Biodiversity, Culture, and Ecology of Trichoptera from Phum Duang tributaries, Surat Thani Province, Southern Thailand

Solomon Boga Valdon

A Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy Aquaculture and Fishery Resources (International Program)
Prince of Songkla University
2022

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Author Mr. Solomon Boga Valdon

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ABSTRACT

Khao Sok, Khlong Phanom, Kaengkrung National parks, and Khlong Saeng Wildlife Sanctuary are among the protected areas in Surat Thani Province. They are located on the western side of Surat Thani city. This area is part of the lowlands of the Lower Phuket Mountain range, an extension of the Tenasserim Hills of the Indo-Malayan Mountain system, and serves as the main source of water supply to the streams of Khlong Sok, Khlong Phanom, Khlong Saeng, and Khlong Yang. These tributaries drain most of the eastern side of the Phuket Mountain range, they converged to form Phum Duang before joining the Tapi river which empties into the Thai gulf. To investigate the occurrence, distribution, and abundance of Trichoptera fauna, and to observe the life cycle and their ecological roles in this area, a survey was carried out in March-December 2019. The survey was conducted along Khlong Sok, Khlong Phanom, Khlong Saeng, and Khlong Yan tributaries. The result showed that eighteen families (18), fifty-one (51) genera, and two hundred and one (201) instant species were found. Families Leptoceridae, Hydropsychidae, Philopotamidae, and Ecnomidae were the most diverse and abundant and constituted more than sixty percent (60%) of the total population of the insects observed. During the research, a new species of Agapetus kaengkrungensis belonging to the Family Glossosomatidae was described and added knowledge to science. Three new records were also found *Polymorphanisus scutellatus* BANKS 1939* *Cheumatopsyche opposita* BANKS 1931* *Cheumatopsyche contexta* ULMER 1951*. The relationship of water quality parameters recorded during the survey was analyzed using Pearson's Correlation method, the result showed that some species displayed both positive and negative responses to some water environmental variables. The life cycle of the *Macrostemum floridum* of the Hydropsychidae family, one of the common and dominant species in the survey was studied. The larval collection was from February to July 2021, a total of one hundred and twenty-five (125) larvae were collected. Identification and morphological description of the final instar were made. The larva has five distinct instar developmental stages (I-V). A graphical representation of the five instars was also produced to

further describe the progressive distribution of the larvae from the first to the final instars. The study included their importance as sources of food for fish as well as their ecological roles in processing organic matter and energy translocation. Further observations extended to the food and feeding habits of *M. floridum* larvae which revealed that its major food resources consumed were blue-green algae, green algae, and diatoms.

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Solomon Boga Valdon

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LIST OF ABBREVIATIONS AND SYMBOLS

cm	=	centimeter
^0C	=	degree Celsius
m	=	meter
pH	=	potential of hydrogen
s	=	second
mg/l	=	milligrams per liter
µS/cm	=	micro siemens per centimeter
DO	=	dissolved oxygen
EC	=	electrical conductivity
TDS	=	total dissolved solids
W	=	watts
UV	=	ultraviolet light
LDO	=	luminescent dissolved oxygen sensors
DC	=	direct current
SD	=	standard deviation
V	=	velocity
N	=	north
E	=	east
KOH	=	potassium hydroxide
*	=	asterisk to signify new record
♂	=	male
♀	=	female

+	=	plus
-	=	minus
Borneo	=	(Brunei, Kalimantan, Sabah, Sarawak)

CHAPTER 1 Introduction

1.1 Research Rationale

The world's tropical zone is considered a zone of greatest biodiversity because it contains most of the biologically diverse species of flora and fauna simply referred to as hotspots of biodiversity (Myers et al., 2000). Asia is the most extensive continent consisting of two biogeographical regions of Oriental and East Palearctic regions, marked by ultimate climate and topography (Morse, 2016). Southeast Asia is located in this zone and is characterized by high biodiversity, especially of aquatic insects (Malicky et al., 2014). The Tenasserim hills of the Indo-Malayan Mountain system in Southeast Asia are found in Thailand. This mountain range runs from the north to the south on the Thai-Malay Peninsula. Tenasserim Mountain System is divided into the Lower, Middle, and Upper ranges (Laudee et al., 2017). The Phuket Mountain range falls on the lower range south of Thailand, the mountain types are limestone in nature and are mostly covered by dense tropical moist forest species which supports the proliferation of insects especially aquatic insects (Malicky et al., 2019).

Aquatic insects are groups of invertebrates that spend part or entire lives in water. There are twelve orders of aquatic insects distributed globally. Their immature stages form a major component of aquatic macroinvertebrates as benthos and are commonly used as biological indicators of their environment. The most frequently used species are members of the order Trichoptera, Ephemeroptera, and Plecoptera. Trichoptera (Caddisflies) are members of the holometabolous insects, with terrestrial adults and aquatic immature stages. These species are widely used for the study of biodiversity, distribution, and ecology of streams, rivers, and other water sources. Caddisflies are widely distributed in Thailand and most of the specimens found were identified as species (Cheunban and Chantaramongkol, 2005; Malicky, 2010). The reports of Thapanya et al. (2004) and Bunlue et al. (2012) showed that caddisflies are comprehensively studied in Doi Suthep-Pui and Doi Inthanon the hotspots of biodiversity in northern Thailand, however, other parts seem to be underexploited. Prommi et al. (2006) and Laudee (2008) reported that the study of Trichoptera in Thailand has been mainly on the diversity of the adults. Moreso, Laudee and Prommi (2011) and Prommi and Permkam (2010) showed that the studies of caddisflies in southern Thailand have been inadequate with many species likely remaining to be observed and described. In addition, Prommi et al. (2006) and Prommi and Thani (2014) showed that there has been little information on the immature stages of Trichoptera in Thailand which are commonly used as natural fish food. Aquatic insects particularly belonging to the order Trichoptera, Ephemeroptera and Plecoptera represent the largest groups of insects that are good indicators of environmental fluctuations (Stoyanova et al., 2014). Dudgeon (1999) revealed that Trichoptera is an extensive group of aquatic insects that function as secondary consumers, tertiary consumers, or predators in the aquatic ecosystem.

Trichoptera larvae and other macroinvertebrates are a staple source of food for many freshwater fishes (Wade, 1972). Harrison et al. (2007) showed that macroinvertebrates of Trichoptera, Ephemeroptera, and Plecoptera are major valuable food for freshwater fish. Caddisflies are important in aquatic ecosystems because they process organic matter and serve as a good source of food for fish (Cavallaro et al., 2015; Wiggins, 2007; Bouchard, 2004; Voshell and Reese, 2002). Further, Wiggins (2007) emphasized that fish are the main predators of Trichoptera, other aquatic insect larvae, and freshwater invertebrates. Generally, Trichopteran larvae constitute a significant proportion of aquatic macroinvertebrates and are beneficial in pond farming because they represent an important source of natural food for fish (Mitra and Kumar, 1988). Holzenthal et al. (2015) showed that Caddisflies larvae constitute a major food item for many predators in aquatic habitats such as fish. Caddisflies insects are popular with fishermen globally, they sometimes construct structures resembling their larvae or adults and use them as baits to attract fish during fishing activities (McCafferty, 1983; Neboiss et al., 1989; Nair et al., 2015).

This study was conducted along Phum Duang tributaries (Khlong Sok, Khlong Phanom, Khlong Saeng, and Khlong Yan streams). This is part of the lowlands of the Lower Phuket Mountain ranges. The Phuket Mountain types are limestone in nature and are mostly covered by dense moist forest species. Phum Duang is the main tributary of the Tapi river and drains the western Land of the Tapi watershed. The presence of three National parks and two wildlife sanctuaries indicates that the area is of high biodiversity. However, unlike plants and terrestrial animals which are well known and studied, no record of aquatic insects (Trichoptera) usually used to assess water quality is unavailable, hence the reason for the study.

1.2 **Objectives**

1.2.1 to study biodiversity and occurrence of Trichoptera in Phum Duang tributaries

1.2.2 to culture dominant species (*Macrostemum floridum*) from Phum Duang tributaries to be used as fish feed

1.2.3 to observe the ecological role of Caddisflies larvae in Phum Duang tributaries

1.3 Expected Advantages

1.3.1 to provide valuable knowledge on biodiversity and distribution of Trichoptera along Phum Duang tributaries

1.3.2 to provide a document on the culture of Trichoptera for artificial multiplication.

1.3.3 reveal the ecological roles of Trichopteran larvae in Phum Duang tributaries

1.3.4 preserve Holotype and Paratype specimens in Natural History museums such as Princess Maha Chakri Sirindhorn Natural History Museum.

1.4 Literature Review

1.4.1 Biodiversity

Biodiversity is a short form of biological diversity, which refers to the diverse groups of living organisms in an ecosystem or on earth. It is a contracted term for biological diversity that largely means the variation and diversities of life on Earth. Biodiversity can be defined as the differences that exist within species, between species, or ecosystems. This can be in form of genetic variation, ecosystem variation, or species variation existing in an area, habitat, or planet (Koperski, 2011. Biodiversity is a broad word that could be used to represent the variety of genes, species, and ecosystems in any territory (Enger and Smith, 2010). It could be a substitute for numerical values, or the population of individual species living within a particular habitat. Biodiversity can be described as the form of habitat diversity, species diversity, and genetic diversity. Habitat diversity represents all kinds of habitats present in a region; species diversities describe the number of species present in an area While genetic diversity refers to the various types of genes in a population (Enger and Smith, 2010). It is important to understand the diversities of flora and fauna, commonly referred to as biodiversity because of its essential values including biological and ecosystem values, resources, and cultural values.

Globally regions of high biodiversity in terms of both flora and fauna are regarded as hotspots of biodiversity. These areas or regions usually have high species richness. Biodiversity hotspots are areas of rich diversities of abundant species, threatened species, rare species, or their combination, experiencing threats of habitat loss (Reid, 1998). This forms the basis for conservation principles to prevent the extinction of species. There has been an increase in the reduction of biodiversity worldwide due to continuous expended pressure on organisms in their domain for different purposes (Diaz et al., 2006). Therefore, it is significant to highlight that biodiversity is lost when populations or biota decrease in size, when ecosystems are destroyed by human activities, or when species become extinct.

Conservation principles usually adopted to preserve biodiversity involve a choice between the desire to use biotic resources and the intention to maintain them. Decisions reached may involve a compromise that allows some aspects of utilization of a resource while conserving some of the biological diversities. Human impacts that threaten biodiversity include habitat loss, predator and pest control activities, the presence of invasive species, exploitation of flora and fauna, and climate change.

1.4.2 Trichoptera

The word Trichoptera originated from the Greek word 'trichos means hairs and 'ptera' means wings, when joined together it means hairy wings or wings covered with hairs, (Holzenthal et al., 2007). This insect order is grouped into two suborders; Integripalpia constructs portable or transportable cases while Annulipalpia constructs fixed or stationary cases (Frandsen et al., 2019; Holzenthal et al., 2017). Trichoptera is one of the most diverse orders of aquatic insects, a holometabolous taxon, with terrestrial adults and aquatic immature stages. They resemble the Lepidopterans (butterflies and moths) whose wings and bodies are covered with scales, while caddisflies' bodies are covered with hairs. The two orders jointly form the superorder Amphiesmenoptera (Kjer et al., 2001). They have numerous colors, but brown, gray, yellow, beige, or a combination of colors is often seen (Holzenthal et al., 2007). Caddisflies are nocturnal, weak flying insects, often found close to the stream or river of their larvae. They are easily attracted to Ultraviolet light; therefore, the use of a UV-pan light trap is recommended for the capture of these insects (Chantaramongkol, 1983; Laudee and Prommi, 2011; Higler et al., 2008). They could easily be seen flying above the water surface, descending on hanging vegetation on water, or dropping into the water and swimming during mating to lay eggs. During the day they hide in moist vegetations close to aquatic habitats, at rest they fold their wings in a tent-like structure over their bodies. Many adult caddisflies have reduced or vestigial and non-functional mouthparts, and most of them are relatively short-lived. The global distribution of Trichoptera is responsible for the division of the Earth into seven Biogeographic regions. These regions are identified based on the diversity and abundance of Trichoptera species, and thus include Neotropical, Oriental, East Palearctic, Nearctic, West Palearctic, Australian, and Afrotropical regions (NT, OL, EP, NA, WP, AU & AT). The distribution of species based on habitats is largely by their attributes determined by the differences in seasonal variability of water temperature and food availability. The water temperature usually follows a pattern, with springs mostly having consistent temperatures throughout the year, whereas the downstream locations often show incessant seasonal variation (Previsic et al., 2010). Asia is the largest continent comprising the Oriental and East Palearctic Biogeographic regions distinguished by ultimate climate and landforms (Morse, 2016). Trichoptera diversity and distribution in the Oriental region is the greatest among all Biogeographical regions (Laudee et al., 2017; Terefe et al., 2018). Trichoptera (Caddisflies) is an aquatic insect order with 16,266 described extant species found dispersed unequally across the globe (Morse, 2019).

Figure. 1.1 *Macrostemum floridum:* taken by Pongsak Laudee

1.4.3. Distribution of Trichoptera in Thailand

The Oriental region holds the greatest diversity and distribution of aquatic insects globally (Morse, 2016; Morse et al., 2019; de moor and Ivanov, 2008). All Southeast Asian countries are located in the Oriental region, including Thailand, and studies have shown that the diversity of Trichoptera and other aquatic insects in Thailand is extensive (Laudee et al., 2017). Thailand is considered to harbor the highest diversity of Trichoptera fauna in Southeast Asia, followed by Yunnan, northern Myanmar, and northeastern India (Malicky et al., 2014). Accordingly, Malicky et al. (2019) reported that a total of 1,020 instant Trichopteran species were described in Thailand and are distributed throughout the various geographical locations in the country. Bunlue et al. (2012) showed that there has been an intensive study on Trichoptera in the hotspots of biodiversity of Doi Suthep-Pui and Doi Inthanon National Parks, north of Thailand. This is pronounced by many authors (Thapanya et al., 2013; Prommi and Thamsenanupap, 2015; Nuntakwang et al., 2014; Phutthanurak and Thapanya, 2020; Thapanya et al., 2004). Caddisflies distribution in the south of Thailand is supported by research reports (Laudee and Prommi, 2011; Malicky et al., 2019; Prommi et al., 2006; Prommi, 2007). Other reports of diversity and distribution of Trichoptera in central and western geographical regions are that of (Prommi and Thani, 2014; Maneechan and Prommi, 2015; Thamsenanupap and Prommi, 2020; Malicky, 2010). These are part of many other studies on Trichoptera fauna in Thailand to support the claim that they are abundant and widespread in the country and generally in southeast Asian countries.

1.4.4 Life cycle of Trichoptera

The body structure of Trichopteran larva is generally elongated and cylindrical depending on the species. It consists of a distinct head, thorax, and abdomen. Head capsule varies with species, are well developed and sclerotized Holzenthal et al. (2007) Holzenthal et al. (2015), have well-developed mouthparts and could be herbivorous or predators. Caddisflies larvae look similar to the caterpillars of moths and butterflies. The thorax is divided into pronotum, mesonotum, and metanotum with various sclerotization levels. The abdomen is made up of ten segments Holzenthal et al. (2015), segment ten bears the prolegs and terminates with very short claws and may be invisible.

Investigation of benthic macroinvertebrates cannot be complete without the study of some aspects of their life cycle. The knowledge of the life cycle can be used in the advancement of logical random collection practices for species of interest (Krueger and Cook, 1984). In contrast to their adults, all caddisflies' immature stages live in water (Thapanya et al., 2013; Laudee et al., 2020). The life cycle begins when a mature male and female mate, the females lay eggs in water. The eggs hatch into larvae which undergo several instar developmental stages depending on the species before reaching the pupal stage. Studies have shown that Caddisflies larvae pass through I - V larval instars or more before the pupal stage, many authors showed that much of the larval growth appears to be in the first three instars, this likely correspond to conducive environmental conditions of food availability, temperature, etc. Glossosomatids usually pass through five larval instars Becker (2005) Anderson and Bourne (1974), this is also observable in many species of Caddisflies. Nevertheless, *Agapetus fuscipes* Curtis seems to be different, many authors reported that they undergo more than five larval developmental stages (Nielson, 1942). *A. fuscipes* species are commonly available in European streams (Botosaneanu and Malicky, 1978; Robbert, 2001). The life cycle of *Cheumatopsyche pettiti* (Banks) was observed by Kondratieff et al. (1997) who reported that *C. pettiti* (Banks) had five larval instars. Zuellig et al. (2004) also observed five larval instars in the life cycle of *cheumatopsyche analis* (Banks). Similarly, Yoga et al. (2014) reported that *Cheumatopsyche species* had five larval instars before the pupal stage. In addition, a study carried out by Laudee (2004) reported that larvae of *Ugandatrichia kerdmuang* Malicky and Chantaramongkol 1991 have five larval instars. Trichoptera species pass through a complete life cycle or complete metamorphosis, this makes them members of the holometabolous insect groups. The time it takes to complete a developmental cycle is an outcome of the interacting factors of environmental conditions, food availability, photoperiod, and genetically determined physiological processes, such as diapause and rates of increase in size and advancement (Jackson and Sweeney, 1995).

