthrum tungyawensis		1								
Leptoceridae										
Goerodes doligung	1									
Leptocerus chiangmaiensis					1					
Leptocerus dirghachuka				2		4	1	28		1
Oecetis tripunctata							1			1
Oecetis sp.2				12		32		16		34
Setodes argentiguttatus				70		264	2		1	73
Setodes sp.3							1			
Calamoceratidae										
Ganomena fuscipenne					1					1

C. rainy season

	UP11	UP12	UP21	UP22	UP31	UP32	Up41	UP42	UP51	UP52
Philopotamidae										
Chimara khamuorum								3		
Polycentopodidae										
Pseudoneur eclipsis abia		8	3	6	1			6		
Ecnomidae										
Ecnomus cincibilus							1		1	3
Ecnomus puro								4	2	28
Ecnomus venimar	1	10								
Ecnomus volovicus			6	153	21	9			26	
Psychomyiidae										
Psychomyia kaiya		1		9						
Psychomyia lak				15						
Dipsoeudopsidae										
Dipsodopsis benardi			3	6	2					
Hydropsychidae										
Cheumatopsyche carna	46	12								
Cheumatopsyche charites			696	606	183	324		69	1	32
Cheumatopsyche cognita					11	5	3	10	4	8
Cheumatopsyche dhanikari							1			
Cheumatopsyche globosa			108	879	292	504	157	390	39	
Cheumatopsyche phaidra			6	39						
Hydropsyche angkangensis	3									
Hydropsyche atropos	1	1								
Hydropsyche baimaii	1									
Hydropsyche camillus	16	28		15	10	15	3	270		
Hydropsyche dolosa	2								1	1

	UP11	UP12	UP21	UP22	UP31	UP32	Up41	UP42	UP51	UP52
Hydromanicus binaria	1									
Hydropsyche clitumnus	1									
Hydropsyche napaea	17	4								
Hydropsyche truncatus	4	1								
Hydromanicus serubabel	2	1								
Potamyia alleni		15	12	117						
Potamyia flavata		4	3	18	12	8		105		7
Potamyia phaidra					10	93	2	9		
Amphipsyche gratiosa			60		1	12		6		
Amphipsyche meridiana			2	2	17	5	7	15	7	8
Amphipsyche sex				3						
Macrostemum dohrni				3						
Macrostemum floridum			3		21	9	40	3	2	
Macrostemum midas	4	1								
Aethaloptera sexpunctata				4	0	1	15	8	7	
Goeridae										
Goera redsat	1	4								
Goera seccio				3						
Goera uniformis						3				
Odontoceridae										
Marilia aerope					3					
Marilia mogtiana					4			36	1	
Marilia sumatrana			18	57	15	15	11	18		
Lepidostomatidae										
Dinarthrum pratetaiensis			3	15		1	5	1	2	1
Goerodes doligung	1				1					
Leptoceridae										
Leptocerus dirghachuka							1			
Oecetis tripunctata							1			
Oecetis sp.2									7	10
Setodes argentiguttatus							2			14
Setodes fluvialis									1	
Setodes sp.3							1			

Table 8 Check list of Trichoptera found in Huai Jo stream before wastewater treatment plant (M1)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Psychomyiidae												
Paduniella semurungensis	0	1	0	0	0	0	0	0	0	0	2	1
Paduniella sampati	0	0	1	0	0	0	0	2	0	1	0	0
Philopotamidae												
Chimarra pipak	0	0	0	1	0	0	0	0	0	0	0	0
Polycentropodidae												
Nyctiophylex maath	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomidae												
Ecnomus atevalus	1	0	0	0	1	0	4	1	0	0	1	2
Ecnomus cincibilus	2	1	0	0	0	0	0	0	0	0	0	0
Ecnomus mammus	1	0	1	2	1	1	0	0	0	0	0	0
Ecnomus puro	0	0	1	0	1	1	1	0	0	0	0	0
Ecnomus pseudotenellus	0	0	0	1	0	0	0	0	0	0	0	0
Ecnomus uttu	0	21	10	5	0	5	9	8	17	7	0	0
Dipseudopsidae												
Dipseudopsis robustior	0	0	1	6	0	4	2	3	0	3	0	0
Hydropsychidae												
Amphipsyche meridiana	8	20	23	16	10	4	63	33	97	24	15	29
Cheumatopsyeche banksi	0	1	0	1	0	0	1	0	0	0	0	0
Cheumatopsyeche cognita	104	72	98	187	101	15	28	27	20	13	20	58
Cheumatopsyeche globosa	2	6	10	2	1	1	1	0	0	1	0	1
Potamyia flavata	24	31	32	10	1	4	1	2	1	8	5	10
Macrostemum floridum	0	0	7	3	0	0	0	0	0	0	0	0
Cheumatopsyche sp.1	0	1	0	0	0	0	0	0	0	0	0	0
Pseudoleptonema quinquefa	0	0	0	0	0	0	0	0	0	0	0	0
Leptoceridae												
Adicella sp.1	0	0	0	1	0	0	0	0	1	0	0	0
Ceraclea idaia	0	0	0	0	0	0	0	0	0	0	0	0
Triplectides sp.1	0	0	2	0	0	0	0	0	0	0	0	0
Leptocerus chiangmaiensis	0	0	0	8	8	7	19	22	35	30	1	0
Leptocerus dirghachata	0	1	0	3	0	0	3	0	0	0	0	0
Leptocerus empusa	0	0	1	1	1	2	3	2	7	0	0	0
Leptocerus lumpunensis	0	0	3	1	0	0	4	3	4	1	0	0
Leptocerus posticus	0	0	0	1	0	0	1	3	12	0	0	0
Setodes argentiguttatus	0	0	10	4	1	5	2	0	1	1	1	0
Setodes sp.2	0	0	0	0	0	0	1	0	0	0	0	0
Oecetis sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.5	0	0	2	12	1	3	12	1	7	2	1	0
Oecetis sp.12	0	0	3	0	0	0	0	0	0	0	0	0
sp.2	0	0	0	0	0	0	0	0	0	0	0	0

Table 9 Check list of Trichoptera found in Huai Jo stream before wastewater treatment plant (M2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Psychomyiidae												
Paduniella semurungensis	0	0	0	0	0	0	0	0	0	0	0	0
Paduniella sampati	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae												
Chimarra pipak	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae												
Nyctiophylex maath	0	3	1	1	1	2	1	0	0	5	3	1
Ecnomidae												
Ecnomus atevalus	0	0	1	1	0	1	1	0	0	1	0	0
Ecnomus cincibilus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus maminus	0	4	3	0	0	0	0	0	0	1	0	0
Ecnomus puro	0	0	0	0	0	0	1	0	0	0	0	0
Ecnomus pseudotenellus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus uttu	0	0	3	1	1	2	2	0	0	4	0	0
Dipseudopsidae												
Dipseudopsis robustior	0	0	5	0	11	8	0	0	1	0	0	0
Hydropsychidae												
Amphipsyche meridiana	31	0	3	12	0	5	29	25	60	51	30	24
Cheumatopsyeche banksi	0	0	0	0	1	0	0	0	0	0	0	0
Cheumatopsyeche cognita	52	15	63	40	23	17	32	25	30	10	25	37
Cheumatopsyeche globosa	0	0	10	1	0	0	0	1	1	1	1	0
Potamyia flavata	1	0	37	0	3	1	0	0	0	4	6	4
Macrostemum floridum	0	0	5	0	0	0	0	0	0	0	0	0
Cheumatopsyche sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoleptonema quinquefa	0	0	0	0	0	0	0	1	0	0	0	0
Leptoceridae												
Adicella sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea idaia	1	0	0	0	0	0	0	0	0	0	0	0
Triplectides sp.1	0	0	0	0	0	0	0	0	0	1	1	0
Leptocerus chiangmaiensis	0	0	26	30	45	32	113	101	82	96	29	13
Leptocerus dirghachata	0	0	5	1	12	2	4	0	0	0	1	0
Leptocerus empusa	0	0	1	0	0	0	0	1	0	1	0	0
Leptocerus lumpunensis	0	0	2	0	1	3	10	2	4	2	0	0
Leptocerus posticus	0	0	0	0	1	0	0	0	0	0	0	0
Setodes argentiguttatus	0	0	2	0	3	0	0	0	0	0	0	0
Setodes sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.5	0	0	3	1	3	2	8	1	3	0	0	0
Oecetis sp.12	0	0	1	0	0	0	1	0	1	0	0	0
sp.2	0	0	0	0	0	0	0	1	0	0	0	0

Table 10 Check list of Trichoptera found in Huai Jo stream after wastewater treatment plant (M3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Psychomyiidae												
Paduniella semurungensis	0	0	0	0	0	0	0	0	0	0	0	0
Paduniella sampati	1	0	0	0	0	0	0	1	0	0	0	0
Philopotamidae												
Chimarra pipak	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae												
Nyctiophylex maath	0	0	0	0	0	0	0	1	0	0	0	0
Ecnomidae												
Ecnomus atevalus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus cincibilus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus mammus	0	0	1	1	0	0	0	0	0	0	0	0
Ecnomus puro	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus pseudotenellus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus uttu	0	0	1	0	0	0	0	3	0	3	1	0
Dipseudopsidae												
Dipseudopsis robustior	0	0	0	0	0	2	1	2	1	0	0	0
Hydropsychidae												
Amphipsyche meridiana	519	90	80	86	9	123	117	78	50	47	117	98
Cheumatopsyeche banksi	0	0	0	0	0	0	0	0	0	0	0	0
Cheumatopsyeche cognita	147	23	28	7	2	21	10	3	5	0	13	22
Cheumatopsyeche globosa	1	0	0	0	0	0	0	0	0	0	0	0
Potamyia flavata	13	3	2	1	0	2	0	0	0	1	1	1
Macrostemum floridum	0	0	1	4	1	0	0	0	0	0	0	0
Cheumatopsyche sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoleptonema quinquefa	0	0	0	0	0	0	0	0	0	0	0	0
Leptoceridae												
Adicella sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea idaia	0	0	0	0	0	0	0	0	0	0	0	0
Triplectides sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerus chiangmaiensis	0	1	0	0	1	1	0	0	0	0	0	0
Leptocerus dirghachata	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerus empusa	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerus lumpunensis	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerus posticus	0	0	0	0	0	0	0	0	0	0	0	0
Setodes argentiguttatus	0	0	0	0	0	8	0	0	0	0	0	0
Setodes sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.2	0	0	1	0	0	3	1	0	0	1	0	0
Oecetis sp.5	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.12	0	1	0	0	0	0	0	0	0	0	0	0
sp.2	0	0	0	0	0	0	0	0	0	0	0	0