Many feeds on various plant materials, both living and non-living. The predatory species are free-living, they feed mainly on other invertebrates, some spin silken nets to capture prey. Caddisflies larvae generally spin silk, therefore, high production of silk used in making larval cases and retreats are baseline characteristics responsible for the success and high proliferation of this insect group (Holzenthal et al., 2017). The ability to construct cases or retreats makes Caddisflies to be considered natural underwater architects (Wiggins, 2007; Frandsen et al., 2019). de Moor and Ivanov (2008) showed that Trichopteran larva can be identified from other insect larvae by the presence of jointed walking legs on the thorax, anal prolegs which bear claws that are small and sometimes invisible in some species.

All caddisflies' larvae pass through a state of suspended feeding and movement referred to as the pupal stage for a period before the adult emerged. Caddisflies' pupation occurs like the pupation of lepidopterans, whose pupal case or cocoon is made from silk. Caddisflies that construct or make cases attach them to some benthic substrates, sealing the anterior and posterior openings against predators but letting inflow of water over the pupate within it. When the pupa is fully developed into an adult they cut through their cocoon with mandibles, swim up to the water surface, shake off larval skin, obsolete gills, and other larval structures, they soon fly off as a newly developed adult. The pupa of some species, swim to the stream bank at the bottom or across the water surface and crawl out of the stream or river and then emerge as adults, many of them can fly soon after shaking off their cocoons. They also reported that Caddisflies brood or emergence can be observed once or more times a year in streams and or rivers. This shows that they may exhibit univoltine, bivoltine, or multivoltine life cycle in a year.

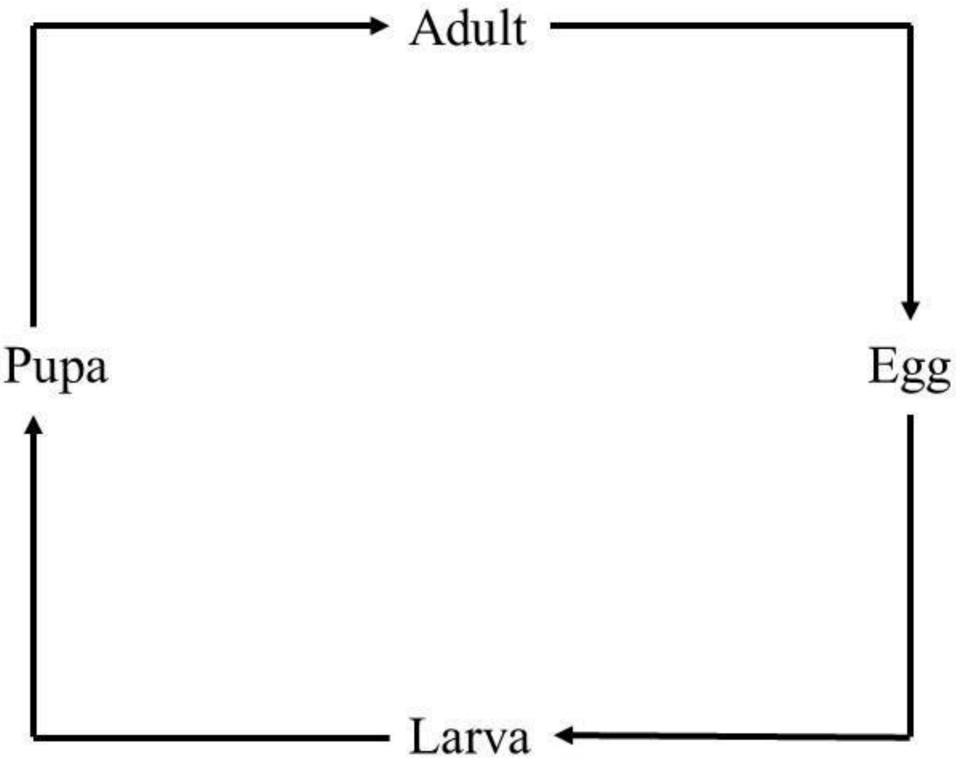

Figure 1.2 The life cycle of Trichoptera

1.4.5 Ecology of Trichoptera

Aquatic ecology is the study of organisms (plants and animals) in water and their interactions with their environment. Aquatic organisms are wholly dependent on the health of rivers, streams, or any water source where they live, they display different responses to changes in water conditions. The ability to tolerate or in-tolerate unconducive agitations in their environment is a major factor in the distribution of aquatic organisms. Aquatic ecology, therefore, studies interrelationships or characteristic behavior of aquatic organisms between themselves and their environment. Aquatic habitat evaluation requires ecological attributes to identify sources and threats to ecosystems and their components (Stevenson, 2014). The ecological study is inevitable for understanding the characteristics of aquatic insects especially those whose life cycle takes place in water, e.g., Trichoptera, Ephemeroptera, Plecoptera, etc., it forms an integral component of aquatic insect existence. The ecological inclination of macroinvertebrates and their responses to various anthropogenic activities are usually used by researchers for the observation of aquatic habitats (White et al., 2017). Trichoptera fauna is the most abundant and largely distributed macroinvertebrates in aquatic environments, especially in freshwater habitats (Phutthanurak and Thapanya, 2020). They are also referred to as benthic macroinvertebrates whose lives rest upon certain water conditions, such as dissolved oxygen concentration, water velocity and pressure, and organic matter availability (Prommi and Thamsenanupap, 2015). Benthic macroinvertebrates occupy vital roles in the aquatic food chain and webs that connect nutrient resources and organic matter (algae, phytoplankton, green plants) with higher trophic levels (Wallace and Webster, 1996). Understanding the life cycle of aquatic species mostly used as biological tools is of importance for all aspects of stream and river ecology and conservation strategies (Epele et al., 2011; Rustigian et al., 2003).

1.4.6 Trichoptera and Water quality conditions

Water quality has been substantially modified throughout the world by human activities. These results are indirect effects caused by the construction of dams and reservoirs, or diversions, or indirectly by land improvement strategies along the drainage basins (Calow, 1996). Rivers and other water sources have been greatly altered by man interference globally, and largely affect the physical factors and invariably the composition and functions of macroinvertebrates' communities (Pirvu and Pacioglu, 2012). Rivers are the primary sources of aquatic ecosystems, these imply that many problems for river management are linked to the scheme of land modifications, water resource development, and industrial advancement which altered the pattern of runoff, nature of river flow and the distribution and amount of sediment translocated (Calow, 1996). The ecological repercussions of the subjection of organisms to contaminants in water habitats are certainly prime to be observed in groups and settlements orientations (Burn, 1995). Presently, observation, evaluation, and supervision of aquatic habitats are mainly based on the chemical evaluation of water quality. However, chemical variables as a single entity do not give enough details for appropriate management of water conditions because they explain a small fraction of the effects of pollutants on living organisms (Calow, 1996). Biological methods of measurements are largely used in water parameters surveillance schemes across the world; nevertheless, several uncertainties rest on their success in predicting the impacts of harmful substances on water environments (Burn, 1995). Natural circumstances and human activities can affect aquatic environments in various areas; such as changes in hydrological patterns and the addition of synthetic substances invariably affect macroinvertebrates (Friedrich et al., 1996). The diversity and distribution of benthic invertebrates depend largely on the physical characteristics of the environment in terms of springs, fast-following streams with bedrocks, boulders, or sediments. The ecosystem's contaminants decrease services and values obtained from water resources for recreation because of diminished water transparency (Carpenter et al., 1999).

1.4.7 Trichoptera as a bioindicator

The understanding that organisms can provide information on the condition of their environment is a widespread and known concept. Some species are known to have a precise requirement for feeding, temperature, or dissolved oxygen concentration. When these are made, the presence of a specific organism in an area suggests that the parameter or the prescribed factor is within the acceptable boundaries of that organism. Therefore, that species or organism can be referred to as a bioindicator (Hellawell, 1986). These are usually macroinvertebrates with high responses to agitations in their environment, their composition in water sources serve as a pointer to evaluating immediate surrounding (Pereira et al., 2012). A bioindicator shall be described as an individual species or group of organisms that reveals the physical and biological status of the habitat, (Hodkinson and Jackson, 2005). Market (2003) defined a biological indicator as any living organism capable of responding to changes in its environment. However, Cairns and Pratt (1993) defined biomonitoring as observation using the reaction of an individual or group of species to certain environmental variables that could determine whether the environment is conducive to the organisms in it. Therefore, it shows that unconducive changes in the environment can affect the composition and structure of a community, habitat, or ecosystem. Biological indicators have specific requirements for many variables in their habitat for optimum physiological functions (Pereira et al., 2012). The use of bioindicators to evaluate the condition of rivers and streams is mostly dependent on benthic macroinvertebrates (Li et al., 2010). Caddisflies larvae form a major part of aquatic macroinvertebrates common to many freshwater streams and are most frequently used to evaluate the water environment due to the positive responsiveness of many species to environmental upset (Prommi, 2016). The use of living organisms to access water quality as mentioned earlier is more than a century-long approach, but its widespread use is mostly in developed countries such as North America and the United Kingdom. The most appropriate groups of freshwater organisms that have been considered for use in biological monitoring are benthic macroinvertebrates such as Trichoptera (Hellawell, 1986). Caddisflies display high sensitivity to agitations in physical and chemical variables of their habitats, which showed that a biological assessment of water conditions depends much more on Trichoptera in developed countries such as Europe, Australia, and North America (Pauls et al., 2008).

CHAPTER **2 Methodology**

2.1 Laboratory equipment

2.1.1 Stereomicroscope

2.1.2 Compound microscope

2.1.3 Ocular micrometer

2.1.4 Burner (hot plate)

2.1.5 Measuring Cylinder

2.1.6 Scintillation vials

2.1.7 Micro forceps

2.1.8 Beakers

2.1.9 funnel

2.1.10 Wash bottles

2.1.11Digital balance

2.1.12 Glass Petri dishes

2.1.13 Plastic Petri dishes

2.1.14 Glass sorting dishes

2.1.15Glass bottles

2.1.16 Slides

2.1.17 Cover slides

2.1.18 Label papers

2.1.19 Pencils and erasers

2.1.20 Aquarium

2.1.21 Leica DM 750

2.1.22 Leica Application Suite

2.2 Chemicals

2.2.1 Ethanol

2.2.2 Potassium Hydroxide

2.2.3 Detergent

2.2.4 Glyceryl

2.2.5 Distilled and Deionized water

2.3 Field equipment

2.3.1 15 W fluorescent UV tubes

2.3.2 12 DC battery

2.3.3 Sample containers

2.3.4 Plastic bowls

2.3.5 Quadratic kick net

2.3.6 EUTECH pH 150 meter

2.3.7 HACH LDO meter (mg/l)

2.3.8 EUTECH Conductivity meter (µS/cm)

2.3.9 EUTECH Temperature meter (^{0}C)

2.4 Description of the study sites

The study area consists of three National parks (Khao Sok, Khlong Phanom, and Kaengkrung) and Khlong Saeng Wildlife Sanctuary located at the western side of Surat Thani city. This is part of the lowlands of the Lower Phuket Mountain range, an extension of the great Tenasserim Hills, a mountain chain, part of the Indo-Malayan Mountain System in Southeast Asia. The Phuket Mountain types are limestone in nature mostly covered with moist dense forest. The range also referred to as the Tenasserim-South Thailand, has semi-evergreen rain forests vegetation or ecoregion is an important region of high biodiversity in Southeast Asia. Most parts of the mountains are protected in various ways to preserve the rich biodiversity of the areas. Four tributaries of Khlong Sok, Khlong Phanom, Khlong Yan, and Khlong Saeng originated from the Phuket range and serve as the main drain at the eastern slopes of the range. These tributaries converged to form the Phum Duang river, the major drain of the western lowlands of the Tapi watershed. Phum Duang joined the Tapi river before emptying into the Thai Gulf. The presence of a dam across the Khlong Saeng tributary, construction of roads and residential houses, and lots of agricultural activities in the area may pose a threat to the high biodiversity of the range and lowlands. A map showing these streams and the various sample collection points is presented in figure 2.1.

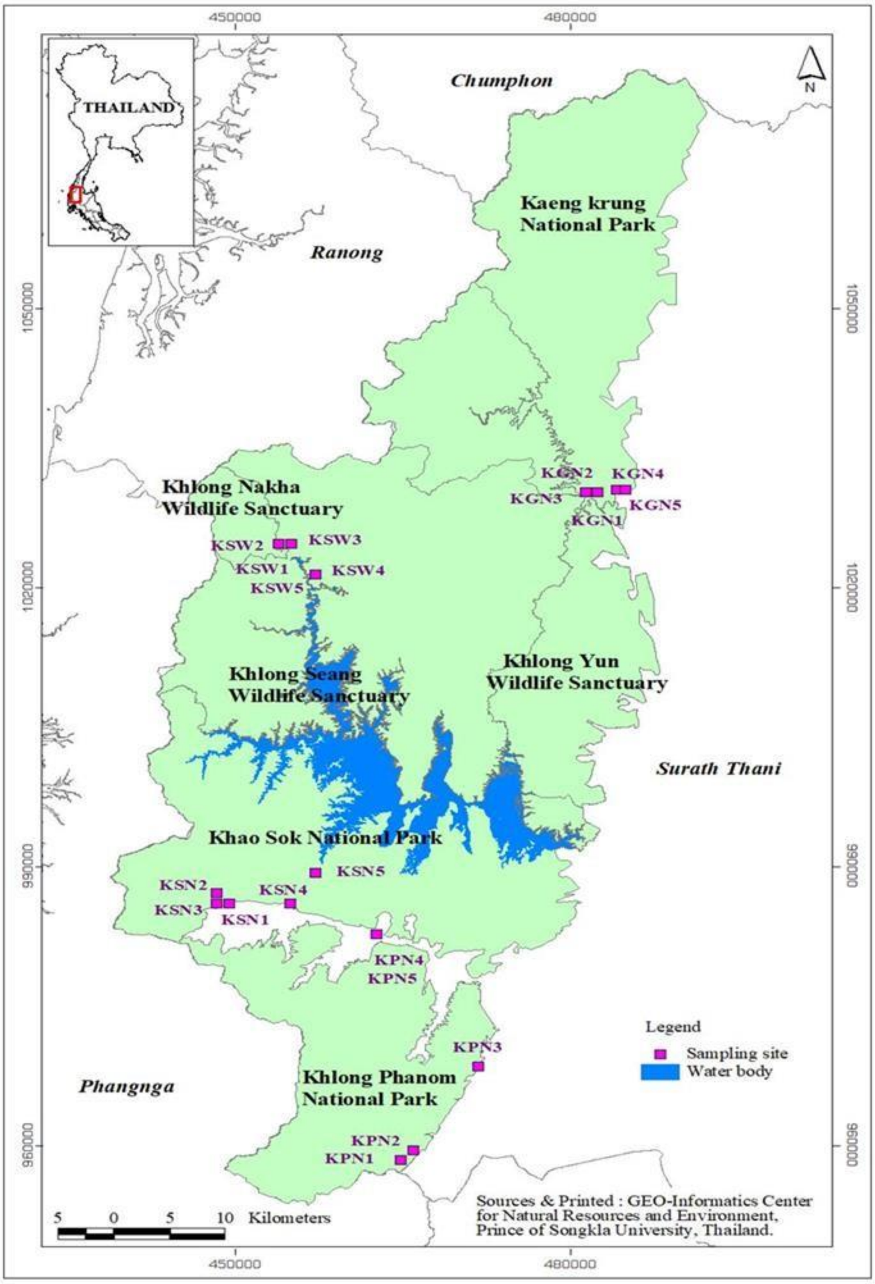

Figure 2.1 Map of the study area

Table 2.1 Sample sites at Khao Sok, Khlong Phanom, Kaengkrung National parks, and Khlong Saeng Wildlife Sanctuary

Site Codes	Site Names	Coordinates	Altitude (m)	Substrates
KSN1	Klong Sok Khao Sok National Park	8°55'07" N 98°31'68" E	97m	Boulder, Cobble, gravel, and sand
KSN2	Khlong Sok Khao Sok National Park	8°54'91" N 98°31'62" E	65m	Cobble, gravel, and sand
KSN3	Khlong Sok Khao Sok National Park	8°54'65" N 98°31'63" E	49m	Boulder, Cobble, gravel, and sand
KSN4	Khlong Sok Khao Sok National Park	8°54'83" N 98°34°76" E	56m	Gravel and sand
KSN5	Khlong Sok Khao Sok National Park	8°56'44" N 98°35'87" E	35m	Gravel and sand
KPN1	Khlong Phanom Khlong Phanom National Park	8°40'00" N 98°41'01" E	140m	Bedrock, boulder, cobble, gravel, and sand
KPN2	Khlong Phanom Khlong Phanom National Park	8°41'02" N 98°41'10" E	128m	Boulder, Cobble, gravel, and sand
KPN3	Khlong Phanom Khlong Phanom National Park	8°45'28" N 98°44'57" E	65m	Gravel and sand
KPN4	Khlong Phanom Khlong Phanom National Park	8°52'90" N 98°39'29" E	94m	Gravel and sand
KPN5	Khlong Phanom Khlong Phanom National Park	8°52'91" N 98°39'30" E	55m	Gravel and sand
KGN1	Khlong Yan Kaengkrung National Park	9°19'18" N 98°49'98" E	62m	Cobble, gravel, and sand
KGN2	Khlong Yan Kaengkrung National Park	9°19'22" N 98°49'90" E	59m	Boulder, gravel, cobble, and sand
KGN3	Khlong Yan Kaengkrung National Park	9°19'17" N 98°50'04" E	90m	Gravel, and sand
KGN4	Khlong Yan Kaengkrung National Park	9°18'82" N 98°51'57" E	60m	Bedrock, gravel, and sand
KGN5	Khlong Yan Kaengkrung National Park	9°18'59" N 98°51'90" E	61m	Cobble gravel, and sand
KSW1	Khlong Saeng Khlong Saeng Wildlife	9°15'79" N 98°34'98" E	102m	Gravel and sand
KSW2	Khlong Saeng Khlong Saeng Wildlife	9°15'87" N 98°35'02" E	90m	Boulder, gravel, and sand
KSW3	Khlong Saeng Khlong Saeng Wildlife	9°15'68" N 98°35'38" E	85m	Boulder, sand, and clay
KSW4	Khlong Saeng Khlong Saeng Wildlife	9°14'15" N 98°35'89" E	99m	Bedrock, boulder. cobble, and sand
KSW5	Khlong Saeng Khlong Saeng Wildlife	9°14'15" N 98°35'82" E	102m	Bedrock, boulder, sand, and clay

The study sites of this survey were Khlong Sok, Khlong Phanom, Khlong Saeng, and Khlong Yang tributaries. Five sampling sites were chosen along each of the four tributaries, giving a total of twenty sites as presented in Figures 2.2-21.

Figure 2.2 Khao Sok National Park site 1 (KSN1)

Figure 2.3 Khao Sok National Park site 2 (KSN 2)

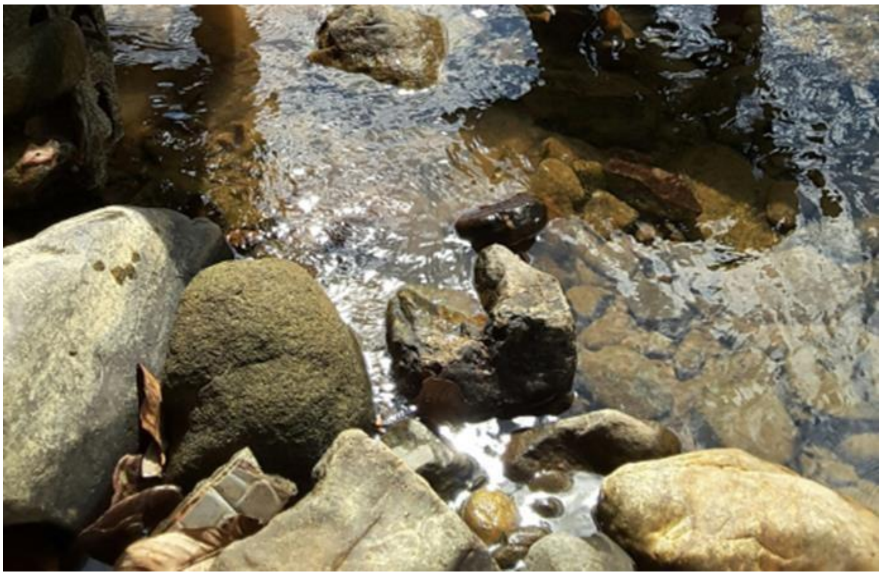

Figure 2.4 Khao Sok National Park site 3 (KSN 3)

Figure 2.5 Khao Sok National Park site 4 (KSN 4)

Figure 2.6 Khao Sok National Park site 5 (KSN 5)

Figure 2.7 Khlong Phanom National Park site 1 (KPN 1)

Figure 2.8 Khlong Phanom National Park site 2 (KPN 2)

Figure 2.9 Khlong Phanom National Park site 3 (KPN 3)

Figure 2.10 Khlong Phanom National Park site 4 (KPN 4)

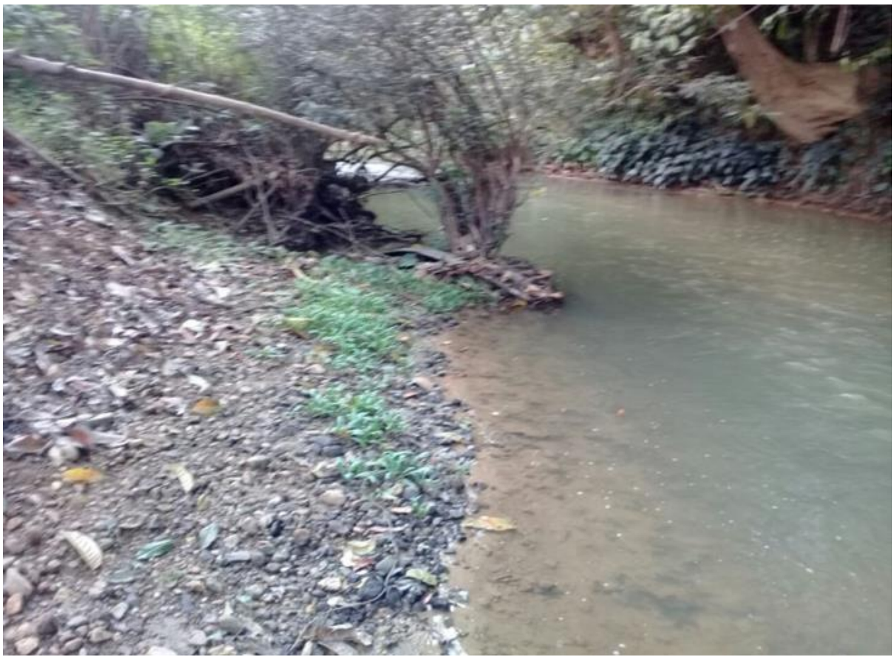

Figure 2.11 Khlong Phanom National Park site 5 (KPN5)

Figure 2.12 Kaengkrung National Park site 1 (KGN 1)

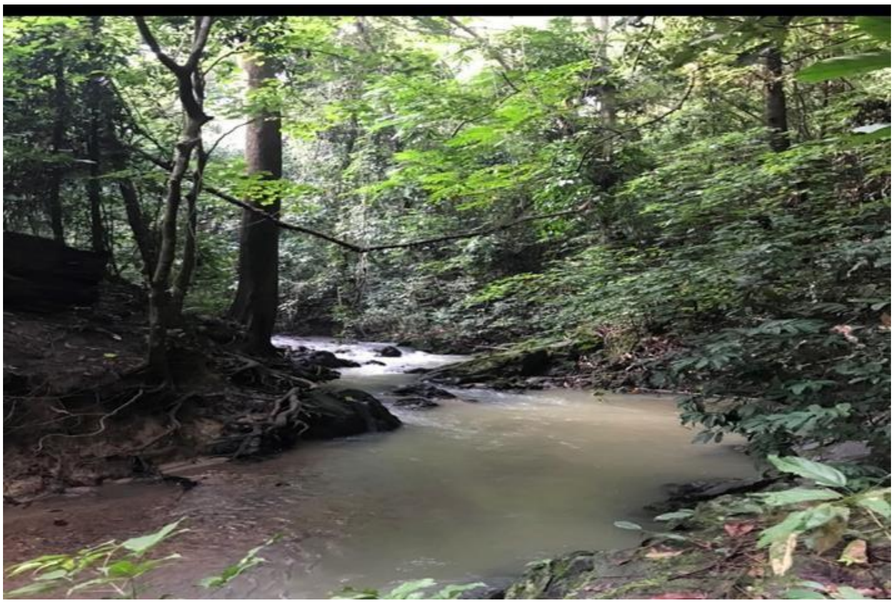

Figure 2.13 Kaengkrung National Park site 2 (KGN 2)

Figure 2.14 Kaengkrung National Park site 3 (KGN 3)

Figure 2.15 Kaengkrung National Park site 4 (KGN 4)

Figure 2.16 Kaengkrung National Park site 5 (KGN 5)

Figure 2.17 Khlong Saeng Wildlife Sanctuary site 1 (KSW 1)

Figure 2.18 Khlong Saeng Wildlife Sanctuary site 2 (KSW 2)

Figure 2.19 Khlong Saeng Wildlife Sanctuary site 3 (KSW 3)

Figure 2.20 Khlong Saeng Wildlife Sanctuary site 4 (KSW 4)

Figure 2.21 Khlong Saeng Wildlife Sanctuary site 5 (KSW 5)

2.5 Sample collection Method

2.5.1 Trichoptera diversity study

Sampling was carried out three times, once during the hot season and twice during the rainy season. Samples were collected using a UV-pan light trap (15W fluorescent, 12x DC battery Fig.2.2), usually, the fluorescent is placed on a container holding some water with a few drops of detergent and operated close to a stream on each sample location and left overnight.

Figure 2.22 UV-Pan light trap

2.5.2 Trichoptera Identification

Fresh samples collected were preserved in 70% ethanol and transported to the laboratory where they were sorted. The posterior end of the male abdomen was cut during the process and macerated in 10% potassium hydroxide (KOH) solution and heated for 30-60oC minutes. The structure was then viewed under a stereomicroscope and using Malicky, 2010, Atlas for Southeast Asian Trichoptera, the specimen. was then identified to species. Sample collection was conducted in March-December 2019.

2.5.3 Water Quality Measurements

Water physio-chemical parameters of Temperature, pH, Dissolved Oxygen, Electrical Conductivity, Total Dissolved Solids, and water velocity were measured in situ during each day of sample collection using aqua probes described below (Table. 2.2).

Table 2.2 Water quality parameters and instruments used.

S/No	Parameter	Units	Methods
1	Temperature	^0C	Probe EUTECH ^0C 150 meter
2	pH		Probe EUTECH pH 150 meter
3	Dissolved Oxygen	mg/l	Probe HACH LDO meter
4	Electrical Conductivity	µS/cm	Probe EUTECH Con 150 meter
5	Water Velocity	m/s	Mechanical and Digital Flowmeter

2.5.4 Larval collection and identification.

Larval identification was based on the use of diagnostic keys and features, after the methods of (Wiggins, 1996; Peumwarunyoo and Prommi, 2013; Prommi, 2016). This involves the use of morphological characteristics of the final larval instar associated with the pupa, and subsequently the pupa to the adult insect. This method is referred to as the metamorphotype technique.

A culture or life cycle study of *Macrostemum floridum* was carried out in the laboratory, this involves going to the stream site to collect larvae in which case the Khlong Yan stream was used (9°18'59" N, 98°51'57" E). The larval collection was done by handpicking. An attempt was always made to group the larvae according to their sizes in each container to prevent possible fighting and cannibalism. They were then transported to the laboratory, Where *M. floridum* larvae were sorted from the rest of other insect larvae with the aid of a light microscope where necessary. Samples were collected monthly from February-June 2021. Two or three larvae having the same size of head capsule width were kept in one plastic container with the bottom made of netting material. They were then set in an aquarium provided with an aerator and maintained at a temperature of 22-25^{0}C. Head capsule width was the main feature that was used to monitor the developmental growth performance of larva from one instar to another. Therefore, the head capsule width was measured at the onset of the experiment using an ocular micrometer to group the larvae into their different instar developmental stages (Bowles and Allen, 1992). The experimental setup was observed weekly for head width increase, taking note of the duration in the increase of head capsule width observed from one instar to another. The setup is shown in figure 2.23 below.

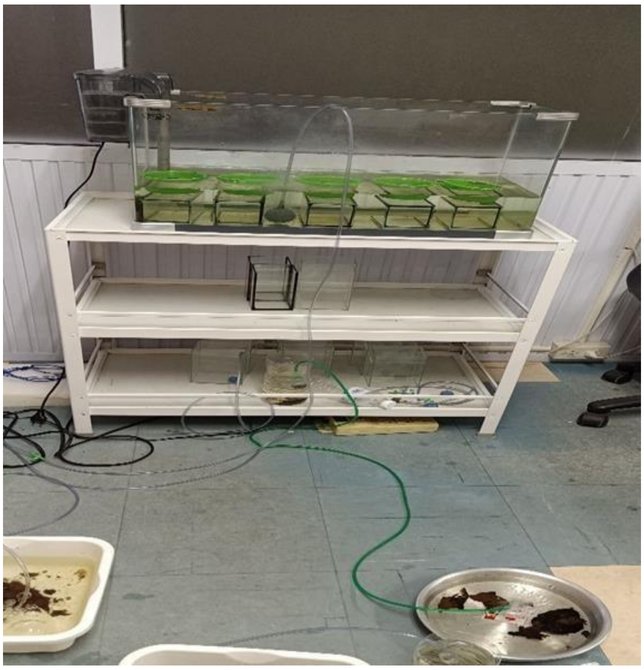

Figure 2.23 Culture/life experimental setup

2.5.5 Observation of larval gut.

Gut content analysis was conducted using the Quantitative Number Method: This method involves observing the larval gut containing food items consumed, and counting the number of each food item in the gut of the larva (*Macrostemum floridum)*, the results obtained are recorded, and thereafter used and expressed as a percentage of the gut contents of each specimen observed, in which the total percentage composition is estimated. The procedure is to remove the head and pull the gut along with it, kept on a slide with a drop of water, the gut is incised and observed under a Leica DM 750 binocular microscope, the number of the food items is obtained (Prommi and Khamrak, 2020).

CHAPTER 3

Results

3.1 Results of Trichoptera Diversity

3.1.1 Diversity of Trichoptera from the Phuket range lowlands

The result of this study revealed that eighteen (18) families, fifty-one (51) genera, and two hundred and one (201) species were sampled and identified as species. It further showed that four families of Leptoceridae Hydropsychidae Philopotamidae and Ecnomiidae were the most abundant and made up more than sixty percent (60%) of the total population of insects caught. Family Leptoceridae had the highest number of species of fifty-five (55) followed by the Hydropsychidae family which had forty (40) species. Philopotamidae had twenty-one (21) species and Ecnomidae had seventeen (17) species. Families: Hydroptilidae had sixteen (16) species Polycentropodidae had eleven (11) species Psychomyiidae had ten (12) species Dipseudopsidae had six (6) species Goeridae, seven (7) species Helicopsychidae had four (4) species Lepidostomatidae and Calamoceratidae had three (3) species each while Rhyacophilidae Glossosomatidae Stenopsychidae Xiphocentronidae Brachycentridae and Odontoceridae had one (1) species each. A new species *Agapetus kaengkrungensis* was described and added to the knowledge of science. In addition, three species of Trichoptera namely Polymorphanisus scutellatus BANKS 1939*, *Cheumatopsyche opposita* BANKS 1931* and *Cheumatopsyche contexta* ULMER 1951* were added to the list of Thailand. In the Leptoceride family, *Setodes kybele* and *S. minotauros* were the most abundant and common species. *Cheumatopsyche charites* in the Hydropsychidae family were the largest in number and most common species. Family Philopotamidae had *Chimarra okuihorum* as the most extensive, while *Ecnomus puro* in the Ecnomidae family was the most abundant. The details of this distribution are contained in table 3.1 below.