Table 11 Check list of Trichoptera found in Huai Jo stream after wastewater treatment plant (M4)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Psychomyiidae												
Paduniella semurungensis	0	0	0	0	0	0	0	0	0	0	0	0
Paduniella sampati	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae												
Chimarra pipak	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae												
Nyctiophylex maath	0	0	0	1	0	0	0	0	0	0	0	0
Ecnomidae												
Ecnomus atevalus	0	0	1	2	1	1	4	3	7	0	0	0
Ecnomus cincibilus	2	0	0	0	0	0	0	0	0	0	0	0
Ecnomus mammus	0	0	0	0	1	5	1	7	0	0	0	0
Ecnomus puro	0	0	0	0	0	1	0	0	0	0	0	0
Ecnomus pseudotenellus	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus uttu	6	0	15	1	0	6	22	37	26	15	1	0
Dipseudopsidae												
Dipseudopsis robustior	1	0	2	2	0	4	4	4	1	0	0	0
Hydropsychidae												
Amphipsyche meridiana	84	35	14	36	25	22	52	22	64	12	50	61
Cheumatopsyeche banksi	0	0	0	0	0	0	0	0	0	0	0	0
Cheumatopsyeche cognita	67	244	42	27	20	2	17	5	11	2	3	20
Cheumatopsyeche globosa	0	0	3	0	0	0	0	0	0	0	0	0
Potamyia flavata	4	0	5	5	4	5	1	0	0	1	1	1
Macrostemum floridum	0	0	2	1	0	0	0	0	0	0	0	0
Cheumatopsyche sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoleptonema quinquefa	0	0	0	0	0	0	0	0	0	0	0	0
Leptoceridae												
Adicella sp.1	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea idaia	0	0	0	0	0	0	0	0	0	0	0	0
Triplectides sp.1	1	0	0	0	0	1	0	0	0	0	0	0
Leptocerus chiangmaiensis	0	0	0	0	1	2	5	0	0	6	0	2
Leptocerus dirghachata	0	0	0	1	0	0	0	0	0	0	0	0
Leptocerus empusa	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerus lumpunensis	2	0	1	1	1	0	0	0	0	0	0	0
Leptocerus posticus	0	0	0	0	0	0	0	0	0	0	0	0
Setodes argentiguttatus	0	0	0	1	0	2	0	0	0	0	0	0
Setodes sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.2	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp.5	6	0	0	2	0	13	3	4	2	0	1	1
Oecetis sp.12	0	0	0	0	0	0	0	0	0	0	0	0
sp.2	0	0	0	0	0	0	0	0	0	0	0	0

Table 12 Mean value of water quality parameters at Mae Taeng watershed

	T11	T12	T11	T12	T31	T32	T41	T42	T51	T52
air temperature (C)	22.333	22.5	22.333	22.5	22.5	22.667	22.333	22.667	23.667	23.667
water temperature(C)	22	22.167	22	22.167	22.167	22.667	22.5	22.667	23.167	23
pH	8.1	8.15	8.1	8.15	8.3133	7.97	8.18	8.1267	7.36	7.4667
conductivity (us/cm)	144.8	141.3	144.8	141.3	171.13	173.77	171.57	137.7	175.43	176.73
TDS (mg/l)	72.4	70.567	72.4	70.567	85.9	86.567	86.1	69.033	88.033	88.633
PO4 (mg/l)	0.5067	0.5667	0.5067	0.5667	0.3167	0.5467	0.3467	0.4467	0.6467	0.7167
NO3-N (mg/l)	1.1667	1.5	1.1667	1.5	1.5333	1.1667	1.3333	1.4333	1.2667	1.3333
NH3-N (mg/l)	0.61	0.5633	0.61	0.5633	0.4867	0.4	0.6	0.6167	0.55	0.5733
Turbid (FTU)	158.67	173	158.67	173	162.67	112	174.33	242.33	231	227.67
alkalinity (mg/l)	27	33.667	27	33.667	29.667	30.067	33.333	30.667	30.667	31.667
DO (mg/l)	8.6333	8.5667	8.6333	8.5667	8.0333	7.7667	8.2333	7.9333	7.5667	7.45
BOD (mg/l)	0.9	0.38	0.9	0.38	1.2967	1.3033	1.38	1.1767	1.74	1.71
width (m)	12.833	17	12.833	17	15.233	3.2333	13	18.333	11.567	12.233
dept (m)	0.9667	0.8133	0.9667	0.8133	1.0333	0.4267	0.7733	1.0267	0.8067	0.9
velocity (m/s)	0.6367	0.56	0.6367	0.56	0.5867	0.29	0.5033	0.63	0.575	0.5383
discharge (cu.m.)	18.423	16.36	18.423	16.36	14.653	0.6034	9.3569	26.155	22.05	23.845

Table 13 Mean value of water quality parameters at Mae Khan watershed

	KH11	KH12	KH21	KH22	KH31	KH32	KH41	KH42	KH51	KH52
air temperature (C)	22.17	22.67	22.33	22.30	23.00	23.93	23.50	23.00	23.83	23.67
water temperature(C	22.60	22.00	21.83	21.83	23.67	23.00	23.23	23.00	24.00	24.17
pH	8.04	8.12	8.12	8.36	8.36	7.68	8.37	7.63	7.50	7.30
conductivity (μs/cm)	195.00	178.50	174.00	351.67	265.67	438.33	372.67	451.00	265.33	325.33
TDS (mg/l)	99.67	89.43	86.70	176.00	132.67	221.33	187.33	227.67	133.27	151.07
PO4 (mg/l)	0.47	0.31	0.33	0.30	0.49	0.36	0.34	0.46	0.38	0.42
NO3-N (mg/l)	0.43	0.57	0.53	0.53	0.60	0.63	0.43	0.63	0.73	0.63
NH3-N (mg/l)	0.15	0.14	0.29	0.12	0.15	0.25	0.12	0.17	0.31	1.13
Turbid (FTU)	78.67	57.00	50.00	73.00	23.67	41.33	17.33	22.67	57.00	30.33
alkalinity (mg/l)	49.33	35.00	28.33	56.00	54.00	44.67	61.33	73.00	40.00	46.00
DO (mg/l)	7.83	7.77	7.60	8.53	7.47	5.60	6.77	5.70	6.47	5.07
BOD (mg/l)	0.87	0.70	1.30	0.84	1.30	4.40	1.77	3.80	3.17	12.97
width (m)	12.17	16.07	4.67	6.30	4.70	1.33	1.30	2.06	5.17	1.23
dept (m)	0.31	0.65	0.23	0.34	0.36	0.12	0.31	0.56	0.78	1.02
velocity (m/s)	0.24	0.64	0.33	0.67	0.41	0.11	0.22	0.21	1.15	0.21
discharge (cu.m.)	2.77	14.41	0.54	2.51	0.95	0.03	0.16	0.65	3.75	0.34

Table 14 Mean value of water quality parameters at Mae Kuang watershed

	K11	K12	K21	K22	K31	K32	K41	K42	K51	K52
air temperature (C)	21.33	21.17	21.67	21.00	22.67	23.17	23.33	25.50	25.67	26.50
water temperature(C)	20.33	20.67	20.83	20.17	22.83	22.83	23.00	24.50	24.33	25.00
pH	7.13	7.03	7.34	7.02	7.30	7.52	6.95	7.04	7.43	7.27
conductivity (μs/cm)	40.47	39.20	45.10	40.90	32.43	46.07	118.27	126.23	184.00	279.67
TDS (mg/l)	20.20	19.47	23.00	21.17	16.23	23.00	53.47	44.00	92.07	140.67
PO4 (mg/l)	0.42	0.37	0.31	0.40	0.30	0.48	0.25	0.44	0.65	0.40
NO3-N (mg/l)	0.43	0.47	0.50	0.37	0.50	0.50	0.50	0.40	0.80	1.00
NH3-N (mg/l)	0.25	0.16	0.21	0.18	0.23	0.22	0.30	0.16	0.50	0.57
Turbid (FTU)	26.00	21.00	27.33	19.00	32.67	33.67	19.67	19.00	37.00	47.33
alkalinity (mg/l)	6.67	5.33	8.00	7.67	6.00	8.67	17.67	20.33	31.00	37.67
DO (mg/l)	8.60	8.30	8.40	8.28	7.80	7.03	7.48	6.87	6.93	6.30
BOD (mg/l)	0.75	0.43	1.08	1.33	1.20	1.69	1.53	2.06	2.24	2.72
width (m)	2.40	1.05	4.43	1.27	4.63	6.35	0.99	3.93	21.70	30.23
dept (m)	0.23	0.12	0.32	0.15	0.38	0.30	0.10	0.71	1.67	1.93
velocity (m/s)	0.73	0.56	0.75	0.55	0.33	0.27	0.33	0.36	0.23	0.17
discharge (cu.m.)	0.50	0.09	1.33	0.12	0.74	0.62	0.04	1.48	10.40	12.19