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
Rhyacophilidae								
Rhyachophila noeibia M&C 1993	1	-	-	2		+	m	p
Glossosomatidae								
Agapetus halong OLAH 1998	-	-	-	3				p
Hydroptilidae								
Hydroptila gaya OLAH 1989	-	-	1	-				
H. sabit WELLS & HUSMAN 1992	-	5	11	4			m	c
H. thuna OLAH 1989	-	2	-	1	+		m	
H. rumpun WELLS & HUSMAN 1992	4	3	4	-			m	p
H. roma M&C 2007	3	-	6	3			m	p
H. tethys M&C 2007	-	-	2	-				
H. portumus M&C 2007	4	-	1	4	+		m	p
H. venus M&C 2007	-	-	2	-				
H. verticordia M&C 2007	-	-	4	-				p
Ugandatrichia hairanga OLAH 1989	-	-	-	1		+		
Oxyethira bogambara SCHMID 1958	-	3	2	-			m	p
Scelotrichia tatius M&C 2007	-	1	-	-				
Chryotrichia tydeus M&C 2007	-	-	2	-				
C. zoroastres M&C 2007	-	-	4	-				p
Orthotrichia bencana OLAH 1989	1	-	-	-				
O. maendrica ULMER 1951	-	3	4	-			m	
Philopotamidae								
Chimarra thienemanni ULMER 1951	55	2	43	4			m	C
C. spinifera KIMMINS 1957	-	1	-	4	+	+	m	P
C. bimbltona MALICKY 1979	62	1	-	17	+	+	m	c
C. chiangmaiensis C&M 1989	-	9	153	1	+		m	a
C. monorum C&M 1989	12	9	7	2	+	+	m	c
C. argax MALICKY 1989	76	1	139	13	+		m	a
C. akkaorum C&M 1989	2	-	-	-		+		
C. shanorum C&M 1989	1	-	-	-				
C. khamuorum C&M 1989	-	1	3	-		+	m	p
C. horok MALICKY 1989	2	-	1	1			m	p

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abun.
C. thaiorum C&M 1989	2	2	-	-			m	p
C. yskal MALICKY 1989	14	-	4	2		+	m	p
C. pipake M&C 1993	5	11	5	-		+	m	c
C. atnia M&C 1993	1	-	-	-		+		
C. rama M&C 1993	1	-	-	-		+		
C. toga M&C 1993	-	-	-	12				p
C. vibena M&C 1993	-	-	-	2				
C. ravanna M&C 1993	-	-	-	1		+		
C. okuihorum MEY 1998	59	113	122	136			m	a
Gunungiella fimfafiazga M&C 1993	1	-	-	-	+	+		
Kisaura peleg MALICKY & LAUDEE 2009	-	-	-	1				
Stenopsychidae								
Stenopsyche siamensis MARTYNOV 1931	1	-	-	1	+	+	m	
Polycentropodidae								
Nyctiophylax khaosokensis M&C 1993	2	5	30	19		+	m	c
N. salma M&C 1993	2	-	-	-				
Polyplectropus matthatha M&C 1993	1	-	-	7		+	m	p
Pseudoneureclipsis ramosa ULMER 1913	109	301	66	1			m	a
P. tramot M&C 1993	-	1	90	1		+	m	c
P. uma M&C 1993	1	3	3	1		+	m	p
P. enos M&C 1993	-	1	-	-		+		
P. cincinatus M&C 2000	-	2	0	-				
P. chrysippus MALICKY & SOMPONG 2000	7	8	6	3		+	m	c
P. magog M&C 2009	-	1	-	-				
Pahamunaya jihmita SCHMID & DENNING 1979	-	-	5	-				p
Psychomyiidae								
Paduniella semarangensis ULMER 1913	-	6	3	1	+	+	m	p
P. hatyaiensis M&C 1993	6	8	-	-			m	p
P. phuketiella	-	3	-	-				p
P. yeratel	-	-	-	1				

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
Psychomyia thienemanni ULMER 1951	303	203	165	92	+	+	m	a
P. indra M&C 1993	-	-	-	269	+	+		a
P. amphiaraos M&C 1997	19	205	1	50		+	m	a
P. pinsuwane LAUDEE & MALICKY 2018	-	-	13	-				p
P. sinon MALICKY & PROMMI 2006	249	86	18	33		+	m	a
Tinodes ragu M&C 1993	2	3	4	-		+	m	p
T. mahalat M&C 2009	3	-	-	-				p
Lype atnia M&C 1993	1	7	2	2		+	m	p
Xiphocentronidae								
Melanotrichia samaconius M&C 1992	-	2	-	-		+		
Ecnomidae								
Ecnomus pseudotenellus ULMER 1930	2	-	1	-		+	m	p
E. digitatus MOSELY 1932	1	-	-	-				
E. robustior ULMER 1951	1	-	1	-		+		
E. penjabi SCHMID 1961	4	-	-	-		+		p
E. battu MALICKY 1993	10	7	-	-		+	m	p
E. talenoi M&C 1993	-	-	3	-		+		p
E. jojachin M&C 1993	1	-	8	-		+	m	p
E. uttu M&C 1993	1	15	4	1		+	m	c
E. totiio M&C 1993	78	112	6	21	+	+	m	a
E. volovicus M&C 1993	48	10	21	-	+	+	m	c
E. puro M&C 1993	28	181	106	30	+	+	m	a
E. plaiwat M&C 1993	3	-	-	-		+		
E. neri M&C 1993	4	44	38	25		+	m	a
E. vebinus M&C 1993	-	-	3	-		+		p
E. anakagung MALICKY 1995	-	-	3	-				
E. thamyris MALICKY & PROMMI 2006	-	-	1	-		+		
E. stentor MALICKY & PROMMI 2006	27	22	135	-		+	m	a
Dipseudopsidae								
Dipseudopsis nebulosa ALBARDA 1881	1	13	16	97		+	m	a

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
D. robustior ULMER1929	2	5	-	88	+		m	c
D. varians ULMER 1929	6	2	-	-	+	+	m	p
D. doehleri ULMER 1929	-	-	4	-				p
D. benardi NAVAS 1930	8	4	-	-	+		m	p
Hyalopsyche winkleri ULMER 1930	2	-	-	-				
Hydropsychidae								
Diplectrona dulitensis KIMMINS 1955	26	1	-	4		+	m	c
D. gombak OLAH 1993	49	7	9	7	+	+	m	c
D. hermione M&C 2002	3	-	-	-		+		p
Polymorphanisus astictus NAVAS 1923	-	-	-	2		+		
P. unipunctus BANKS 1939	1	-	-	-				
P. scutellatus BANKS 1939 *	-	-	1	-				
Macrostemum fenestratum ALBARDA 1887	28	-	-	-		+		
M. dohrni ULMER 1905	1	-	1	-	+	+	m	
M. floridum NAVAS 1929	11	5	112	12	+	+	m	a
M. midas M&C 1998	-	1	-	5		+	m	p
M. dione M&C 1998	19	-	-	-	+			p
Pseudoleptonema quinquefasciatum MARTYNOV1935	-	16	6	11		+	m	c
Amphipsyche gratiosa NAVAS 1922	-	20	255	16			m	a
Hydromanicus unicolor ULMER 1951	-	-	-	2				
H. abiud M&C 1993	2	-	-	1		+	m	p
H. serubabel M&C 1993	2	1	-	1		+	m	p
H. inferior C&M 1995	4	14	3	1	+	+	m	c
Potamyia flavata BANKS 1934	1	12	8	3	+	+	m	c
P. phaidra M&C 1997	5	6	16	14	+	+	m	c
P. alleni M&C 1997	6	-	1	-	+		m	p
P. chaos MALICKY & THANI 2000	-	4	5	26		+	m	c
Cheumatopsyche lucida ULMER 1907	283	36	18	3			m	a
C. globosa ULMER 1910	-	-	2	-		+		

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
C. opposita BANKS 1931*	17	4	-	-			m	c
C. dubitans MOSELY 1942	-	1	-	75		+	m	c
C. contexta ULMER 1951*	1	33	145	-			m	a
C. dhanikari MALICKY 1979	15	25	6	29			m	c
C. trilari M&C 1997	13	4	4	6		+	m	c
C. copia M&C 1997	-	16	-	13	+	+	m	c
C. chryseis M&C 1997	-	124	3	-		+	m	c
C. chrysothemis M&C 1997	8	126	186	9		+	m	a
C. charites M&C 1997	675	217	434	227	+	+	m	a
C. tramota M&C 1997	-	-	-	9	+	+		p
C. cocles M&Y 1997	-	2	-	-				
C. theophane MALICKY & PROMMI 2006	-	42	6	-		+	m	c
Hydropsyche formosana ULMER 1911	-	1	1	19			m	c
H. appendicularis MARTYNOV 1931	1	-	-	-				
H. camillus M&C 2000	-	5	8	18	+	+	m	c
H. brontes M&C 2000	3	-	-	11	+	+	m	p
H. atropos M&C 2000	-	-	-	3		+		p
Brachycentridae								
Micrasema fortiso M&C 1992	-	-	-	1	+	+		
Goeridae								
Gastrocentrides sumatranus ULMER 1930	189	53	12	15			m	a
Goera uniformis BANKS 1931	14	62	11	24	+	+	m	a
G. redsat M&C 1992	5	-	-	-		+		p
G. echo MALICKY & THANI 2000	-	3	-	-		+		p
G. matuila M&C 1992	-	8	1	-			m	p
G. redsomar M&C 1992	-	-	-	1				
G. ateduna M&C 1992	-	3	-	-		+		p
Helicopsychidae								
Helicopsyche lata ULMER 1951	1	-	-	-				
H. angusta ULMER 1951	1	33	17	2			m	c

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abun.
H. martynovi MOSELY 1939	-	2	-	1			m	p
H. anaksaku MALICKY 1995	-	1	1	-			m	
Lepidostomatidae								
Lepidostoma doligung MALICKY 1979	1	-	-	-		+		
Lepidostoma schwendingeri M&C 1994	3	-	-	1		+	m	p
L. pseudabrutum M&C 1994	2	-	-	-				
Leptoceridae								
Oecetis tripunctata FABRICIUS 1793	15	55	94	2	+	+	m	a
O. hemerobioides MACLACHLAN 1866	1	-	3	-		+	m	p
O. jacobsoni ULMER 1930	-	-	-	1	+			
O. biramosa MARTYNOV 1936	-	11	-	2	+		m	p
O. scutulata MARTYNOV 1936	10	-	-	-				p
O. asmada MALICKY 1979	2	-	4	-	+	+	m	p
O. raghava SCHMID 1995	3	-	-	-				p
O. devakiputra SCHMID 1995	-	-	1	-				
O. empusa MALICKY & CHAIBU 2000	-	-	3	4	+		m	p
O. lotis MALICKY & THAPANYA 2004	57	109	35	10	+	+	m	a
O. kyanippos MALICKY &SOMPONG 2005	17	-	1	-		+	m	p
O. laodike MALICKY & CHEUNBARN 2005	3	1	1	-	+		m	p
O. hyperion MALICKY2005	1	-	-	-		+		
O. numitor MALICKY 2005	6	-	-	-				p
O. momos MALICKY 2005	-	1	-	-		+		
O. meleagros MALICKY & THANI 2005	-	-	-	1	+			
O. ladon MALICKY & LAUDEE 2005	-	-	4	-				p
Adicella evadine SCHMID 1994	3	-	1	-		+	m	p
Cereclea idaia MALICKY & CHAIBU 2002	24	7	1	-	+		m	c
C. iambe MALICKY & PROMMI 2002	-	3	-	-				p

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
C. hersilia MALICKY & CHANGTHONG 2002	-	18	7	-	+		m	c
C. harpalyke MALICKY & CHANGTHONG 2002	-	-	1	-	+			
C. iuno M&C 2003	-	1	-	-				
Poecilopsyche gyges M&C 2002	-	-	-	1				
Tagalopsyche brunnea ULMER 1905	-	-	1	-		+		
Triaenodes pellectus ULMER 1908	1	6	1	-		+	m	p
T. dursa SCHMID 1965	-	-	1	-		+		
T. narkissos MALICKY 2005	-	-	-	2		+		
Trichosetodes pales MALICKY & CHAIBU 2006	331	261	80	1	+		m	a
Parasetodes respersella RAMBUR 1842	7	3	2	-	+		m	p
Leptocerus amoenus ULMER 1951	-	-	1	-		+		
L. dirghachuka GORDON & SCHMID 1987	24	35	15	36	+	+	m	a
L. Tursiops MALICKY 1979	5	-	4	-		+	m	p
L. lampunensis M&C 1991	17	47	13	-	+		m	c
L. chiangmaiensis M&C 1991	-	-	-	8				p
L. inthanonensis M&C 1991	1	-	-	-	+	+		
L. Masik MALICKY 1995	29	10	1	2			m	c
L. posticoides MALICKY 1995	-	-	-	1		+		
L. faunus M&C *2002*	-	-	1	-		+		
L. skamandrios MALICKY & PROMMI 2006	2	-	-	-	+	+		
Setodes fluvialis KIMMINS 1963	-	2	1	-			m	p
S. gangaya GORDON & SCHMID 1987	21	55	-	20	+		m	c
S. akrura GORDON & SCHMID 1987	-	-	-	4				p
S. thoneti M&C 2006	7	-	-	7	+		m	p
S. iulus M&C 2006	5	16	1	12			m	c
S. kybele M&C 2006	514	362	6	86			m	a

Table 3.1 Distribution and abundance of Trichoptera along Phum Duang tributaries (continued)

Family	KSN	KPN	KGN	KSW	L&P	PT	Dist.	Abund.
S. opora M&C 2006	217	2	-	-		+	m	a
S. minotauros M&C 2006	-	277	680	86		+	m	a
S. neleus M&C 2006	73	13	4	83		+	m	a
S. leto M&C 2006	23	-	-	-				c
S. larva M&C 2006	60	107	295	1			m	a
S. melpomene M&C 2006	6	-	-	-				p
S. okyrrhoe M&C 2006	546	6	1	-			m	a
S. isis MALICKY & NAWVONG 2006	-	-	1	-	+	+		
S. lertpongsombatae LAUDEE & MALICKY 2018	1	-	-	-				
Odontoceratidae								
Marilia sumatrana ULMER 1951	5	2	3	-	+	+	m	p
Calamoceratidae								
Ganonema fuscipenne ALBARDA 1881	6	4	3	-	+	+	m	p
Anisocentropus brevipennis ULMER 1906	-	2	3	-	+	+	m	p
A. pan M&C 1994	3	-	3	1		+	m	p

Remark: KSN = Khao Sok National Park, KPN = Khlong Phanom National Park, KGN = Kaengkrung National Park, KSW = Khlong Saeng Wildlife Sanctuary, M&C = Malicky, and Chantaramongkol, C&M = Chantaramongkol and Malicky, MH = Hans Malicky, Dist. = Distribution, Abund. = Abundance, p = 3-20 specimens found in the sample, m = species found in other sites and neighboring countries, c = common, 20-100 specimens were found in the sample, a = abundant, more than 100 specimens were found.

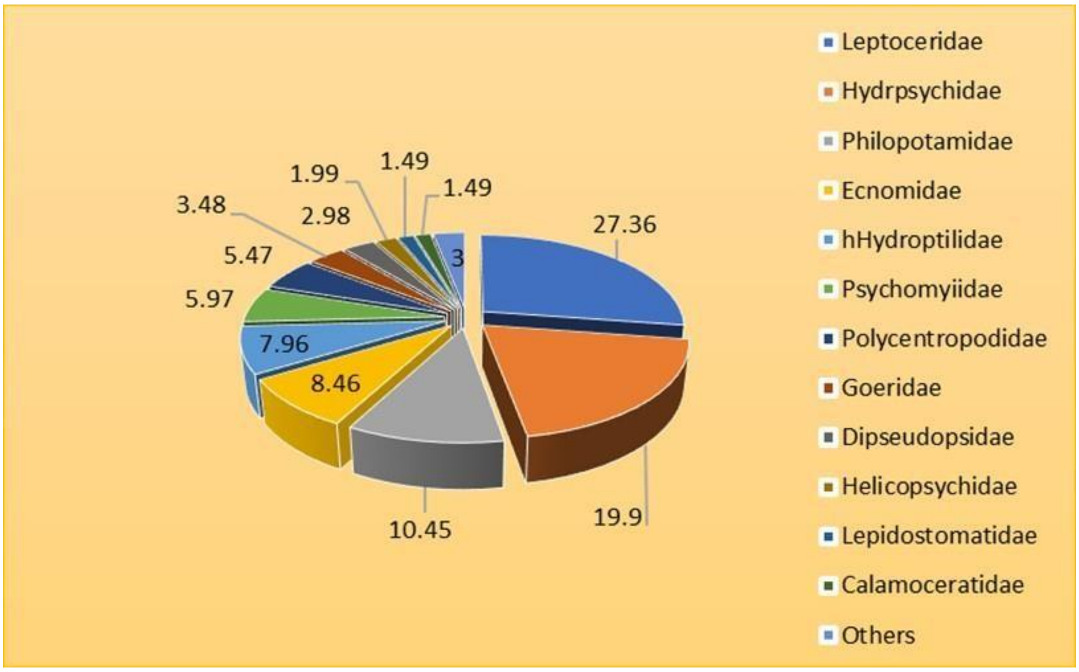

Figure 3.1 Percentages of species richness in each family; (Others - Rhyacophilidae, Glossosomitidae, Stenopsychidae, Xiphocentronidae, Brachycentridae, and Odontoceridae)

3.2 Khao Sok National Park Diversity of species

The diversity of Trichoptera along the Khlong Sok stream showed that fifteen (15) families, thirty-eight (38) genera, and one hundred and twenty-two (122) species were found in this area. Family Leptoceridae had the highest number of species, thirty-two (32) in number followed by the Hydropsychidae family represented by twenty-four (24) species. Family Philopotamidae had fourteen (14) species; Family Ecnomidae had thirteen (13) species; Families Polycentropodidae and Psychomyiidae had six (6) species each. Family Dipseudopsidae had five (5) species; Family Hydroptilidae had four (4) species; Families Goeridae and Lepidostomatidae had three (3) species each. Families Helicopsychidae and Calamoceratidae had two (2) species each, while Rhyacophilidae, Stenopsychidae, and Odontoceridae had one (1) species each. *Setodes okyrrhoe* in Family Leptoceridae had the greatest abundance of the individual specimens observed. *Cheumatopsyche charites* in the Hydropsychidae family had the highest number of individual specimens found. *Chimarra bimbltona* in the Philopotamidae family had the highest number of specimens. Two new records of *Cheumatopsyche opposita* BANK 1931* and *C. contexta* ULMER 1951* in Family Hydropsychidae were observed in this area. A total of four thousand four hundred and twenty-nine (4,429) species were caught and observed during this survey. Table 3.2 below presents the detailed distribution and abundance of Caddisflies in Khao Sok sample locations while table 3.3 shows the results of the means and standard deviations of water quality parameters observed during the study.

Table 3.2 Khao Sok National Park Diversity of species

Taxonomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
Rhyacophilidae							
Rhyachophila noeibia M&C 1993	1	-	-	-	-		
Hydroptilidae							
Hydroptila rumpun WELLS & HUSMAN 1992	2	-	-	2	-	m	p
H. roma M&C 2007	-	-	1	2	2	m	p
H. portumus M&C 2007	-	-	-	2	2	m	p
Orthotrichia bencana OLAH 1989	-	-	-	1	-		
Philopotamidae							
Chimarra thienemanni ULMER 1951	7	48	-	-	-	m	c
C. bimbltona MALICKY 1979	46	25	1	1	-	m	c
C. monorum C&M 1989	49	2	2	-	-	m	c
C. argax MALICKY 1989	-	-	72	4	-	m	c
C. akkuorum C&M 1989	-	2	-	-	-		
C. shanorum C&M 1989	-	1	-	-	-		
C. horok MALICKY 1989	2	-	-	-	-		
C. thaiorum C&M 1989	2	-	-	-	-		
C. yskal MALICKY 1989	4	10	-	-	-	m	p
C. pipake M&C 1993	4	1	-	-	-	m	p
C. atnia M&C 1993	1	-	-	-	-		
C. rama M&C 1993	1	-	-	-	-		
C. okuihorum MEY 1998	14	3	-	6	36	m	c
Gunungiella finfafiazga M&C 1993	-	1	-	-	-		
Stenopsychidae							
Stenopsyche siamensis MARTYNOV 1931	1	-	-	-	-		
Polycentropodidae							
Nyctiophylax khaosokensis M&C 1993	-	2	-	-	-		
N. salma M&C 1993	-	-	-	2	-		
Polyplectropus matthatha M&C 1993	1	-	-	1	-	m	
Pseudoneureclipsis ramosa ULMER 1913	1	3	18	87	2	m	c
P. uma M&C 1993	-	1	-	-	-		
P. chrysippus MALICKY & SOMPONG 2000	3	1	3	-	-	m	p
Psychomyiidae							
Paduniella hatyaiensis M&C 1993	-	-	-	6	-		c
Psychomyia thienemanni ULMER 1951	17	1	-	262	23	m	a

Table 3.2 Khao Sok National Park Diversity of species (continued)

Taxonomic Group Family	Sites 1	2	3	4	5	Dist.	Abund.
P. amphiaraos M&C 1997	143	16	-	3	-	m	a
P. sinon MALICKY & PROMMI 2006	216	31	1	1	4	m	a
Tinodes ragu M&C 1993	2	-	-	-	-		
T. mahalat M&C 2009	3	-	-	-	-		
Lype atnia M&C 1993	1	-	-	-	-		
Ecnomidae							
Ecnomus pseudotenellus ULMER 1930	-	-	-	2	-		
E. digitatus MOSELY 1932	-	-	-	1	-		
E. robustior ULMER 1951	-	-	-	1	-		
E. penjabi SCHMID 1961	-	2	-	1	-	m	p
E. battu MALICKY 1993	-	-	-	8	3	m	p
E. jojachin M&C 1993	-	-	1	-	-		
E. uttu M&C 1993	1	-	1	-	-	m	r
E. totiio M&C 1993	5	1	68	4	-	m	c
E. volovicus M&C 1993	-	1	21	27	-	m	c
E. puro M&C 1993	3	-	19	6	-	m	c
E. plaiwat M&C 1993	2	-	-	-	-		
E. neri M&C 1993	-	1	-	1	2	m	p
E. stentor MALICKY & PROMMI 2006	-	-	15	12	-	m	p
Dipseudopsidae							
Dipseudopsis nebulosa ALBARDA 1881	-	-	1	-	-		
D. varians ULMER 1929	3	-	-	-	-		p
D. robustior ULMER 1929	-	-	1	1	-	m	
D. benardi NAVAS 1930	-	-	-	-	8		p
Hyalopsyche winkleri ULMER 1930	-	-		-	1		
Hydropsychidae			-				
Diplectrona dulitensis KIMMINS 1955	18	8	-	-	-	m	p
D. gombak OLAH 1993	26	16	1	9	2	m	c
D. hermione M&C 2002	3	-	-	-	-		p
Polymorphanisus unipunctus Banks 1939	-	-	-	1	-		
Macrostemum fenestratum ALBARDA 1887	2	2	8	18	2	m	p
M. dohrni ULMER 1905	-	-	1	-	-		
M.floridum NAVAS 1929	5	1	4	-	2	m	p
M. dione M&C 1998	-	-	19	-	-		p
Hydromanicus abiud M&C 1993	-	-	-	2	-		
H. serubabel M&C 1993	1	-	-	-	1	m	
H. inferior C&M 1995	3	1	-	-	-	m	p

Table 3.2 Khao Sok National Park Diversity of species (continued)

Taxonomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
Potamyia flavata BANKS 1934	-	-	-	-	1		
P. phaidra M&C 1997	1	-	2	2	-	m	p
P. alleni M&C 1997	-	-	-	3	2	m	p
Cheumatopsyfeedslucida ULMER 1907	-	-	1	183	79	m	a
C. opposita BANKS 1931 *	-	-	1	11	3	m	p
C. contexta ULMER 1951*	-	-	-	1	-		
C. dhanikari MALICKY 1979	12	3	-	-	-	m	p
C. trilari M&C 1997	6	-	7	-	-	m	p
C. chrysothemis M&C 1997	-	5	2	-	-	m	p
C. charites M&C 1997	94	2	9	416	83	m	p
Hydropsyche appendicularis MARTYNOV 1931	-	-	-	-	1		
H. camillus M&C 2000	2	-	-	3	-	m	p
H. brontes M&C 2000	2	-	3	1	-	m	p
Goeridae							
Gastrocentrides sumatranus ULMER 1930	-	-	-	137	42	m	a
Goera uniformis BANKS 1931	-	2	2	1	11	m	p
G. redsat M&C 1992	2	3		-	-	m	p
Helicopsychidae							
Helicopsyche lata ULMER 1951	-	-	-	-	1		
H. angusta ULMER 1951	-	1		-	-		
Lepidostomatidae							
Lepidostoma doligung MALICKY 1979	-	1	-	-	-		
L. schwendingeri M&C 1994	1	2	-	-	-	m	p
L. pseudabruptum M&C 1994	1	1	-	-	-	m	
Leptoceridae			-				
Oecetis tripunctata FABRICIUS 1793	5	-	-	6	-	m	p
O. hemerobioides MACLACHLAN 1866	-	-	-	1	-		
O. scutulata MARTYNOV 1936	-	-	-	10	-		p
O. asmada MALICKY 1979	-	-	1	1	-	m	
O. raghava SCHMID 1995	-	-	-	3	-		p
O. lotis MALICKY & THAPANYA 2004	-	-	5	47	5	m	c
O. laodike MALICKY & CHEUNBARN 2005	-	-	-	2	1	m	p
O. kyanippos MALICKY & SOMPONG 2005	-	-	17	-	1	m	p
O. hyperion MALICKY2005	-	-	-	-	1		

Table 3.2 Khao Sok National Park Diversity of species (continued)

Taxonomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
Adicella evadne SCHMID 1994	2	-	-	1	-	m	p
Ceraclea idaia MALICKY & CHAIBU 2002	-	-	1	1	21	m	p
Triaenodes pellectus ULMER 1908	-	-	-	1	-		
Trichosetodes pales MALICKY & CHAIBU 2006	1	-	-	253	154	m	a
Parasetodes respersella RAMBUR 1842	1	-	-	3	3	m	p
Leptocerus dirghachuka GORDON & SCHMID 1987	-	1	-	11	12	m	p
L. tursiops MALICKY 1979	-	-	-	1	3	m	p
L. lampunensis M&C 1991	-	-	-	17	6	m	p
L. inthanonensis M&C 1991	-	-	-	1	-		
L. masik MALICKY 1995	-	-	-	29	4	m	c
L. skamandrios MALICKY & PROMMI 2006	2	-	-	-	-		
Setodes gangaya GORDON & SCHMID 1987	-	-	-	-	21		c
S. thoneti M&C 2006	-	6	2	1	-	m	p
S. iulus M&C 2006	2	3	-	-	-	m	p
S. kybele M&C 2006	28	24	110	176	-	m	a
S. opora M&C 2006	3	-	-	3	211	m	a
S. neleus M&C 2006	29	20	6	8	16	m	c
S. leto M&C 2006	2	-	-	21	-	m	c
S. larva M&C 2006	-		-	38	22	m	c
S. melpomene M&C 2006	-	-	-	-	6		p
S. okyrrhoe M&C 2006	-	-	2	229	219	m	a
S. lertpongsombatae LAUDEE & MALICKY 2018	-	-	-	1	-		
Odontoceridae							
Marilia sumatrana ULMER 1951	-	1	1	2	1	m	p
Calamoceratidae							
Ganonema fuscipenne ALBARDA 1881	-	-	2	5	-	m	p
Anisocentropus pan M&C 1994	1	1	-	1	-	m	p

Table 3.3 Khao Sok National Park water quality parameter values (Mean and SD)

Parameters	1	2	3	4	5
Temperature ^{0}C	22.72 ± 0.55	22.53 ± 0.74	23.06 ± 0.21	24.03 ± 0.76	24.02 ± 0.75
pH	7.93 ± 0.07	8.44 ± 0.58	7.78 ± 0.08	7.41 ± 0.45	7.76 ± 0.01
Dissolved Oxygen mg/l	7.67 ± 0.10	7.54 ± 0.03	7.69 ± 0.12	7.67 ± 0.10	7.28 0.29
Electrical conductivity µS/cm	47.31 ± 11.98	42.69 ± 16.60	56.98 ± 2.31	68.54 ± 9.25	80.95 ± 21.66
Water velocity m/s	0.26 ± 0.05	0.16 ± 0.05	0.22 ± 0.01	0.22 ± 0.01	0.20 ± 0.20

Parameter ranges: Temperature ^{0}C 22.53–24.03 ^{0}C; pH 7.41-8.44; Dissolved Oxygen 7.28-7.69mg/l; Electrical Conductivity 42.69-80.95µS/cm; Water velocity m/s 0.16- 0.26m/s.

3.3 Khlong Phanom National Park Diversity of species

The results of this sample site revealed that fourteen (14) families, thirtythree (33) genera, and one hundred and seven (107) species were observed from the survey. Family Hydropsychidae had the largest diversity of twenty-six (26) species, this was followed by the Family Leptoceridae with twenty-four (24) species. Family Philopotamidae followed with ten (10) species; Families Polycentropodidae and Psychomyiidae had eight (8) species each. Family Ecnomidae had seven (7) species; Family Hydroptilidae had six (6) species; Family Dipseudopsidae had four (4) species; Family Goeridae had five (5) species; Families Helicopsychidae and Calamoceratidae had three (3) species each, while Families Xiphocentronidae, Brachycentridae, and Odontoceridae had one (1) species each. Two new records of Cheumatopsyche opposita BANKS 1931* and *Cheumatopsyche contexta* ULMER 1951* both in the Hydropsychidae family were found in this area of study. This is added to the Trichoptera Checklist of Thailand. A total of three thousand seven hundred and twenty-four (3,724) adult Caddisflies were caught and identified. Table.3.4 below contains the mode of distribution of Trichoptera fauna along the Khlong Phanom tributary, and the means and standard deviation of the water quality parameters observed are presented in table 3.5.

Table 3.4 Khlong Phanom National Park Diversity of species (continued)

Taxonomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
Hydroptilidae							
Hydrotila sabit WELLS & HUSMAN 1992	1	-	-	2	2	m	p
H. thuna OLAH 1989	-	-	-	2	1	m	p
H. rumpun WELLS & HUSMAN 1992	-	2	1	-	-	m	p
Oxyethira bogambara SCHMID 1958	2	-	1	-	-	m	p
Scelotrichia tatius M&C 2007	1	-	-	-	-		
Orthotrichia maendrica ULMER 1951	-	-	-	2	1	m	p
Philopotamidae							
Chimarra thienemanni ULMER 1951	2	-	-	-	-		
C. spinifera KIMMINS 1957	-	1	-	-	-		
C. bimbltona MALICKY 1979	-	1	-	-	-		
C. chiangmaiensis C&M 1989	7	2	-	-	-	m	p
C. monorum C&M 1989	-	7	-	-	-		p
C. argax MALICKY 1989	10	-	-	-	-		p
C. khamuorum C&M 1989	-	-	-	1	-		
C. pipake M&C 1993	3	8	-	-	-	m	p
C. toga M&C 1993	-	-	8	-	-		p
C. okuihorum MEY 1998	-	1	67	45	-	m	c
Polycentropodidae							
Nyctiophylax khaosokensis M&C 1993	-	2	3	-	-	m	p
Pseudoneureclipsis ramosa ULMER 1913	-	-	32	269	-	m	a
P. tramot M&C 1993	1	-	-	-	-		
P. uma M&C 1993	1	2	-	-	-	m	p
P. enos M&C 1993	-	1	-	-	-		
P. cincinatus M&C 2000	2	-	-	-	-		
P. chrysippus MALICKY & SOMPONG 2000	6	2	-	-	-	m	p
P. magog M&C 2009	-	1	-	-	-		
Psychomyiidae							
Paduniella semarangensis ULMER 1913	2	-	-	2	2	m	p
P. hatyaiensis M&C 1993	-	-	8	-	-		p
P. phuketiella	-	-	-	2	1	m	p
Psychomyia thienemanni ULMER 1951	2	2	18	180	1	m	a
P. amphiaraos M&C 1997	86	119	-	4	-	m	a

Table 3.4 Khlong Phanom National Park Diversity of species (continued)

Taxanomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
P. sinon MALICKY & PROMMI 2006	83	3	-	-	-	m	p
Tinodes ragu M&C 1993	1	-	-	1	-	m	
Lype atnia M&C 1993	6	-	-	1	-	m	p
Xiphacentronidae							
Melanotrichia samaconius M&C 1992	-	-	-	1	1	m	
Ecnomidae							
Ecnomus battu MALICKY 1993	-	-	3	1	1	m	p
E. uttu M&C 1993	-	-	1	11	3	m	p
E. totiio M&C 1993	5	33	1	50	-	m	p
E. volovicus M&C 1993	1	-	-	1	8	m	p
E. puro M&C 1993	7	-	9	162	3	m	a
E. neri M&C 1993	18	26	-	4	-	m	c
E. stentor MALICKY & PROMMI 2006	-	-	1	21	-	m	p
Dipseudopsidae							
Dipseudopsis nebulosa ALBARDA 1881	1	-	-	11	3	m	p
D. robustior ULMER 1929	-	-	-	-	5		p
D. varians ULMER 1929	-	-	1	1	-	m	r
D. benardi NAVAS 1930	-	-	1	3	-	m	p
Hydropsychidae							
Diplectrona dulitensis KIMMINS 1955	-	1	-	-	-		
Diplectrona gombak OLAH 1993	-	3	-	3	-	m	p
Macrostemum floridum NAVAS 1929	-	-	-	5	-		p
M. midas M&C 1998	-	1	-	-	-		
Pseudoleptonema quinquefasciatum MARTYNOV 1935	2	-	-	14	-	m	p
Amphipsyche gratiosa NAVAS 1922	7	-	-	13	-	m	c
Hydromanicus serubabel M&C 1993	1	-	-	-	-		
H. inferior C&M 1995	9	3	-	-	-	m	p
Potamyia flavata BANKS 1934	-	2	-	7	-	m	p
P. phaidra M&C 1997	4	1	-	-	1	m	p
P. alleni M&C 1997	1	-	-	-	-		
P. chaos MALICKY & THANI 2000	2	-	-	2	-	m	p
Cheumatopsyche lucida ULMER 1907	-	-	36	-	-		c

Table 3.4 Khlong Phanom National Park Diversity of species (continued)

Taxanomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
C. opposita BANKS 1931*	-	-	-	2	2	m	p
C. dubitans MOSELY 1942	-	-	-	1	-		
C. contexta ULMER 1951*	7	-	-	18	-	m	p
C. dhanikari MALICKY 1997	6	17	-	1	-	m	c
C. trilari M&C 1997	3	1	-	-	-	m	p
C. copia M&C 1997	14	2	-	-	-	m	p
C. chryseis M&C 1997	7	21	-	138	-	m	a
C. chrysothemis M&C 1997	-	107	-	1	-	m	a
C. charites M&C 1997	36	4	3	143	-	m	a
C. cocles M&C 1997	-	-	-	2	-		
C. theophane MALICKY & PROMMI 2006	7	35	-	7	-	m	c
Hydropsyche formosana ULMER 1911	1	-	-	-	-		
H. camillus M&C 2000	-	5	-	-	-		p
Brachycentridae							
Micrasema fortiso M&C 1992	1	-	-	-	-		
Goeridae							
Gastrocentrides sumatranus ULMER 1930	-	-	23	8	21	m	c
Goera uniformis BANKS 1931	2	8	-	21	31	m	c
G. matuilla M&C 1992	1	7	-	-	-	m	p
G. ateduna M&C 1992	-	3	-	-	-		p
G. echo MALICKY & THANI 2000	3	-	-	-	-		p
Helicopsychidae							
Helicopsyche martynovi MOSELY 1939	-	-	1	1	-	m	
H. angusta ULMER 1951	-	21	-	11	-	m	c
H. anaksaku MALICKY 1995	1	-	-	-	-		
Leptoceridae							
Oecetis tripunctata FABRICIUS 1793	1	-	-	48	1	m	c
O. biramosa MARTYNOV 1936	-	11	-	-	-		p
O. lotis MALICKY & THAPANYA 2004	51	31	5	18	-	m	c
O. laodike MALICKY & CHEUNBARN 2005	-	-	1	-	-		
O. momos MALICKY 2005	-	-	-	1	-		
Cereclea idaia MALICKY & CHAIBU 2002	-	-	-	7	-		p
C. iambe MALICKY & PROMMI 2002	-	-	-	3	-		p

Table 3.4 Khlong Phanom National Park Diversity of species (continued)

Taxonomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
C. hersilia MALICKY & CHANGTHONG 2002	-	-	-	18	-		p
C. iuno M&C 2003	-	-	1	-	-		
Triaenodes pellectus ULMER 1908	-	-	6	-	-		c
Trichosetodes pales MALICKY & CHAIBU 2006	5	23	71	159	-	m	a
Parasetodes respersella RAMBUR 1842	-	-	-	3	-		c
Leptocerus dirghachuka GORDON & SCHMID 1987	-	-	4	30	1	m	c
L. lampunensis M&C 1991	1	-	21	25		m	c
L. masik MALICKY 1995	-	-	1	9	-	m	p
Setodes fluvialis KIMMINS 1963	-	-	2	-	-		
S. gangaya GORDON & SCHMID 1987	-	-	-	2	-		
S. iulus M&C 2006	-	13	-	1	-	m	p
S. kybele M&C 2006	1	5	7	343	6	m	a
S. opora M&C 2006	-	-	-	-	2		
S. minotauros M&C 2006	245	-	32	-	-	m	a
S. neleus M&C 2006	-	10	-	3	-	m	p
S. larva M&C 2006	15	-	18	158	6	m	a
S. okyrrhoe M&C 2006	1	-	-	-	5	m	p
Odontoceridae							
Marilia sumatrana ULMER 1951	-	-	-	2	-		
Calamoceratidae							
Ganonema fuscipenne ALBARDA 1881	1	-	-	-	3	m	p
A. brevipennis ULMER 1906	-	-	-	2	-		
Anisocentropus pan M&C 1994	1	-	-	-	-		

Table 3.5 Khlong Phanom National Park water quality parameter values (Mean and SD)

Parameters	1	2	3	4	5
Temperature ^{0}C	25.17 ± 0.13	24.94 ± 0.36	25.13 ± 0.17	25.35 ± 0.05	25.90 ± 0.06
pH	7.22 ±0.25	7.28 ± 0.19	8.00 ± 0.53	7.50 ± 0.03	7.36 ±0.11
Dissolved Oxygen mg/l	7.58 ±0.47	7.76 ±0.29	8.31 ±0.26	8.0 ±0.04	8.57 ±0.52
Electrical Conductivity µS/cm	236.20 ±74	233.25 ±72.05	119.35 ±42.85	93.90 ±68.30	128.30 ±33.90
Water velocity m/s	0.22 ±0.01	0.22 ±0.01	0.21 ±0.00	0.23 ±0.02	0.19 ±0.02

Parameter ranges: Temperature ^{0}C 24.94–25.90 ^{0}C; pH 7.22-8.00; Dissolved Oxygen 7.58-8.57mg/l; Electrical Conductivity 93.90-236.20µS/cm; Water velocity m/s 0.16-0.26m/s.