Table 15 Mean value of water quality parameters at
Mae Ngat watershed

	N11	N12	N21	N22	N31	N32	N41	N42	N51	N52
air temperature (C)	21	21	21.333	22	21.167	21.5	23.833	23.5	24.167	24.1
water temperature(C)	20.567	20.433	21.133	21.5	20.833	20.833	23	23.3	23	23.167
pH	8.2433	8.1333	8.1333	7.1267	8.12	8.03	7.44	7.5967	7.4167	7.5633
conductivity (μs/cm)	243.83	237.33	338	219.33	322	293.67	57.867	76.1	81.633	66.1
TDS (mg/l)	120.97	116.17	168.67	110	161.67	146.33	29.033	38.1	40.867	33.1
PO4 (mg/l)	0.5567	0.5033	0.26	0.3467	0.5167	0.5833	0.14	0.3833	0.3633	0.4167
NO3-N (mg/l)	0.13	0.1433	0.8	0.3333	1.3667	1.4	1.2333	1.2	1.6	1.2333
NH3-N (mg/l)	0.22	0.2433	0.4767	0.76	0.5867	1.1067	0.5267	0.79	0.82	0.77
Turbid (FTU)	79	89	111	107	97.667	304.67	128	146.67	121	99.333
alkalinity (mg/l)	28.733	29.9	52.667	48	37.667	49	38	22.667	14.467	15.867
DO (mg/l)	8.2	7.8	8.1833	7.9	7.3	7.2	7.2333	7.2667	6.7333	6.7
BOD (mg/l)	0.8433	0.76	2.3667	0.9967	1.9667	0.9167	2.53	2.0867	3.0667	2.5833
width (m)	2.4333	2.4	2.4333	0.9667	2.2667	2.0333	1.8333	16.833	3.6	3.2667
dept (m)	0.11	0.1067	0.1433	0.1067	0.16	0.1333	0.14	1.0667	0.25	0.4733
velocity (m/s)	0.5733	0.5267	0.25	0.2567	0.56	0.75	0.3033	0.5867	0.29	0.45
discharge (cu.m.)	0.1659	0.1514	0.1402	0.0411	0.3397	0.237	0.0963	35.802	0.5317	1.4887

Table 16 Mean value of water quality parameters at the second part of Mae Ping watershed

	P11	P12	P21	P22	P31	P32	P41	P42	P51	P52
air temperature (C)	20.17	21.20	20.60	23.17	21.83	20.67	22.23	21.60	25.00	25.07
water temperature(C	19.33	21.23	20.93	21.03	19.43	20.00	21.00	21.50	25.80	25.60
pH	8.40	7.58	8.33	7.83	7.73	7.50	8.47	8.63	7.58	7.69
conductivity (μs/cm)	396.00	35.83	113.70	120.70	89.87	183.40	322.00	339.00	172.13	189.40
TDS (mg/l)	195.67	19.83	56.37	59.07	44.97	91.50	162.67	170.33	86.13	95.83
PO4 (mg/l)	0.23	0.26	0.31	0.40	0.31	0.67	0.49	0.33	0.31	0.34
NO3-N (mg/l)	2.00	0.97	0.42	0.80	1.00	1.10	1.43	1.40	1.03	1.37
NH3-N (mg/l)	0.20	0.24	0.09	0.15	0.13	0.20	0.12	0.14	0.27	0.34
Turbid (FTU)	18.33	30.67	11.00	24.67	11.33	10.33	14.67	32.00	31.00	39.00
alkalinity (mg/l)	65.33	13.00	20.33	20.00	15.00	29.00	55.00	57.67	42.00	60.67
DO (mg/l)	7.85	6.80	7.40	7.30	6.85	7.33	7.10	7.77	6.63	6.60
BOD (mg/l)	1.45	2.08	1.83	1.05	2.38	1.82	1.60	1.77	2.12	2.84
width (m)	1.25	3.30	1.43	2.72	1.20	2.40	4.17	6.50	33.77	34.80
dept (m)	0.07	0.11	0.17	0.17	0.14	0.50	0.61	0.35	2.05	2.19
velocity (m/s)	0.54	0.49	0.47	0.32	0.32	0.14	0.37	0.62	0.19	0.18
discharge (cu.m.)	0.06	0.17	0.15	0.18	0.07	0.24	1.58	2.70	14.24	15.65

Table 17 Mean value of water quality parameters at Mae Rim watershed

	R11	R12	R21	R22	R31	R32	R41	R42	R51	R52
air temperature (C)	19.83	19.83	22.83	21.17	20.10	19.67	22.33	24.17	24.00	24.00
water temperature(C)	19.33	19.33	22.90	21.17	18.83	19.50	22.33	22.17	22.73	22.33
pH	7.05	7.03	7.53	7.43	7.21	7.56	8.13	7.62	7.59	7.76
conductivity (μs/cm)	30.30	36.57	162.83	138.87	184.07	170.47	164.77	219.67	150.17	146.27
TDS (mg/l)	14.63	18.87	81.17	68.83	92.33	85.37	82.37	108.80	76.10	69.90
PO4 (mg/l)	0.22	0.29	0.71	0.18	0.27	0.33	0.44	0.45	0.61	0.41
NO3-N (mg/l)	0.75	0.70	1.03	0.83	0.83	0.67	0.87	0.97	0.79	0.77
NH3-N (mg/l)	0.25	0.33	0.58	0.32	0.27	0.30	0.30	0.36	0.51	0.38
Turbid (FTU)	36.00	28.33	42.00	31.67	44.33	35.00	61.33	59.67	59.00	56.33
alkalinity (mg/l)	23.67	20.83	33.67	23.67	30.47	26.33	26.00	31.67	39.33	35.67
DO (mg/l)	7.50	7.83	7.57	7.80	7.88	7.90	7.77	7.35	5.75	6.05
BOD (mg/l)	0.90	0.84	1.57	0.93	1.52	1.25	1.77	3.45	4.35	3.65
width (m)	0.82	1.30	1.10	1.70	1.07	2.33	2.83	2.57	5.00	7.00
dept (m)	26.67	26.17	0.19	0.31	0.14	0.28	0.31	0.30	1.52	0.48
velocity (m/s)	0.43	0.51	0.25	0.43	0.22	0.33	0.39	0.23	0.19	0.23
discharge (cu.m.)	0.16	0.32	0.09	0.40	0.06	0.38	0.52	0.17	2.37	1.31

Table 18 Mean value of water quality parameters at the upper part of Mae Ping watershed

	UP11	UP12	UP21	UP22	UP31	UP32	UP41	UP42	UP51	UP52
air temperature (C)	21.333	21	22.5	22.667	23	22.833	24.833	24.333	24.5	24.167
water temperature(C	20.833	20.667	21.167	21.333	21.667	21.833	23.167	23.833	23.667	23.1
pH	8.4233	8.4833	7.6667	7.74	7.9267	7.7333	7.4733	8.1833	8.04	8.0333
conductivity(μs/cm)	419	383.33	344	339.33	303.67	345.67	167.5	266.67	375	260.67
TDS (mg/l)	210.33	193.33	239	169.67	149.73	174	79.967	133.67	193.67	130.33
PO4 (mg/l)	0.1767	0.1833	0.1267	0.13	0.2133	0.1467	0.33	0.38	0.29	0.3467
NO3-N (mg/l)	0.3133	0.2933	0.54	0.3167	0.44	0.4067	0.44	0.3533	0.14	0.4
NH3-N (mg/l)	0.09	0.1733	0.2333	0.1167	0.25	0.1733	0.4767	0.4433	0.7633	0.3967
Turbid (FTU)	48.333	50.333	29.667	22.667	34	23.667	32.333	26.667	28.667	41.333
alkalinity (mg/l)	141	160.33	124.67	124.67	112.33	126.67	28.667	34.667	65.333	47.667
DO (mg/l)	8.05	7.92	7.4533	7.4	7.1667	7.2667	7.1667	7.5	6.3667	7.7167
BOD (mg/l)	0.9533	0.8833	1.4133	1.4733	2.2267	1.6167	1.9167	1.6	1.6667	0.8667
width (m)	1.5333	1.8	8.6333	8.8	1.9333	8.9667	2.1	8.5933	2.4333	10.083
dept (m)	0.2067	0.14	0.98	0.6333	0.2833	0.65	0.3167	1.04	0.2867	1.08
velocity (m/s)	0.4833	0.55	0.5	0.5767	0.6333	0.55	0.1867	0.43	0.3033	0.2467
discharge (cu.m.)	0.21	0.18	5.2	4.51	0.43	4.76	0.17	0.8	0.27	3.22

Table 19 Water quality parameters at site before wastewater treanment plant (M1) in Huai Jo stream

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
air temperature (C)	19	22	24	23	21	25	24	23.5	22	21	20.5	20
water Temperature (C)	22.2	23	26.5	26	21	28	26	26.2	23	24	22.3	22.5
pH	7.46	7.8	7.8	7.9	7.8	7.6	7.6	8.1	8	7.8	7.6	7.3
conductivity (uS/cm)	215	220	171.2	114.4	141.2	83.7	128	150	133.7	185.1	184.5	153.3
TDS	107.8	111	85.7	56.7	70.7	41.8	64	74.7	66.9	92.5	92.1	76.7
PO4 (mg/l)	0.38	0.35	0.26	0.57	0.39	0.22	0.19	0.18	0.2	0.39	0.34	0.27
NO3-N (mg/l)	0.8	0.8	1	0.9	1	0.9	2	0.9	0.7	1	0.8	0.8
NH3-N (mg/l)	0.43	0.45	0.41	0.58	0.57	0.48	0.49	0.5	0.34	0.28	0.44	0.38
turbidity (FTU)	42	67	31	60	70	85	487	93	54	126	58	42
alkalinity (mg/l)	28	27	25	22	21	18	14	18	21	28	28	18
DO (mg/l)	7.7	7.8	6.9	6	6.8	8.2	7.35	7.8	7.8	7.9	7.9	7.6
BOD5 (mg/l)	1.2	1	4.3	1.29	10.2	0.9	1.02	0.9	0.7	1.8	0.8	1.2
width (m)	13	25	15	10	12	12	20	22	13	35	16	10
depth (m)	3.5	3.41	2.3	2.4	4	4	3.8	3.9	3	4	3.2	3.4
velocity (m/s)	2.65	3.24	2.25	3	5.4	5.7	2.48	4.2	1.83	2.28	2.8	3.41