3.4 Kaengkrung National Park Diversity of species

Trichopteran fauna along the Khlong Yan stream showed that twelve (12) families, thirty-six (36) genera one hundred and twelve (112) species were observed. Family Leptoceridae was the most extensive with thirty-one (31) species and was followed by the Hydropsyhidae family which had twenty-two (22) species. Family Ecnomidae had thirteen (13) species Family Hydroptilidae had twelve (12) species followed by Family Philopotamidae with nine (9) species. Family Psychomyiidae had seven (7) species Family Polycentropodidae had six (6) species. Families: Goeridae Helicopsychidae and Calamoceratidae had three (3) species each. Family Dipseudopsidae had two species and Family Odontoceridae had one species. Here is a new species; n.sp. *kaenkrungensis* was described and has been added to the knowledge of science. The new species belong to the Family Glossosomatidae. Two new records were observed: Polymorphanisus scutellatus BANKS 1939*, Cheumatopsyche contexta ULMER 1951* in the Hydropsychidae family. *Setodes minotauros* of the Leptoceridae family were the most abundant species. The highest number of individual specimens in the Hydropsychidae family was *Cheumatopsyche charites*. *Ecnomus stentor* in the Ecnomidae family had the highest number of individual specimens. A total of four thousand and thiry-two (4,032) adult Trichoptera insects were caught and identified during the survey. The pattern of distribution is presented in table 3.6 below, the means, standard deviation, and the range of water quality parameters recorded are presented in table 3.7

Table 3.6 Kaengkrung National Park Diversity of species

Taxanomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
Hydroptilidae							
Hydroptila gaya OLAH 1989	-	1	-	-	-		
H. sabit WELLS & HUSMAN 1992	-	11	-	-	-		p
H. rumpun WELLS & HUSMAN 1992	-	1	-	-	-		
H. roma M&C 2007	-	6	-	-	-		p
H. tethys M&C 2007	-	2	-	-	-		
H. portumus M&C 2007	-	-	1	-	-		
H. venus M&C 2007	-	-	2	-	-		
H. verticordia M&C 2007	-	-	-	2	2	m	p
Oxyethira bogambara SCHMID 1958	-	2	-	-	-		
Chryotrichia tydeus M&C 2007	-	3	-	-	-		p
C. zoroastres M&C 2007	-	4	-	-	-		p
Orthotrichia maendrica ULMER 1951	-	2	2	-	-	m	p
Philopotamidae							
Chimarra thienemanni ULMER 1951	8	35	-	-	-	m	c
C. chiangmaiensis C&M 1989	1	217	-	-	7	m	a
C. monorum C&M 1989	5	-	2	-	-	m	p
C. argax MALICKY 1989	32	-	6	82	65	m	c
C. khamuorum C&M 1989	2	-	1	-	-	m	p
C. horok MALICKY 1989	1	-	-	-	-		
C. yskal MALICKY 1989	-	3	1	-	-	m	p
C. pipake M&C 1993	-	5	-	-	-		p
C. okuihorum MEY 1998	1	-	-	18	101	m	a
Polycentropodidae							
Nyctiophylax khaosokensis M&C 1993	1	22	-	7	-	m	c
Pseudoneureclipsis cf ramosa ULMER 1913	3	8	1	42	12	m	c
P. tramot M&C 1993	41	14	1	53	6	m	c
P. uma M&C 1993	2	1	1	-	-	m	p
P. chrysippus MALICKY & SOMPONG 2000	6	-	-	-	-		p
Pahamunaya jihmita SCHMID & DENNING 1979	-	4	1	-	-	m	p

Table 3.6 Kaengkrung National Park Diversity of species (continued)

Taxanomic Group Family	Sites 1	2	3	4	5	Dist.	Abund.
Psychomyiidae							
Paduniella semarangensis ULMER 1913	-	3	-	-	-		p
Psychomyia thienemanni ULMER 1951	40	19	-	60	43	m	p
P. amphiaraos M&C 1997	-	-	-	-	1		
P. sinon MALICKY & PROMMI 2006	18	-	-	-	-		p
P. pinsuwane LAUDEE & MALICKY 2018	-	-	1	-	-		
Tinodes ragu M&C 1993	-	2	2	-	-	m	p
Lype atnia M&C 1993	1	-	-	1	-	m	
Ecnomidae							
Ecnomus pseudotenellus ULMER 1930	-	-	-	-	1		
E. robustior ULMER 1951	-	-	-	-	1		
E. talenoi M&C 1993	-	2	1	-	-	m	p
E. jojachin M&C 1993	-	-	-	8	-		p
E. uttu M&C 1993	-	-	-	4	-		p
E. totiio M&C 1993	3	1	-	2	-	m	p
E. volovicus M&C 1993	18	3	-	-	-	m	c
E. puro M&C 1993	9	17	2	48	4	m	c
E. neri M&C 1993	1	1	27	9	-	m	c
E. vebinus M&C 1993	10	-	4	-	-	m	p
E. anakagung MALICKY 1995	-	-	-	3	-		p
E. thamyris MALICKY & PROMMI 2006	-	1	-	-	-		
E. stentor MALICKY & PROMMI 2006	72	24	-	39	1	m	c
Dipseudopsidae							
Dipseudopsis nebulosa ALBARDA 1881	1	-	-	15	-	m	p
D. doehleri ULMER 1929	-	4	-	-	-		p
Hydropsychidae							
Diplectrona gombak OLAH 1993	2	4	2	1	-	m	P

Table 3.6 Kaengkrung National Park Diversity of species (continued)

Taxanomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
Polymorphanisus scutellatus BANKS 1939 *	1	-	-	-	-		
Macrostemum dohrni ULMER 1905	-	1	-	-	-		
M. floridum NAVAS 1929	111	-	-	11	1	m	a
Pseudoleptonema quinquefasciatum MARTYNOV1935	1	4	-	-	-	m	p
Amphipsyche gratiosa NAVAS 1922	223	2	-	16	8	m	a
Hydromanicus inferior C&M 1995	2	-	-	1		m	p
Potamyia flavata BANKS 1934	-	1	-	-	7	m	p
P. phaidra M&C 1997	-	3	-	3	7	m	p
P. alleni M&C 1997	-	-	-	1	-		
P. chaos MALICKY & THANI 2000	-	-	-	-	5		p
Cheumatopsyche lucida ULMER 1907	14	-	-	1	3	m	p
C. globosa ULMER 1910	-	-	-	-	2		
C. contexta ULMER 1951 *	6	1	-	39	111	m	a
C. dhanikari MALICKY 1979	3	-	2	-	1	m	p
C. trilari M&C 1997	1	-	1	-	-	m	
C. chryseis M&C 1997	-	-	3	-	-		p
C. chrysothemis M&C 1997	17	108	6	-	-	m	a
C. charites M&C 1997	151	12	-	358	25	m	a
C. theophane MALICKY & PROMMI 2006	4	-	1	-	1	m	p
Hydropsyche formosana ULMER 1911	-	-	-	1	-		
H. camillus M&C 2000	2	-	-	-	7	m	p
Goeridae							
Gastrocentrides sumatranus ULMER 1930	5	1	-	3	3	m	p
Goera uniformis BANKS 1931	4	4	-	3	-	m	p
G. matuilla M&C 1992	1	-	-	-	-		

Table 3.6 Kaengkrung National Park Diversity of species (continued)

Taxonomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
Helicopsychidae							
Helicopsyche martynovi MOSELY 1939	-	1	-	-	-		
H. angusta ULMER 1951	2	-	11	-	-	m	p
H. anaksaku MALICKY 1995	-	1	-	-	-		
Leptoceridae							
Oecetis tripunctata FABRICIUS 1793	1	17	3	61	5	m	c
O. hemerobioides MACLACHLAN 1866	-	-	-	3	-		p
O. asmada MALICKY 1979	-	4	-	-	-		p
O. devakiputra SCHMID 1995	-	1	-	-	-		
O. empusa MALICKY & CHAIBU 2000	-	-	-	-	3		p
O. lotis MALICKY & THAPANYA 2004	59	25	-	7	27	m	a
O. kyanippos MALICKY &SOMPONG 2005	1	-	-	-			
O. laodike MALICKY & CHEUNBARN 2005	-	1	-	-	-		
O. ladon MALICKY & LAUDEE 2005	4	-	-	-	-		p
Adicella evadine SCHMID 1994	-	1	-	-	-		
Cereclea idaia MALICKY & CHAIBU 2002	-	-	-	1	-		
C. hersilia MALICKY & CHANGTHONG 2002	-	-	-	4	2	m	p
C. harpalyke MALICKY & CHANGTHONG 2002	-	-	-	1	-		
Tagalopsyche brunnea ULMER 1905	-	-	-	1	-		
Triaenodes pellectus ULMER 1908	-	-	-	1	-		
T. dursa SCHMID 1965	-	-	1	-	-		
Trichosetodes pales MALICKY & CHAIBU 2006	1	11	-	35	36	m	c
Parasetodes respersella RAMBUR 1842	2	-	-	-	1	m	p
Leptocerus amoenus ULMER 1951	-	1	-	-	-		
L. tursiops MALICKY 1979	-	4	-	-	-		p

Table 3.6 Kaengkrung National Park Diversity of species (continued)

Taxanomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
L. dirghachuka GORDON & SCHMID 1987	1	5	-	8	1	m	p
L. lampunensis M&C 1991	1	-	-	7	5	m	p
L. Masik MALICKY 1995	-	-	-	1	-		
L. faunus M&C 2002	-	2	-	-	-		
Setodes fluvialis KIMMINS 1963	-	-	-	1	-		
S. iulus M&C 2006	1	-	-	-	-		
S. kybele M&C 2006	-	3	1	1	1	m	p
S. minotauros M&C 2006	260	137	8	11	199	m	a
S. neleus M&C 2006	1	2	-	-	2	m	p
S. larva M&C 2006	92	17	1	176	26	m	a
S. okyrrhoe M&C 2006	-	-	-	1	-		
Odontoceridae							
Marilia sumatrana ULMER 1951	-	1	-	1	1	m	p
Calamoceratidae							
Ganonema fuscipenne ALBARDA 1881	-	1	2	-	-	m	p
Anisocentropus brevipennis ULMER 1906	-	2	-	-	-		
A. pan M&C 1994	-	-	3	-	-		p

Table 3.7 Kaengkrung National Park water quality parameter values (Mean and SD)

Parameters	1	2	3	4	5
Temperature ^{0}C	25.00 ±0.19	24.20 ±0.58	23.27 ±1.54	25.85 ±1.02	25.73 ±0.92
pH	7.44 ±0.11	7.31 ±0.02	6.93 ±0.40	7.53 ±0.20	7.43 ±0.10
Dissolved Oxygen mg/l	7.70 ±0.18	7.03 ±0.49	7.05 ±0.47	7.95 ±0.43	7.89 ±0.37
Electrical Conductivity µS/cm	111.10 ±21.71	133.03 ±0.22	165.63 ±32.82	105.38 ±27.43	148.90 ±16.09
Water velocity m/s	0.34 ±0.06	0.26 ±0.22	0.12 ±0.12	0.29 ±0.05	0.23 ±0.01

Parameter ranges: Temperature ^{0}C 23.27–25.85 ^{0}C; pH 6.93-7.53; Dissolved Oxygen 7.03-7.95mg/l; Electrical Conductivity 111.10-165.63µS/cm; Water velocity 0.12-0.34m/s.

3.5 Khlong Saeng Wildlife Sanctuary Diversity of species

The results of the Caddisflies survey from the Khlong Saeng tributary showed that sixteen (16) families of thirty-one (31) genera and ninety-two (92) species were observed. Family Hydropsychidae had the highest diversity with twenty-five (25) species. This was followed by Family Leptoceridae had twenty-one (21) species. Family Philopotamidae had twelve (12) species Psychomyiidae family had seven (7) species. Family Hydroptilidae had five (5) species Family Ecnomidae had four (4) species. Families: Dipseudopsidae Goeridae and Helicopsychidae had two (2) species each while families Rhyacophilidae Glossosomatidae Stenopsychidae Brachycentridae Lepidostomatidae and Calamoceratidae had one (1) species each. *Cheumatopsychidae charites* are the most abundant in the Hydropsychidae family, *Setodes kybele* had the largest number of specimens in the Family Leptoceridae. Family Dipseudopsidae appeared to be commonly found in all sampling locations in this area. Two thousand and sixty-three (2,063) individual specimens were found and their distribution is presented in table 3.8 below. In addition, the means, standard deviation, and the range of water quality parameters recorded during data collection are shown in table 3.9.