Table 20 Water quality parameters at site before wastewater treanment plant (M2) in Huai Jo stream

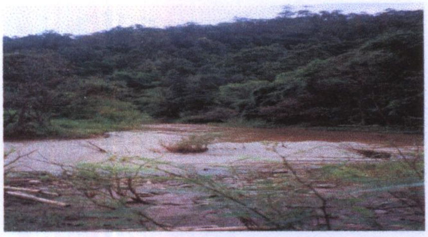
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
air temperature (C)	19	21	24.5	23	21	25	24	23	22	22	21	20
water Temperature (C)	22	23.5	26	26	21	27.5	26	26	23	24	22.5	22
pH	7.3	8.1	7.8	7.9	7.7	7.3	7.6	8.1	8	7.8	7.8	7.3
conductivity (uS/cm)	222	243	173.9	105.9	141.4	88.7	129.9	152.2	133.7	189.2	186.3	154.8
TDS	111.5	122	87.2	58.4	70.7	44.3	64.9	76.1	65.5	94.6	92.2	77.42
PO4 (mg/l)	0.31	0.3	0.12	1.03	0.33	0.15	0.22	0.2	0.17	0.4	0.34	0.28
NO3-N (mg/l)	0.8	0.8	1.6	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.7	0.9
NH3-N (mg/l)	0.4	0.45	0.38	0.58	0.5	0.5	0.43	0.43	0.32	0.24	0.4	0.41
turbidity (FTU)	40	42	32	61	64	78	389	84	54	110	61	39
alkalinity (mg/l)	30	29	25	22	25	14	15	22	22	29	29	16
DO (mg/l)	7.8	7.5	7.8	5	6.65	8.3	7.7	7.4	7.35	7.9	8.1	7.3
BOD5 (mg/l)	1.25	0.7	7.3	1	9.8	1.2	1.1	1.1	0.95	0.8	1.2	1.3
width (m)	17	28	22	20	25	25	20	31	35	65	23	14
depth (m)	3.5	3.5	2.4	2.5	3.8	4.2	3.5	3.5	3.2	4.2	3.6	3.4
velocity (m/s)	2.5	3.1	2.4	2.55	5.6	5.4	2.48	3.69	2.14	2.5	2.83	2.98

Table 21 Water quality parameters at site after wastewater treanment plant (M3)
in Huai Jo stream

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
air temperature (C)	19	21	24	24	20.5	26	24	23	22.5	22	21	20.5
water Temperature (C)	22.5	23	26	26.5	21	28	26.5	26	24	24	23	22.5
pH	7.3	7.3	8.2	7.8	7.6	7.3	7.7	8.3	7.9	8	7.9	7.6
conductivity (uS/cm)	236	230	172.2	126.8	197.3	101.7	142.5	154.6	136.2	197.7	191.7	160.1
TDS	119	115	86	63.5	98.6	51	71.2	77.3	68.1	99.1	95.87	80
PO4 (mg/l)	0.44	0.33	0.18	0.71	0.97	0.33	0.2	0.25	0.25	0.33	0.8	0.35
NO3-N (mg/l)	0.9	0.8	1.1	1.1	0.9	1	0.9	1.1	0.7	0.7	1	1.4
NH3-N (mg/l)	0.77	1.05	0.46	1.12	2.76	1.11	0.6	0.61	0.52	0.38	0.81	0.59
turbidity (FTU)	49	48	34	71	85	84	184	105	56	103	78	44
alkalinity (mg/l)	36	38	25	18	28	16	17	23	21	31	35	25
DO (mg/l)	8.6	7.8	7.7	5.9	5.1	7.8	7	7.5	7	7.8	7.9	7.8
BOD5 (mg/l)	12.3	7.8	6.7	2.4	13.2	3.1	2.5	1.6	3.4	1.2	1.6	2.8
width (m)	30	35	30	30	30	30	40	40	40	73	34	30
depth (m)	2.7	2.3	2.1	2.3	3.5	3.5	3.4	3.2	3.5	4	2.9	2.8
velocity (m/s)	2.2	3	2.2	3	3.6	4.2	2.57	4.7	1.34	1.87	2.55	2.51

Table 22 Water quality parameters at site after wastewater treatment plant (M_4) in Huai Jo stream

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
air temperature (C)	19	21	24	23	19	25.5	23.5	23.5	22.5	20.2	20.5	20
water Temperature (C)	22.2	23	26	26	21	28	27	26	24	23.5	23	22.5
pH	7.33	7.4	8.2	8.1	7.5	7.3	7.8	8.2	7.8	8.1	7.8	7.8
conductivity (uS/cm)	238	232	176.4	128	205	106.4	151	165.4	141.5	197.3	191.6	162.2
TDS	119.2	116	88.3	64.2	103	53	75.6	82.2	70.8	98.7	95.8	82.1
PO4 (mg/l)	0.25	0.31	0.2	0.81	0.86	0.5	0.24	0.25	0.25	0.33	0.39	0.31
NO3-N (mg/l)	0.8	0.9	1.1	1.1	1.4	1.3	1.1	0.8	0.9	0.7	0.9	0.9
NH3-N (mg/l)	0.47	0.81	0.35	0.86	3.14	0.44	0.62	0.64	0.53	0.23	0.47	0.47
turbidity (FTU)	33	50	37	64	66	84	285	85	62	97	60	40
alkalinity (mg/l)	28	32	26	22	30	16	16	23	21	34	31	17
DO (mg/l)	7	7.7	7.2	6.7	4.4	7.8	7	7	7	7.2	7	7.4
BOD5 (mg/l)	4.5	4.3	6.1	2.5	9.6	2.2	2	0.9	2.2	1	0.8	2.2
width (m)	22	25	18	25	10	15	20	21	20	44	20	21
depth (m)	3.4	3.3	2.1	2.5	4.1	4.5	4.5	4	4	4.5	3.4	3.6
velocity (m/s)	2.1	2.44	2.1	4	3.4	4.7	2.6	4.7	1.34	2.1	2.31	2.5



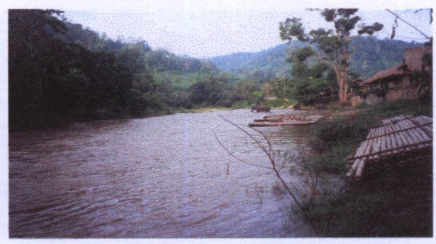
Ban Pang Ko (T11)

Ban Thung Pa Sang (T12)

Ban Huai San (T21)

Ban sop Kai (T22)

Ban Mae Taman (T31)



Elephant Training Camp (T32)

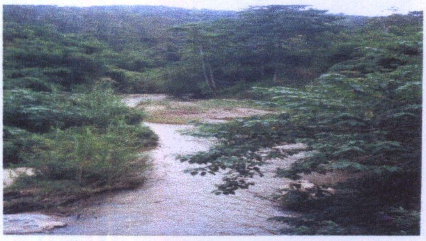
Ban Hua Thung (T41)

Ban Hua Pa Sang (T42)

Amphoe Mae Taeng (T51)

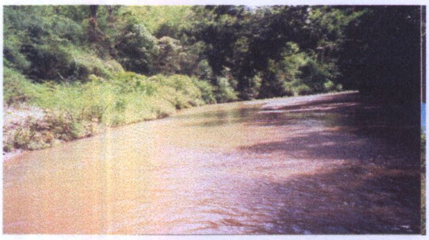
Taeng river side village (T52)

Figure 1 Study sites in Mae Taeng
The first number mean watershed class and the second number mean the replicate in each watershed class.

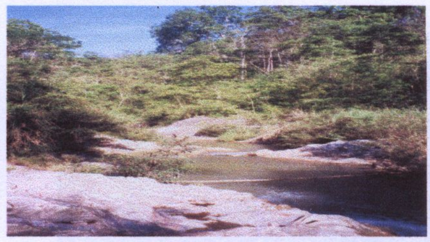


Huai Chok (KH11)

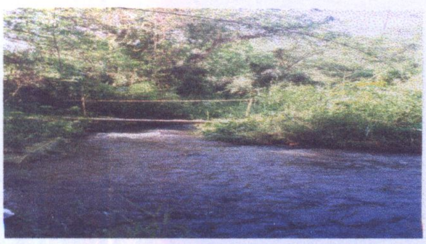
Ban Hat Som Poi (KH12)



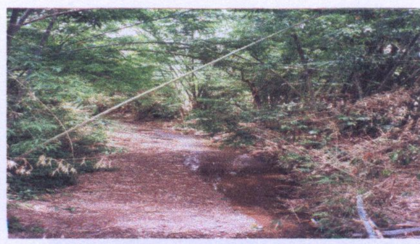
Ban Mae Khan (KH21)



Ban Mae Lan Kham (KH22)

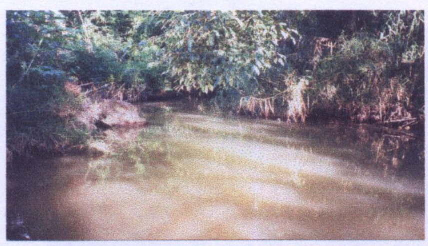


Mae Sap Reservoir (KH31)



Ban Om Long (KH32)

Ban Pa Kluai Long (KH41)



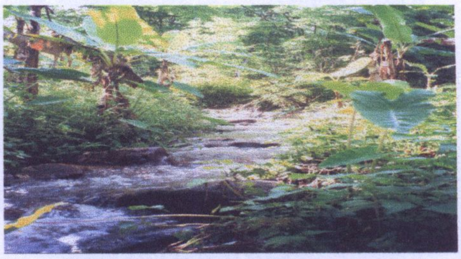
Ban Lao Saen Tong (KH42)

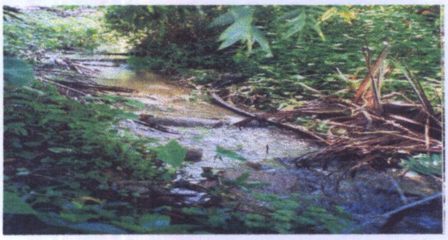
Ban Piang (KH51)

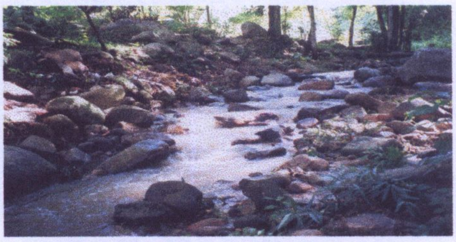
Ban Makai Yon (KH52)

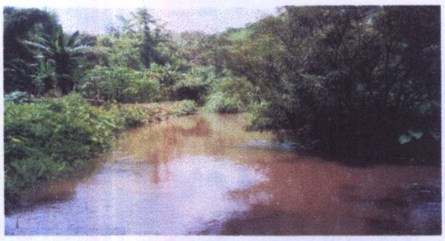
Figure 2 Study sites in Mae Khan
The first number mean watershed class and the second number mean the replicate in each watershed class.

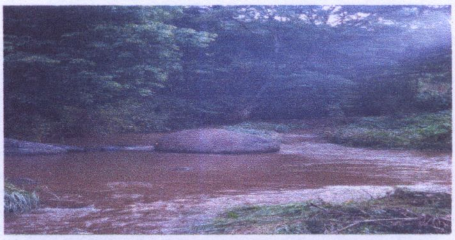

Ban Pang Mun (K11)

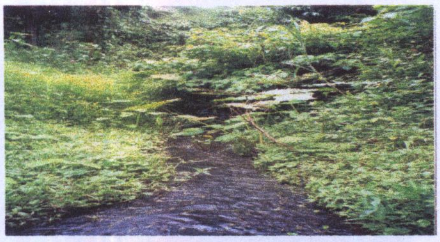

Ban Pang Aun (K12)


Ban Pang Num Thu (K22)


Ban Moe (K21)


Num Mae Wang (K31)


Num Mae won (K32)


Ban Sala Pang Sak (K41)


Ban Pong Din (K42)


Ban Rom Pa Tong (K51)

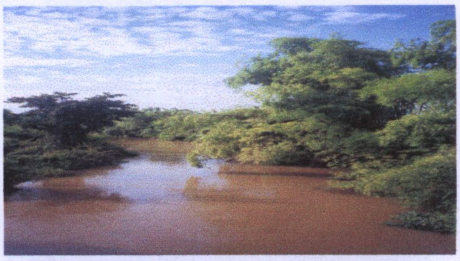
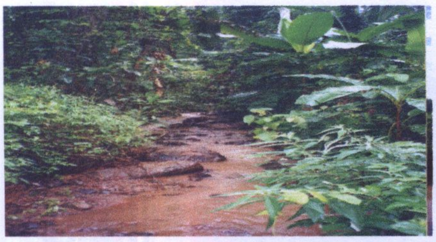
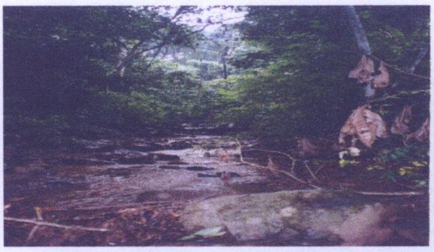

Amphoe Muang Lumphun (K52)

Figure 3 Study sites in Mae Kuang
The first number mean watershed class and the second number mean the replicate in each watershed class.



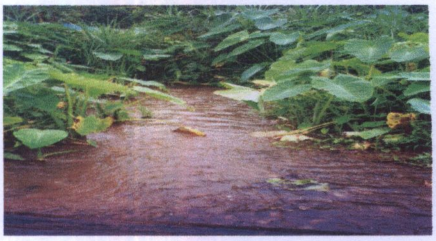
Huai Mae Phaeng (N11)



Mon Hin Lin (N12)

Huai Mae Rang (N21)

Ban Pha Hin (N22)



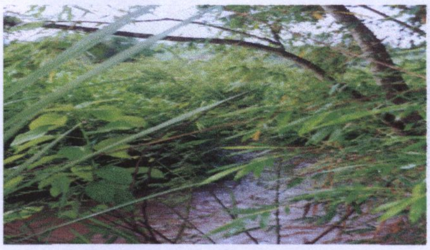
Ban Mae Rangong (N31)

Ban Mae Rangong Noi (N32)

Ban Thung Dang (N41)

Ban Na muang (N42)

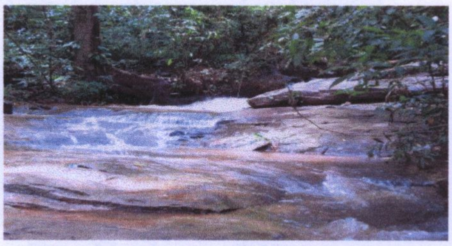
Ban Sop Pang (N51)



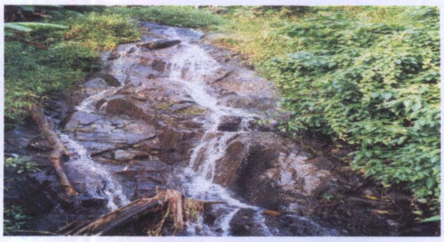
Ban Huai Sai (N52)

Figure 4 Study sites in Mae Ngat
The first number mean watershed class and the second number mean the replicate in each watershed class.

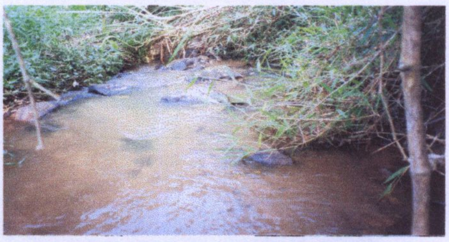
Huai Nong Hoi (P11)



Huai Kaew stream (P12)



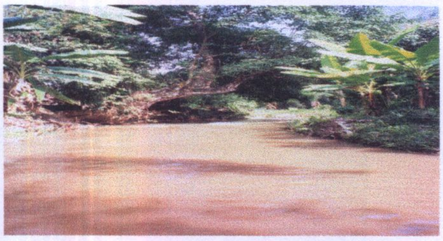
Na Liu Water fall (P21)



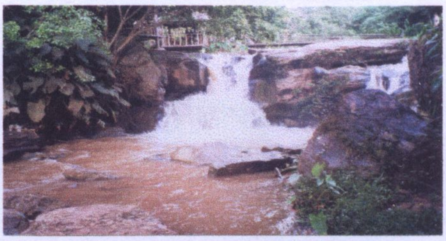
Huai Mae Hoi (P22)

Ban Kong Hae (P31)

Huai Suwan (P32)

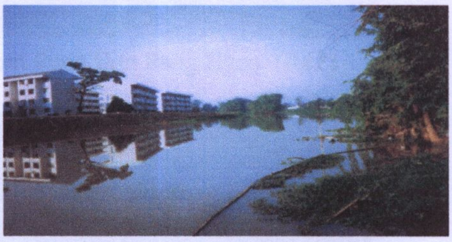


Ban Mae Mhae (P41)



Nam Mae Sa (P42)

Amphoe Muang Chiang Mai (P51)



Meangrai Bridge (P52)

Figure 5 Study sites in the second part of Mae Ping watershed
The first number mean watershed class and the second number mean the replicate in each watershed class.

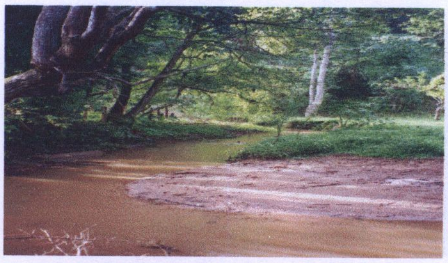
Ban Mae Luang (R11)

Ban Yang Mae Luang (R12)

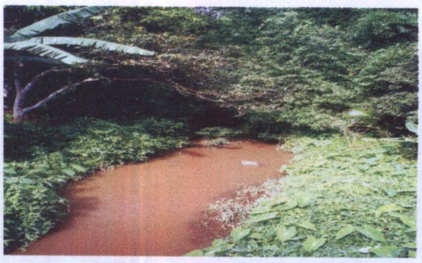
Ban Pang Pa Kha (R21)

Ban Pang Lamyai (R22)

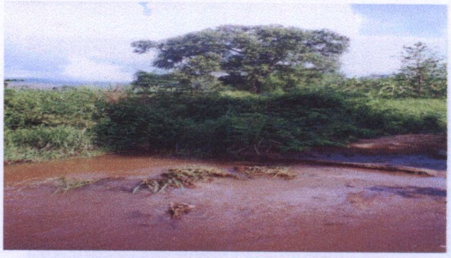
Huau Khrau (R31)



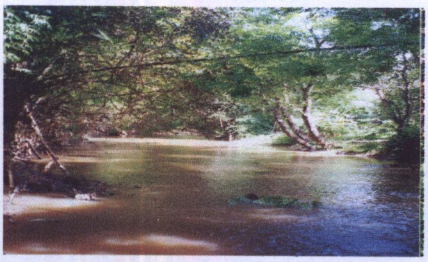
Ban Pang Hai (R32)



Ban Mae Ram Noi (R41)



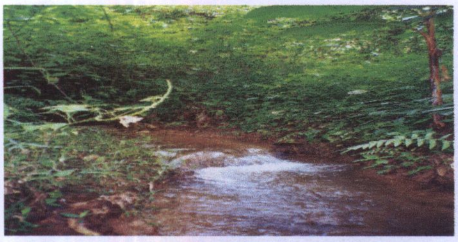
Huai Pang,Ban Pang Haeo (R42)



Amphoe Mae Rim (R51)

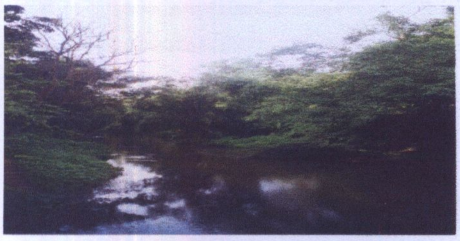
Ban Oi (R52)

Figure 6 Study sites in Mae Rim
The first number mean watershed class and the second number mean the replicate in each watershed class.