Table 3.8 Khlong Saeng Wildlife Sanctuary Diversity of species

Taxonomic Group	Sites					Dist.	Abund.
Family	1	2	3	4	5		
Ryacophilidae							
Ryachophila noeibia M&C 1993	-	-	-	-	2		
Glossosomatidae							
Agapetus halong OLAH 19998	1	-	-	2	-	m	p
Hydroptilidae							
Hydroptila sabit WELLS & HUISMAN 1992	1	-	-	-	-		
H. thuna OLAH 1989	1	-	-	-	-		
H. roma M&C 2007	1	2	-	-	-	m	p
H. portumus M&C 2007	-	2	-	2	-	m	p
Ugandatrichia hairanga OLAH 1989	1	-	-	-	-		
Philopotamidae							
Chimarra thienemanni ULMER 1951	1	2	-	1	-	m	p
C. spinifera KIMMINS 1957	-	-	-	1	3	m	p
C. bimbltona MALICKY 1979	3	2	-	12	-	m	p
C. chiangmaiensis C&M 1989	-	1	-	-	-		
C. momrum M&C 1989	-	-	-	1	1	m	
C. argax MALICKY 1989	-	-	-	-	1		
C. horok MALICKY 1989	-	-	-	1	-		
C. yskal MALICKY 1989	-	1	-	-	-		
C. toga M&C 1993	4	4	1	1	1	m	p
C. vibena M&C 1993	-	-	-	2	-		
C. ravana M&C 1993	-	-	-	-	1		
C. okuihorum MEY 1998	5	7	-	41	84	m	c
Kisaura peleg MALICKY & LAUDEE 2009	-	-	-	1	-		
Stenopsychidae							
Stenopsyche siamensis MARTYNOV 1931	1	-	-	-	-		
Polycentropodidae							
Nyctiophylax khaosokensis M&C 1993	1	1	2	8	-	m	p
Polyplectropus matthatha M&C 1993	-	1	-	6	-	m	p
Pseudoneureclipsis ramosa ULMER 1913	1	-	-	-	-		
P. tramot M&C 1993	2	-	-	-	-		

Table 3.8 Khlong Saeng Wildlife Sanctuary Diversity of species (continued)

Taxonomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
P. uma M&C 1993	-	1	-	-	-		
P. chrysippus MALICKY & SOMPONG 2000	-	-	-	3	-		p
Psychomyiidae							
Paduniella semarangensis ULMER 1913	3	-	-	-	-		p
P. yeratel	-	1	-	-	-		
Psychomyia thienemanni ULMER 1951	15	30	21	6	20	m	c
P. indra M&C 1993	30	78	112	36	10	m	a
P. amphiaraos M&C 1997	24	15	-	45	3	m	c
P. sinon MALICKY 7 PROMMI 2006	5	6	-	23	-	m	c
Lype atnia M&C 1993	-	-	-	2	-		
Ecnomidae							
E. uttu M&C 1993	-	-	-	-	1		
E. totiio M&C 1993	7	4	10	-	2	m	c
E. puro M&C 1993	-	-	-	-	30		c
E. neri M&C 1993	-	5	6	14	3	m	c
Dipseudopsidae							
Dipseudopsis nebulosa ALBARDA 1881	22	16	36	7	9	m	c
D. robustior ULMER 1929	2	9	26	31	20	m	c
Hydropsychidae							
Diplectrona dulitensis KIMMINS 1955	-	-	-	1	3	m	p
Diplectrona gombak OLAH 1993	-	1	-	1	5	m	p
Polymorphanisus astictus NAVAS 1923	-	2	-	-	-		
Macrostemum floridum NAVAS 1929	-	1	-	-	11	m	p
M. midas M&C 1998	1	-	-	4	-	m	p
Pseudoleptonema quinquefasciatum MARTYNOV1935	7	2	-	-	2	m	p
Amphipsyche gratiosa NAVAS 1922	11	3	1	-	-	m	p
Hydromanicus unicolor ULMER 1951	-	1	-	-	1	m	
H. serubabel M&C 1993	-	-	-	1	-		

Table 3.8 Khlong Saeng Wildlife Sanctuary Diversity of species (continued)

Taxonomic Group Family	Sites 1	 2	 3	 4	 5	Dist.	Abund.
H. inferior C&M 1995	-	-	-	1	-		
Potamyia flavata BANKS 1934	-	-	-	-	3		p
P. phaidra M&C 1997	1	1	11	-	-	m	p
P. chaos MALICKY & THANI 2000	19	6	1	-	-	m	p
Cheumatopsyche lucida ULMER 1907	-	2	-	-	1	m	p
C. dubitans MOSELY 1942	33	92	15	-	-	m	c
C. dhanikari MALICKY 1997	3	20	-	15	-	m	c
C. tilari M&C 1997	-	-	-	-	6		p
C. copia M&C 1997	13	-	-	-	-		p
C. chrysothemis M&C 1997	-	3	-	-	3	m	p
C. charites M&C 1997	215	130	70	5	2	m	a
C. tramota M&C 1997	10	-	-	-	-		p
Hydropsyche formosana ULMER 1911	3	11	1	3	1	m	p
H. Camillus M&C 2000	5	2	2	7	-	m	p
H. brontes M&C 2000	7	1	1	-	-	m	p
H. atropos M&C 2000	-	-	-	3	-		p
Brachycentridae							
Micrasema fortiso M&C 1992	-	-	-	-	1		
Goeridae							
Gastrocentrides sumatranus ULMER 1930	7	4	2	-	-	m	p
Goera uniformis BANKS 1931	9	8	4	3	-	m	p
G. redsonar M&C 1992	-	-	-	1	-		
Helicopsychidae							
Helicopsyche martynovi MOSELY 1939	-	-	-	1	-		
H. angusta ULMER 1951	-	1	-	1	-	m	
Lepidostomatidae							
Lepidostoma schwendingeri M&C 1994	1	-	-	-	-		
Leptoceridae							
Oecetis tripunctata FABRICIUS 1793	-	-	-	-	2		
O. jacobsoni ULMER 1930	-	-	-	1	-		

Table 3.8 Khlong Saeng Wildlife Sanctuary Diversity of species (continued)

Taxonomic Group Family	Sites 1	2	3	4	5	Dist.	Abund.
O. biramosa MARTYNOV 1936	-	2	-	-	-		
O. empusa MALICKY & CHAIBU 2000	-	-	-	1	-		
O. lotis MALICKY & THAPANYA 2004	1	-	-	9	-	m	p
O. meleagros MALICKY & THANI 2005	-	1	-	-	1	m	
Poecilopsyche gyges M&C 2002	-	-	-	1	-		
Triaenodes narkissos MALICKY 2005	-	-	-	-	2		
Trichosetodes pales MALICKY & CHAIBU 2006	1	-	-	-	-		
Leptocerus dirghachuka GORDON & SCHMID 1987	-	-	-	-	36		c
L. chiangmaiensis M&C 1991	-	-	-	-	8		p
L. Masik MALICKY 1995	-	-	-	-	2		
L. posticoides MALICKY 1995	-	-	-	-	1		
Setodes gangaya GORDON & SCHMID 1987	-	-	-	-	20		c
S. akrura GORDON & SCHMID 1987	4	-	-	-	-		p
*S. thonet*i M&C 2006	1	-	-	6	-		p
S. iulus M&C 2006	-	-	-	12	-		p
S. kybele M&C 2006	50	6	1	39	-	m	c
S. minotauros M&C 2006	7	40	27	1	2	m	c
S. neleus M&C 2006	1	24	5	51	2	m	c
S. larva M&C 2006	-	-	-	1	-		
Calamoceratidae							
Anisocentropus pan M&C 1994	-	-	-	-	1		

Table 3.9 Khlong Saeng Wildlife Sanctuary water quality parameter values (Mean and SD)

Parameters	1	2	3	4	5
Temperature^{0}C	24.07 ±0.40	24-03 ±0.31	23.93 ±0.26	23.05 ±0.62	23.36 ±0.31
pH	6.93 ±0.20	6.92 ±0.21	6.95 ±0.18	7.28 ±0.15	7.57 ±0.44
Dissolved Oxygen mg/l	7.38 ±0.17	7.47 ±0.08	7.71 ±0.16	7.70 ±0.15	7.48 ±0.07
Electrical Conductivity µS/cm	60.00 ±12.87	61.38 ±11.49	66.93 ±5.94	116.52 ±43.65	59.60 ±13.27
Water velocity m/s	0.28 ±0.04	0.24 ±0.02	0.20 ±0.02	0.20 ±0.02	0.21 ±0.01

Parameter ranges: Temperature^{0}C 23.05–24.07^{0}C; pH 6.92-7.57; Dissolved Oxygen 7.38-7.71mg/l; Electrical Conductivity 60.00-116.52µS/cm; Water velocity 0.20-0.28m/s.

3.6 Relationship between water quality parameters and Trichoptera species

The relationship between water quality parameters and species diversity was subjected to Pearson's correlation analysis. Fifteen species out of the list of abundant species were selected, and their responses to some water environmental variables were analyzed by Pearson's correlation method. The result obtained is presented as *Diplectrona gombak* and *Setodes larva* had a moderate positive correlation with temperature. *Diplectrona gombak* and *Dipseudopsis nebulosa* responded moderately to the pH condition in their habitats. The relationship between *Setodes minotauros* and electrical conductivity demonstrated a moderate correlation between the species and the water environment, this confirms that the larvae are more comfortable in water habitats of optimum electrical conductivity. *Macrostemum floridum* and *Amphipsyche gratiosa* exhibited a very high positive correlation with water velocity, details presented in table 3.10 below.

Table 3.10 Result of Correlation analysis

Species	Temperature	pH	Electrical Conductivity	Water Velocity
Diplectrona gombak	.547*	.556*		
Macrostemum floridum				.610**
Amphipsyche gratiosa				.621**
Dipseudopsis nebulosa		.500*		
Cheumatopsyche charites				.487*
Setodes minotauros			.474*	
Setodes neleus	-565**			
Setodes larva	.547*			.474*

3.7 Life Cycle of *Macrostemum floridum* NAVAS 1929

A seasonal collection of adult *Macrostemum floridum* insects by use of a UV-light trap was from March-December 2019, the hot season (March-May), the wet season I (July-September), wet season II (October-December). The results indicated that it has a nonseasonal life cycle as contained in table 3.11.

Table 3.11 *Macrostemum floridum* seasonal collection

Location	March-May	July-September	October-December
Khao Sok Natioal park	8	3	1
Khlong Phanom Nationa park	3	-	2
Kaengkrung National Park	122	-	1
Khlong Saeng Wildlife Sanctuary	12	-	-

From the monthly samples of February-July, a total of one hundred and twenty-five (125) larvae were collected. Head capsule width was distributed with values from 0.45-1.5mm. The frequency distribution of each instar stage is contained in Figure 3.2 below. Analysis of the head capsule (HCW) showed that there are five larval instars present. The ranges and mean ± SD of head capsule width are Instar I: HCW=0.45-0.55mm, 0.5±0.05mm (n=5), Instar II: HCW=0.65-0.75mm, 0.7±0.05mm (n=6), Instar III: HCW=0.9-1.00mm, 0.95±0.05mm (n=19), Instar IV: HCW=1.20-1.30mm, 1.25±0.05mm (n=15), Instar V: HCW=1.40-1.50mm, 1.45±0.05mm (n=80). Other details are shown in table 3.12.

Table 3.12 Larval instars I-V

S/No.	Larval instars	Number collected	Body length	Head capsule width	Body-color (ethanol)
1	I	5	3.75-5.00mm	0.45-0.55mm	Mandibles with patches of yellow color, spots of color on the thoracic joint, body are pale
2	II	6	5.75-7.00mm	0.65-0.75mm	Yellowish patches on the head and thoracic joints, the body is pale
3	III	19	7.50-9.00mm	0.90-1.00mm	Head, lateral sides of thoracic segments, and joints are yellowish as well as yellowish patches on the abdomen
4	IV	15	11.00-16.00mm	1.20-1.30mm	Bright yellow
5	V	80	10.00-14.00mm	1.40-1.50mm	Yellow

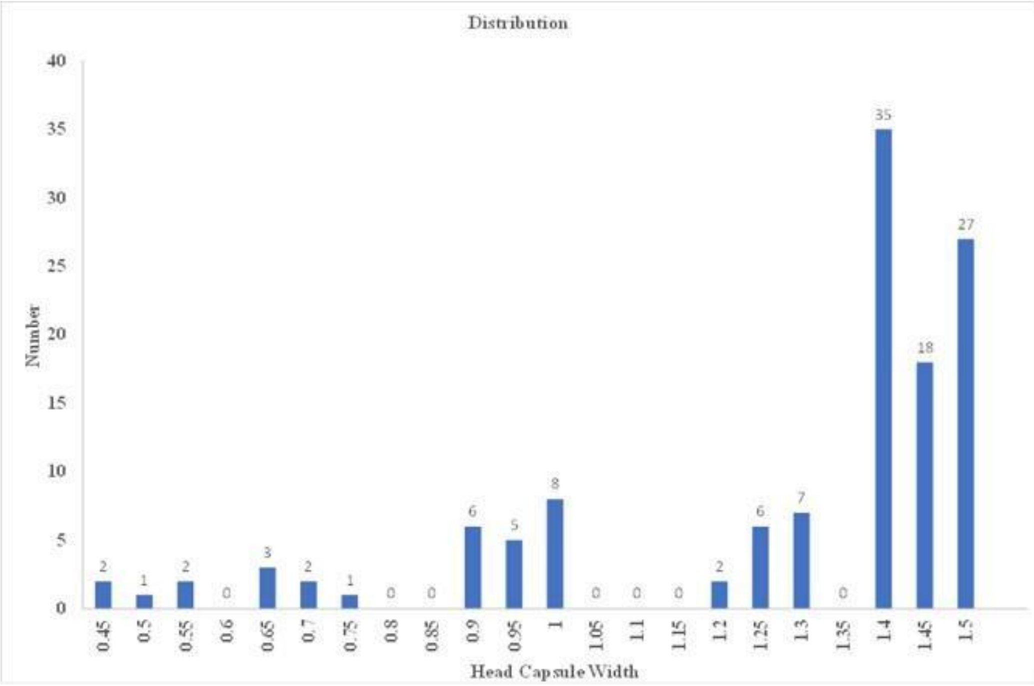

Figure 3.2 Distribution of head capsule width (mm) of the larvae of *Macrostemum floridum*

3.8 Progressive larval development of *M. floridum*

Progressive larval growth development was carried out in the laboratory. This showed that instar I larva takes two weeks to develop to instar II. Larval instar II takes four weeks to develop to instar II (Table 3.13). No record was obtained of larval development from instar III to IV, instar IV to V, and instar V to pupa. This information is presented in the table below. *Macrostemum floridum* larva construct case tube-like in shape and fixed to a substrate. Larval cases of the subterminal instars can be differentiated from those of the final instars because the sand grains are loosely packed in the subterminal instar cases while those of the final instars and pupae are firmly packed (Figures 3.3 larval and pupal cases, and 3.4 larva in natural habitat).

Table 3.13 Summary of developmental stages between instars

S/No.	Instars	Developmental duration (weeks)
1	I	
2	II	2
3	III	4
4	IV	-
5	V	-
6	Pupa	-
7	Adult	-

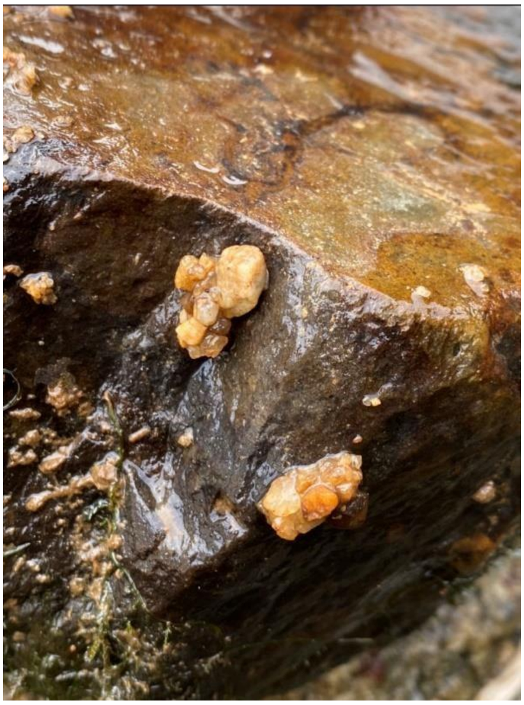

Figure 3.3 Larval and pupal cases of *M. floridum*

Figure 3.4 Larva of *M. floridum* in natural habitat

3.9 Description of fifth larval instar of *Macrostemum floridum*

Macrostemum floridum NAVAS 1929, instar five was examined as follows: body length; 10.00-14.00mm, body structure elongated and cylindrical (Figure 3.5), head capsule width 1.40-1.50 mm, larval case length 14.50 mm-15.00 mm, tube-like more or less straight

Head: Yellow with a dark brown coloration of mandibles, extending anteriorly to the dorsal and ventral parts of parietal sclerites. The dorsal surface of the head flattened to the anterior with a well-defined U-shaped carina (Figure 3.6). The head capsule consists of large paired parietal sclerites medially separated by frontoclypeal apotome to the anterior, posteriorly joining beyond the carinal line to form the coronal suture, (Figure 3.6). Frontoclypeus is a conspicuous triangularshaped structure found at the center of the dorsum and the main feature of the dorsal surface of the head. One pair of long hairs is situated anteriorly in front of each stemma or eye, while another pair is located posteriorly before the carinal line, and 14 pairs occur on the carinal ridges at the lateral sides of the head. Two pairs of dark brown pigments are located at the center of the frontoclypeus with numerous muscle scars distributed across the dorsal head capsule (Figure 3.6). A pair of antennae are located each in front of the eye towards the base of mandibular joints at the anterolateral corners. The eyes or stemmata are found anterolaterally on the carinal line. At the ventral side of the head is the ventral apotome joined by an ecdysial suture to the occipital margin posteriorly, also located on each side of this suture is an area of fine transverse/stridulating ridges (Figure 3.7). Two dark brown symmetrical mandibles are found anterior laterally at each side of the head, they both possess some mesal hairs, the right mandible has two apical, three mesal teeth (Figure 3.8), and the upper mesal tooth is pointed while the other two are blunt. The left has two apical and five mesal teeth, the two upper mesal teeth are pointed but the three lower ones are blunt (Figure3.9). The labrum is a membranous structure, with a pair of discrete sclerites at the base, dense setae brush on each side, and sometimes seen protruding anteriorly in a semi-circle shape (Figure 3.9). This is located dorsally within the inter mandibular space, and ventrally the labial palps are situated in front of each mandibular strand and enclose the silk gland orifice.

Thorax: The three thoracic segments of pronotum, mesonotum, and metanotum are yellow and sclerotized, each bearing a pair of jointed walking legs, with dark brown or black coloration at their lateral sides towards the joints. A mediodorsal line referred to as an ecdysial line divides the pronotum into two halves, each half bearing four pairs of long hairs anterolaterally, one pair laterally and another pair mediolaterally (Figure 3.10), while the mesonotum and metanotum are without an ecdysial suture. Mesonotum has two pairs of anterolateral long hairs, a pair of mediolateral and two pairs laterally located. The metanotum has three pairs of mediolateral and a pair found laterally. A black spot in the form of a bat-shaped structure is found medio-posteriorly on the mesonotum (Figure 3.11). A dark red or dark brown spot resembles a hoof of a horse-like structure posterior-medially on the metanotum (Figure 3.12). There are muscle scars on the pronotum and mesonotum situated around the fore and middle thoracic joints. Two stripes and more scattered muscle scars are seen around the lateral sides of the metanota joints. On the ventral side of the mesonotum, is a row of gill filaments, and two pairs on the metanotal segment, which extends to the ventral and lateral abdominal regions of segments I-VII (Figure 3.13). Jointed appendages (legs) are generally divided into; the coxa, trochanter, femur, tibia, and tarsus. The pronotum bears the foretrochantin and is well forked and sclerotized with a prominent process at the base of the femur (Figure 3.14). Other parts of the forelegs are covered with setae, but long hairs are seen on the hind ventral side of the femora, and with an unusual dense long hair on tibiae and tarsi. The middle (Figure 3.15) and hind legs (Figure 3.16) are similar in structure, shape, and size but the hind legs' tarsi claw and basal seta are more pronounced. The hind legs also consist of conspicuous long setae found on the femur, tibiae, and tarsi. Short stout setae are found at the ventral sides of the femora, tibiae, and tarsi.