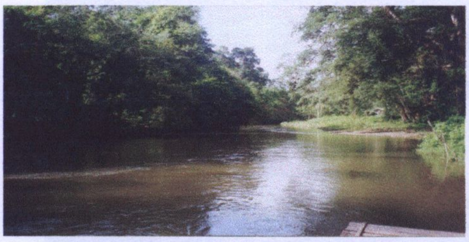


Ban Muso Hua Mae Ja 1 (UP11)

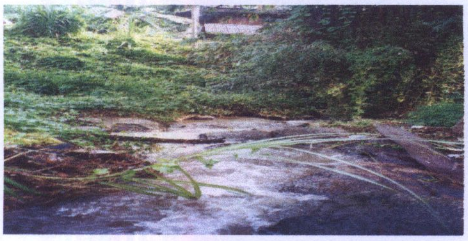
Ban Muso Hua Mae Ja 2 (UP12)



Chiang Dao (UP21)



Ban Mae Talai (UP22)

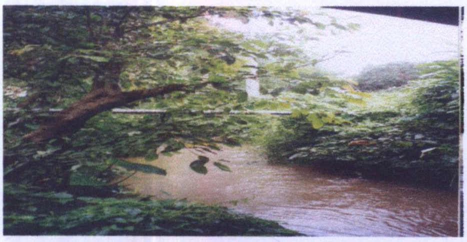


Keang Pan Tao (UP31)

Ban Tubkanin (UP32)

Num Mae Khon (UP41)

Ban Ping Kong (UP42)

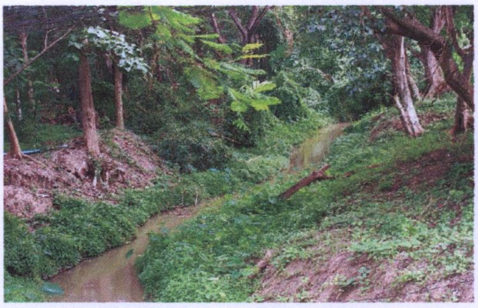


Huai Kit, Chiang Dao (UP51)

Ban Mae Ja (UP52)

Figure 7 Study sites in the upper Part of Mae Ping
The first number means watershed class and the second number means the replicate in each watershed class.

M1: before wastewater treatment plant



M2: before Wastewater treatment plant

M3: after wastewater treatment plant

M4: after wastewater treatment plant

Figure 8 Study in Huai Jo stream

Appendix B

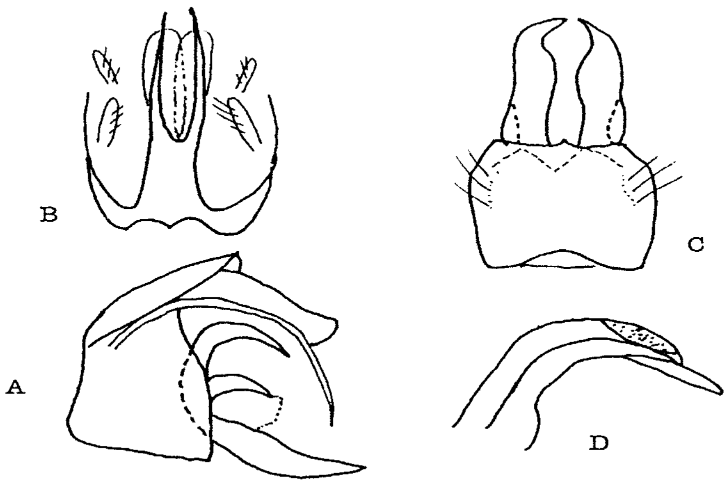


Figure 1 Male genitalia of *Setodes* sp.1

A. genitalia, lateral view, B. dorsal view, C. ventral view,

D. aedeagus, lateral view.

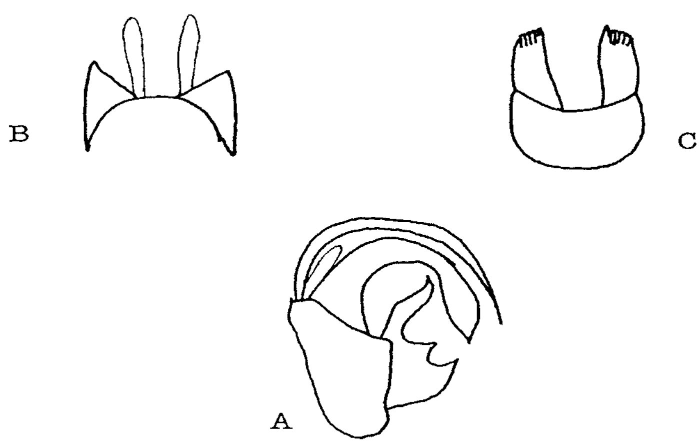


Figure 2 Male genitalia of *Setodes* sp.2

A. genitalia, lateral view, B. dorsal view, C. ventral view.

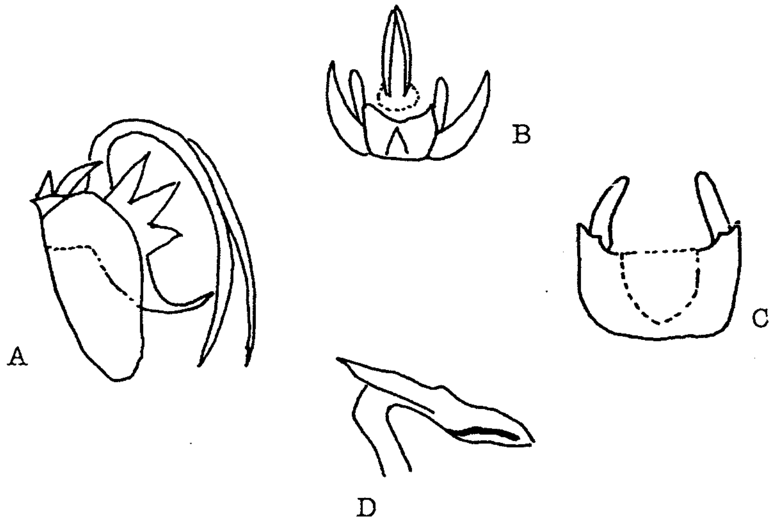


Figure 3 Male genitalia of *Setodes* sp.3

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

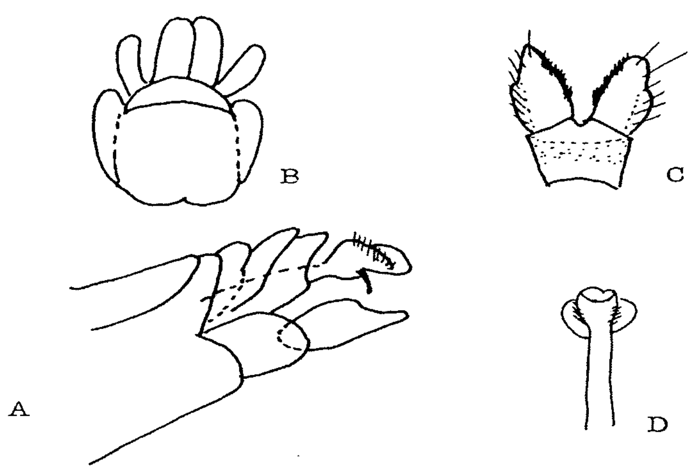


Figure 4 Male genitalia of *Adicella* sp.1

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

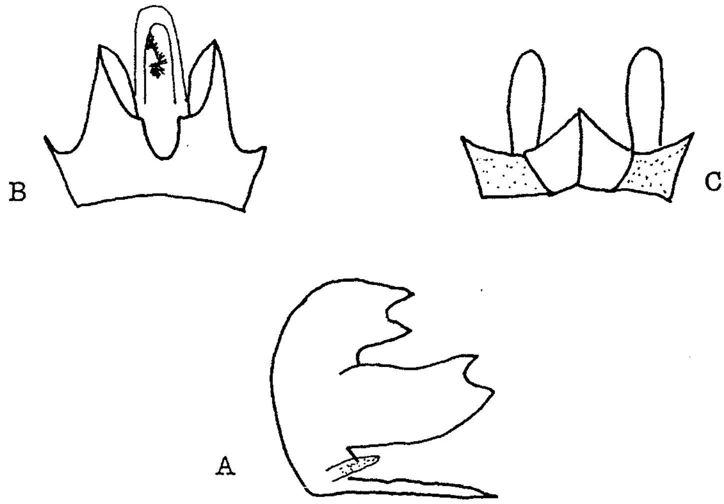


Figure 5 Male genitalia of *Adicella* sp.2

A. genitalia, lateral view, B. dorsal view, C. ventral view

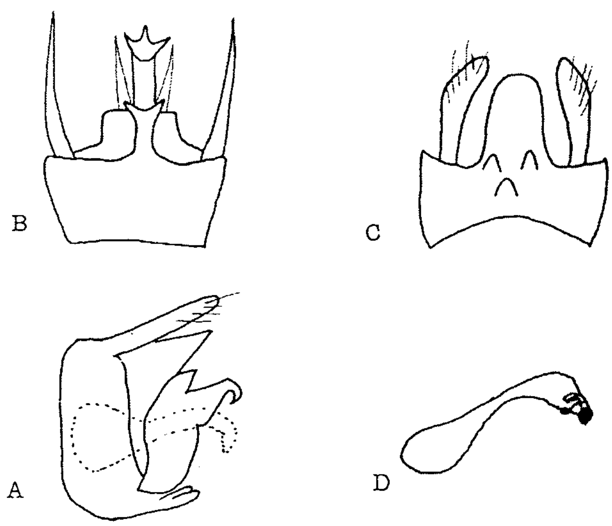


Figure 6 Male genitalia of *Adicella* sp.3

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus lateral view.

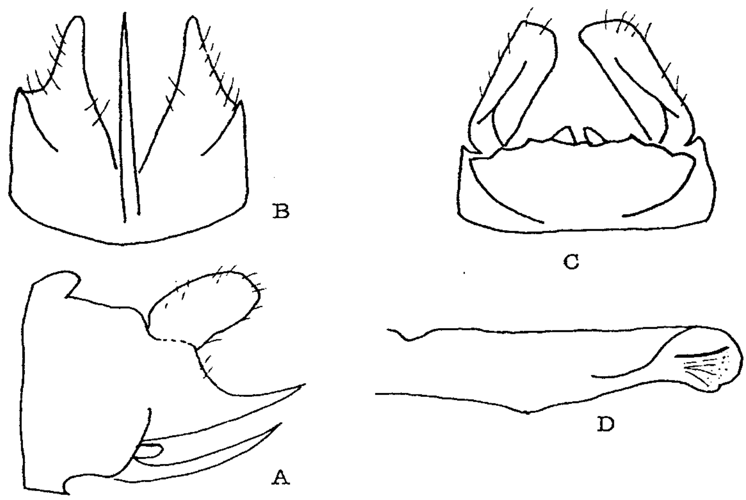


Figure 7 Male genitalia of *Adicella* sp.4

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus lateral view.

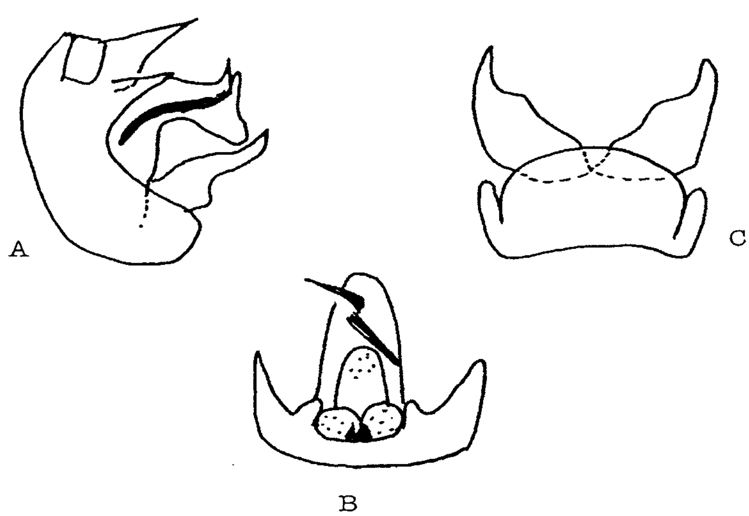


Figure 8 Male genitalia of *Adicella* sp.5

A. genitalia, lateral view,B. dorsal view, C. ventral view.

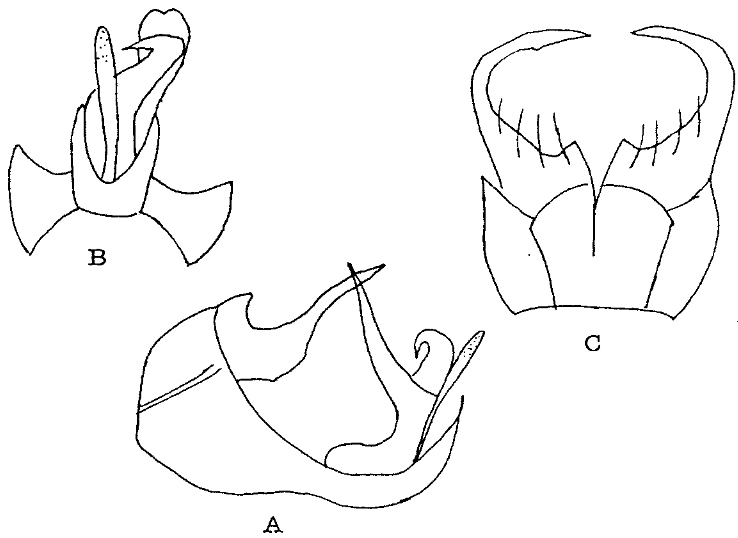


Figure 9 Male genitalia of *Ceraclea* sp.1

A. genitalia, lateral view, B. dorsal view, C. ventral view.

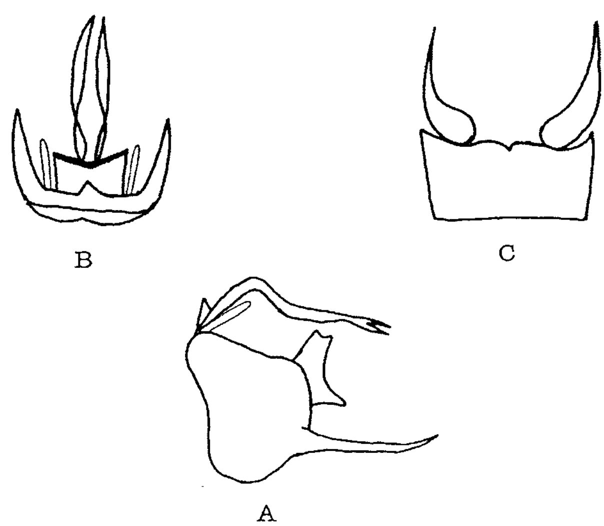


Figure 10 Male genitalia of *Ceraclea* sp.2

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

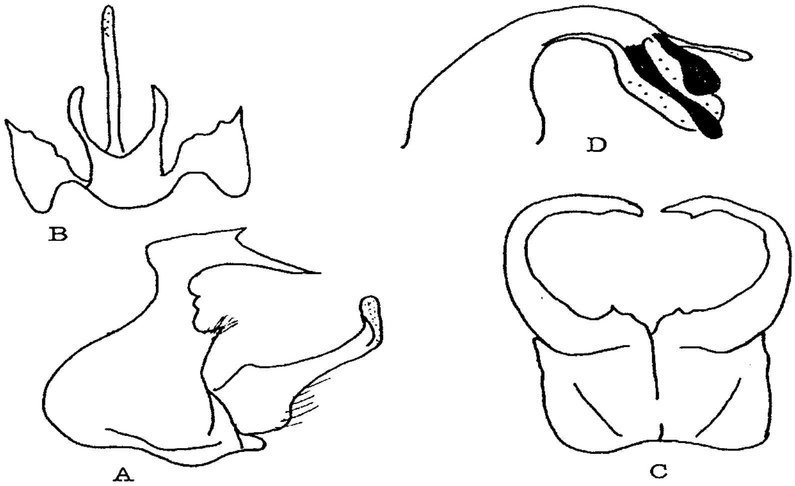


Figure 11 Male genitalia of *Ceraclea* sp.3

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus lateral view.

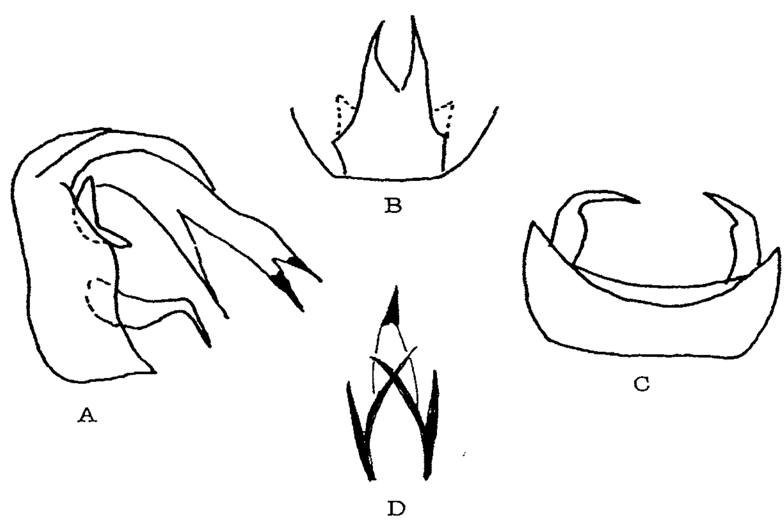


Figure 12 Male genitalia of *Ceraclea* sp.4

A. genitalia, lateral view, B. dorsal view,

C. ventral view.

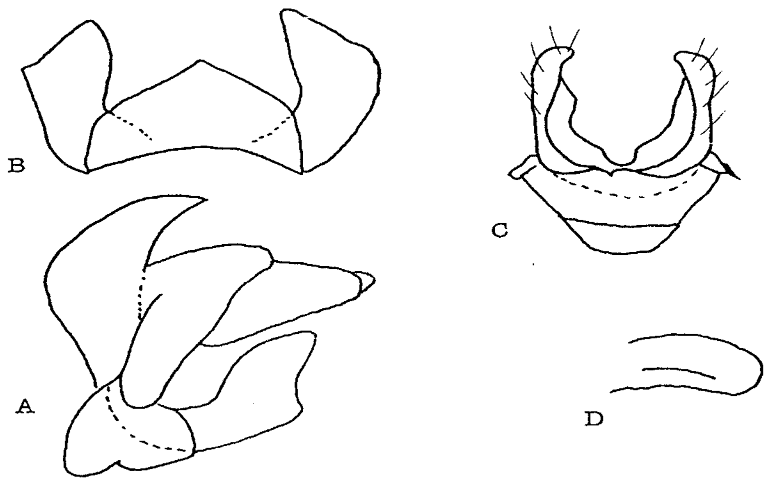


Figure 13 Male genitalia of *Ceraclea* sp.5

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

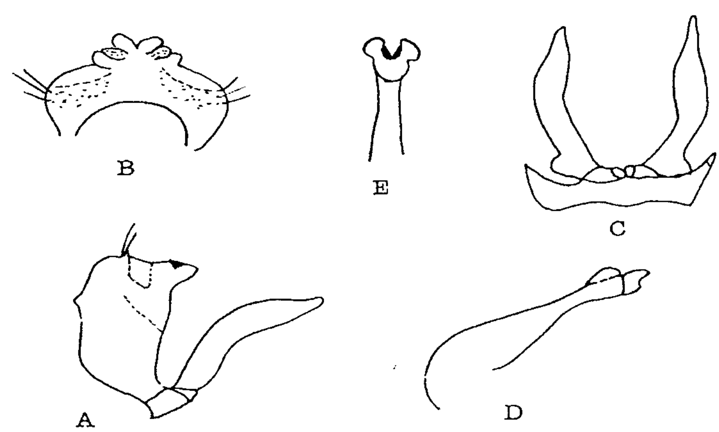


Figure 14 Male genitalia of *Cheumatopsyche* sp.1

A. genitalia, lateral view, B. dorsal view, C. ventral view,

D. aedeagus dorsal view, E. aedeagus ventral view

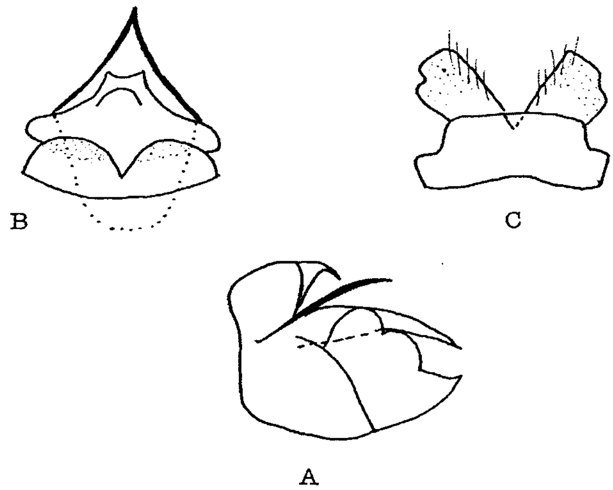


Figure 15 Male genitalia of *Leptoceridae* sp.1

A. genitalia, lateral view, B. dorsal view,

C. ventral view

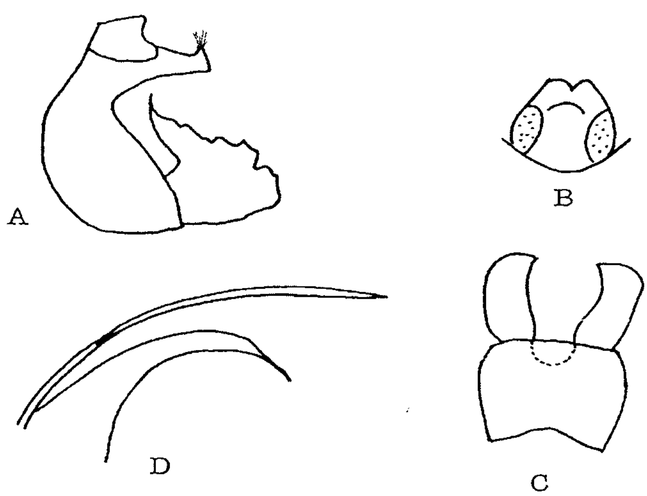


Figure 16 Male genitalia of *Leptoceridae* sp.2

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

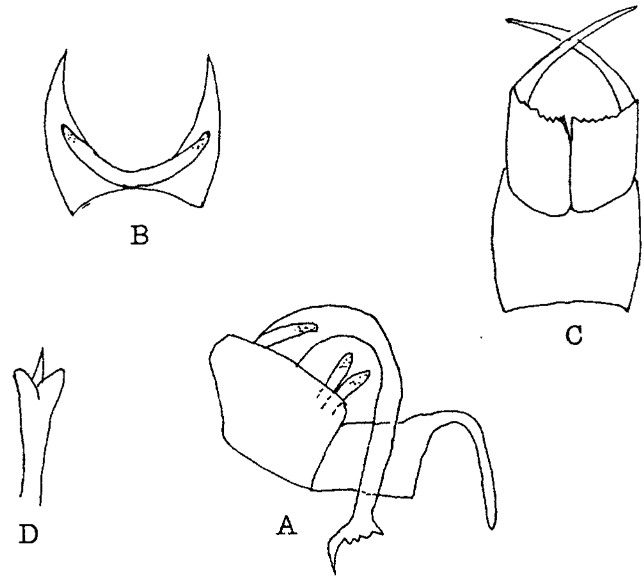


Figure 17 Male genitalia of *Leptocerus* sp.3

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view

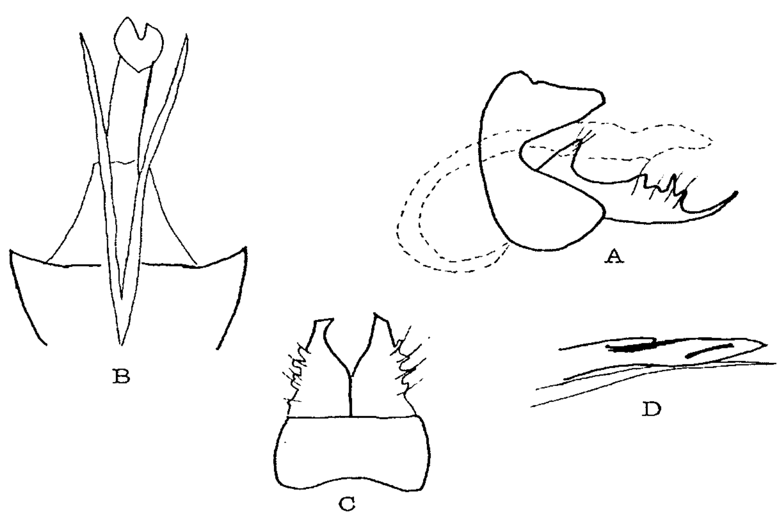


Figure 18 Male genitalia of unknown sp.1

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

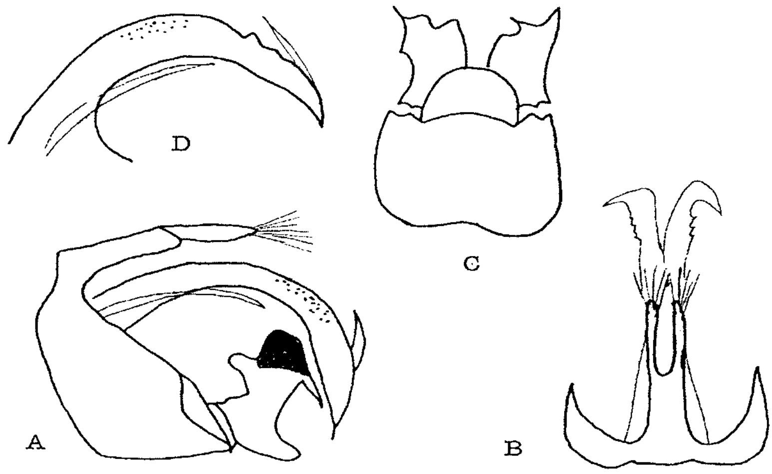


Figure 19 Male genitalia of *Triaenodes* sp.1

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

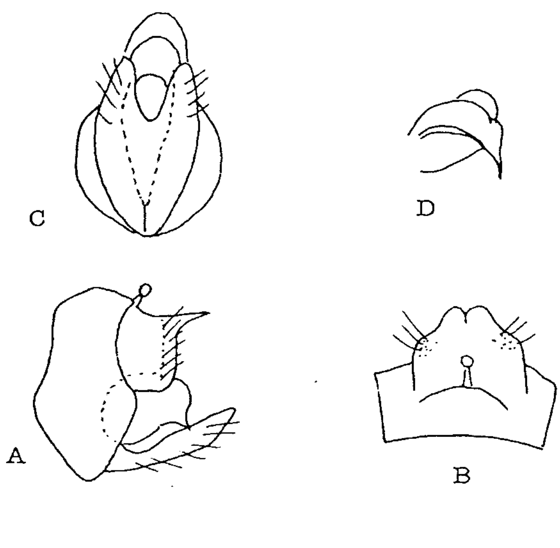


Figure 20 Male genitalia of unknown sp. 2

A. genitalia, lateral view, B. dorsal view,

C. ventral view, D. aedeagus dorsal view.

Vita

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Malicky H., Chantaramongkol P., Siraporn C. and Saengpradab N. 2001. Einige neue Kocherfliegen (Trichoptera)aus Thailand (Arbeit Nr. 32 uber thailandische Kocherfliegen) Braueria., 28, 11-14.

Malicky H., Chantaramongkol P., Saengpradab N., Chaibu P., Thani I., Changthong N., Cheunbarn S., Laudee P., Prommi T. and Sompong S. 2002. Neue asiatische Leptoceridae (Trichoptera)(Zugleich Arbeit Nr. 33 Uber thailandische Kocherfliegen) Braueria., 29, 15-30.