Abdomen: Abdominal segments are ten in number. Segment I bear some folds at the larval integument. The dorsal surface of the abdominal segments I-IX consists of brownish setae (Figure 3.17), with strands of long hairs scattered within them and more numerous on segments VII-IX. The abdomen is generally yellowish or brownish, a prominent streak of the dark brown area could be seen in segments I-VII. A pair of sclerites are visible on the ventral side of segment IX (figure 3.18), also found is a pair of patches of sclerites at the joints of the prolegs with segment IX. A tuft of stout long hairs at the dorsal end of anal prolegs. A pair of sclerotized anal hooks pointing inwards ventrally occurred at the end of the prolegs (Figure 3.19).

Figure 3.5 *Macrostemum floridum* larval structure

Figure 3.6 Dorsal view of the head capsule with U-shaped carina

Figure 3.7 Ventral view of the head capsule with transverse ridges

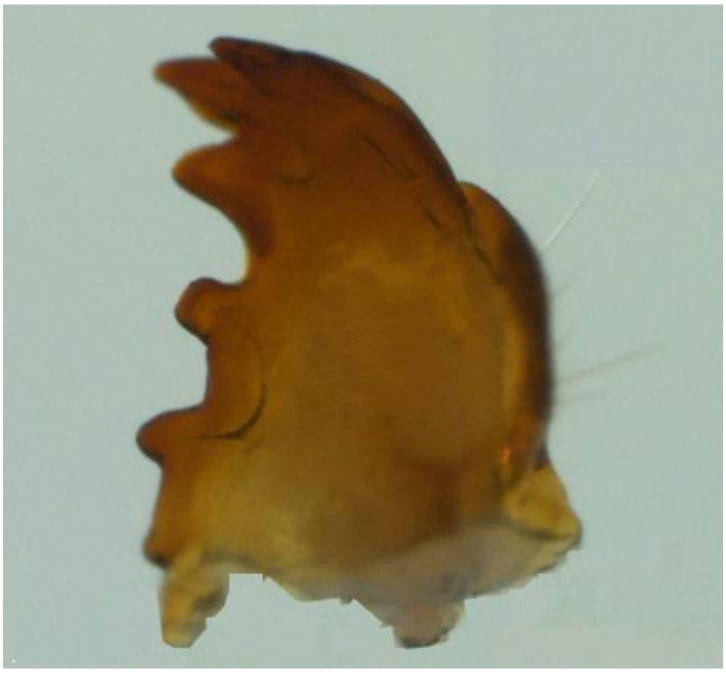

Figure 3.8 Right mandible showing apical and mesal teeth

Figure 3.9 Left mandible showing apical and mesal teeth

Figure 3.10 Labrum with dense brushes of setae

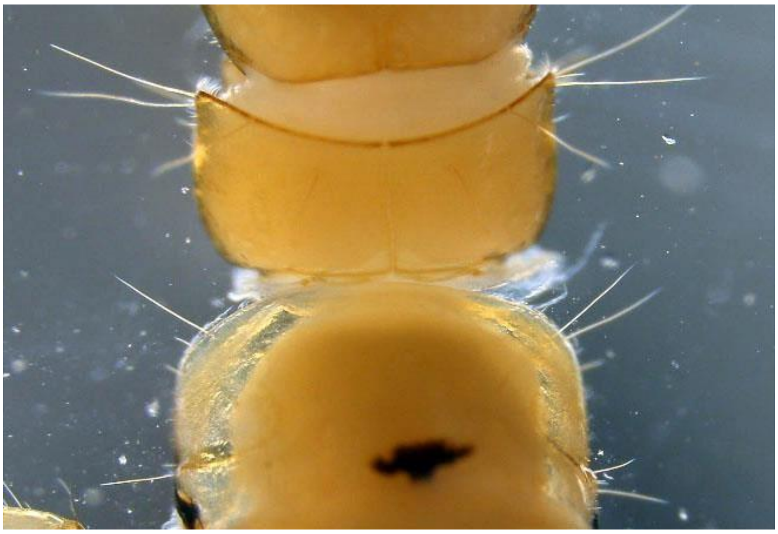

Figure 3.11 Pronotum with dorsal medial ecdysial line

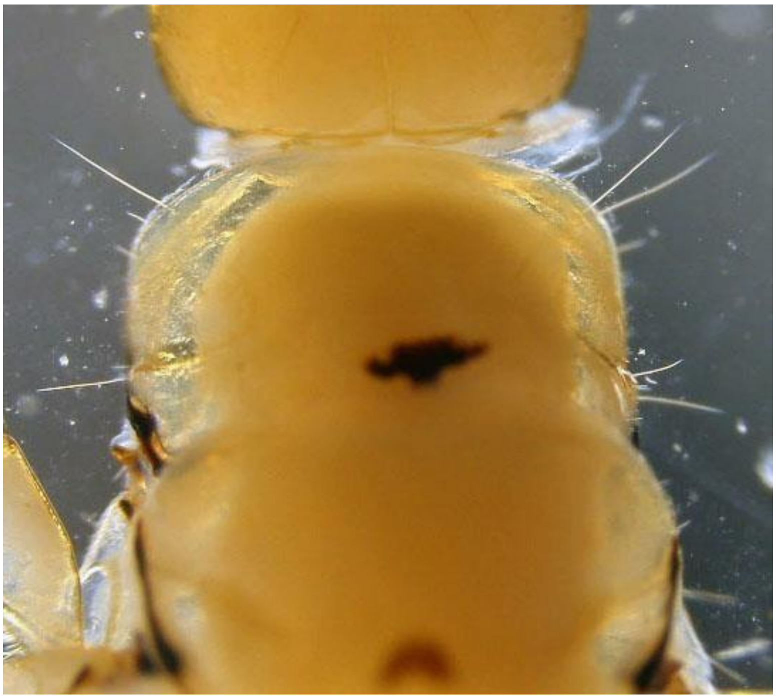

Figure 3.12 Mesonotum with bat-shaped structure

Figure 3.13 Metanotum with dark brown hoof-shaped structure

Figure 3.14 Fore leg with forked foretrochantin and dense hairs on the tibia and tarsus

Figure 3.15 Mid leg with long hairs on mostly on ventral side

Figure 3.16 Hind leg with long hairs on dorsal and ventral sides

Figure 3.17 Dorsal view of the abdomen

Figure 3.18 Ventral view of the abdomen with numerous gill filaments

Figure 3.19 Anal prolegs with claws

3.10 Gut content analysis

A total of twelve larvae were incised and the gut contents were viewed under Leica DM 750 microscope. The contents observed were quantitatively assessed and analyzed which gave rise to the following various types of food substances; Cyanophyta (blue-green algae), Chlorophyta (green algae), and Bacillariophyta (diatoms) examples are *Cylindrospermopsis* spp., *Ankistrodesmus* spp., *Achnanthidium* spp., *Fragilaria* spp. e.t.c. The food materials ingested by *M. floridum*, are presented in the photographs (Figures 3.20-30; and quantitative description in Table 3.9). *Macrostemum floridum* belongs to the group of collector-filterers, which usually use special adaptations to collect fine particle organic matter directly from the water column in the stream.

Figure 3.20 *Cylindrospermopsis* spp.

Figure 3.21 *Hapalosiphon* spp.

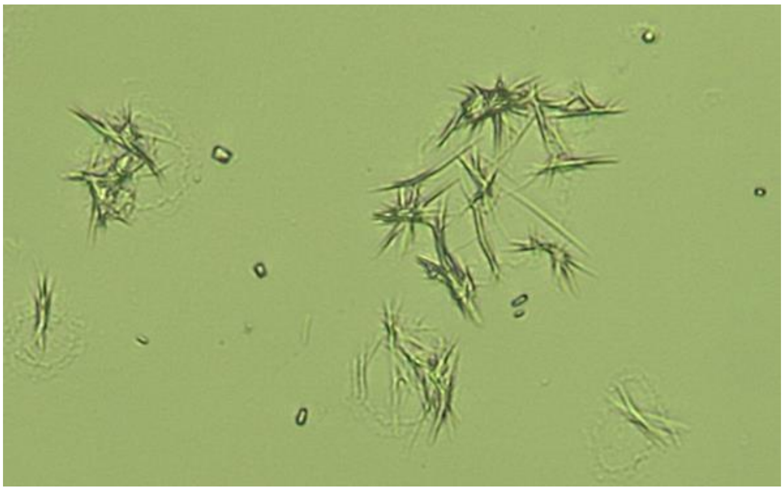

Figure 3.22 *Ankistrodemus* spp.

Figure 3.23 *Closterium* spp.

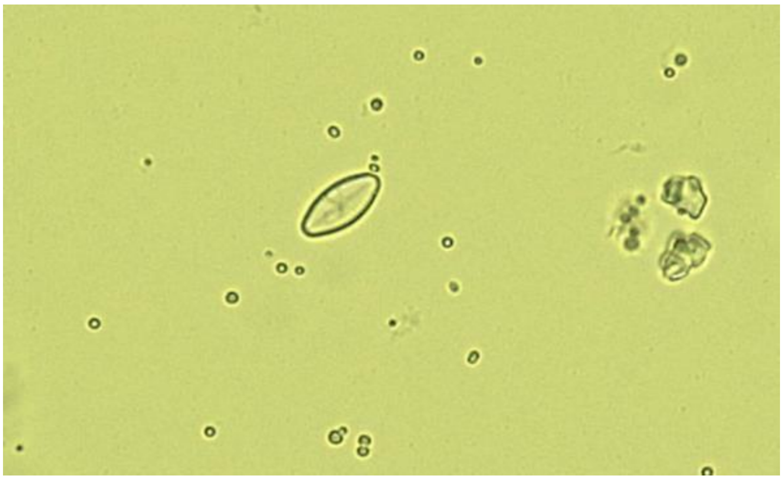

Figure 3.24 *Achnanthidium* spp.

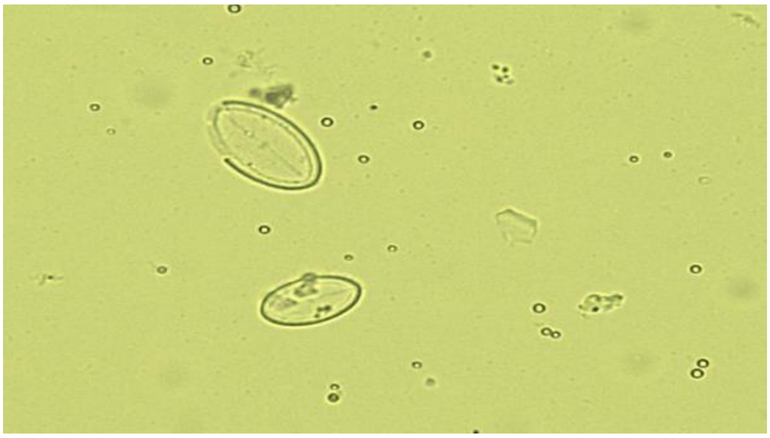

Figure 3.25 *Cocconeis* spp.

Figure 3.26 *Craticula* spp.

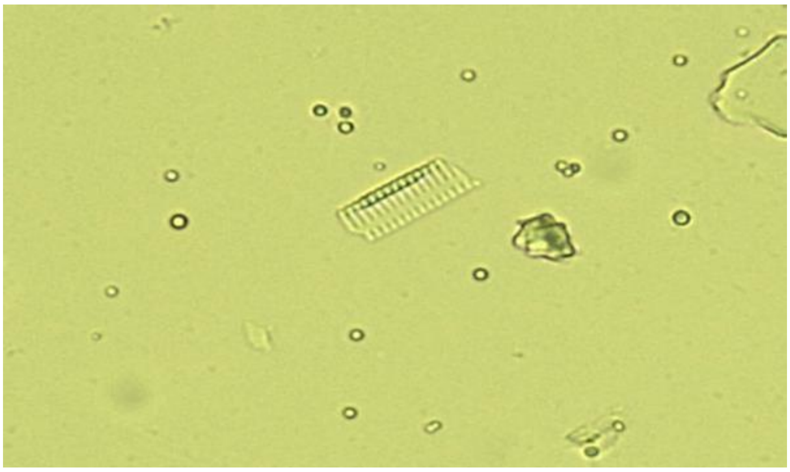

Figure 3.27 *Fragilaria* spp.

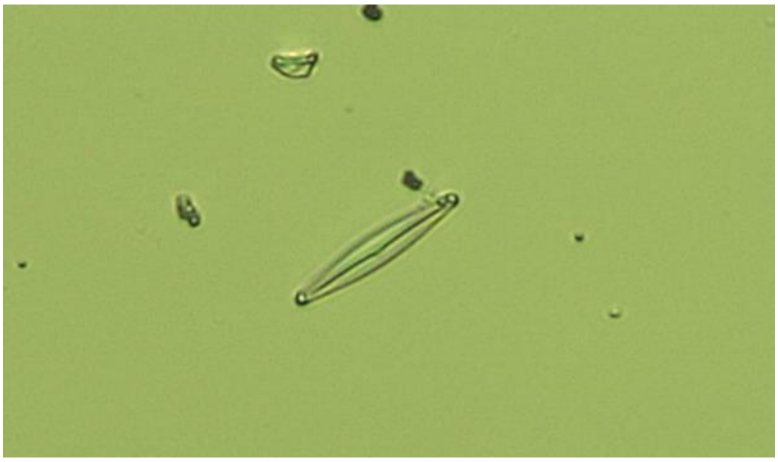

Figure 3.28 *Frustulia* spp.

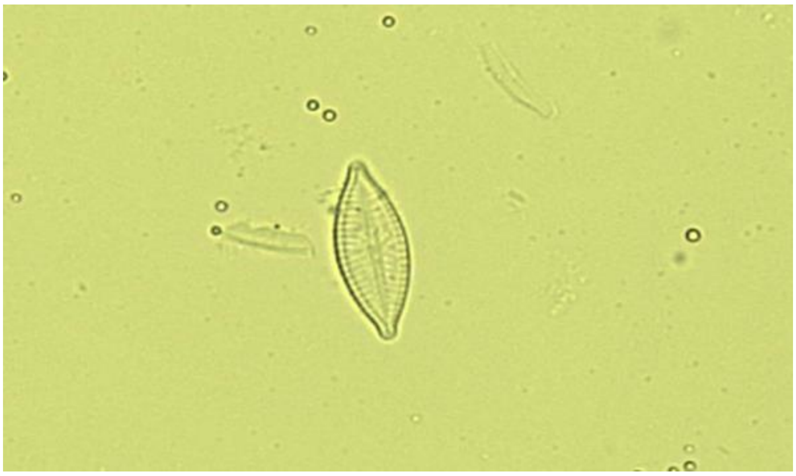

Figure 3.29 *Navicula* spp.

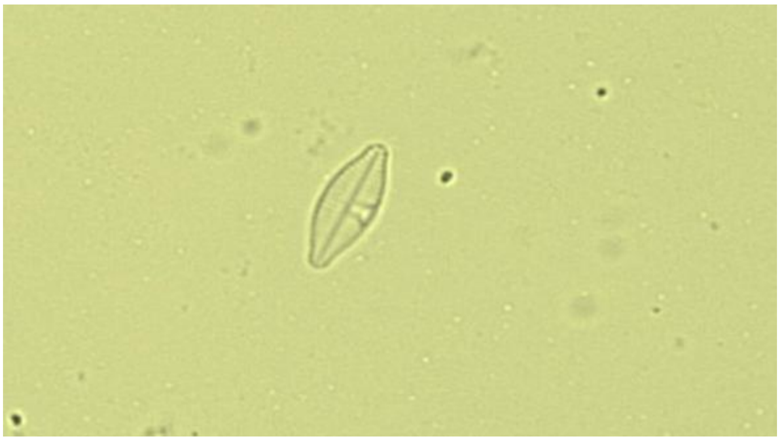

Figure 3.30 *Planothidium* spp.

Table 3.14 Quantitative description of food items observed n=12

Food Items		Instar IV				Instar V						
Divisions	1	2	3	4	5	6	7	8	9	10	11	12
Cyanophyta												
Cylindrospermopsis spp.	-	++	+	-	-	++	-	+	++	+++	+	-
Hapalosipon spp.	+	-	+	-	++	-	+	-	+++	++	++	++
Chlorophyta												
Ankistrodesmus spp.	+	-	+	-	-	++	++	-	++	-	+++	++
Closterium spp.	-	-	++	-	+	+	-	++	-	++	++	+++
Bacillariophyta												
Achnanthidium spp.	+	++	-	+++	++	-	-	-	++	-	+	+
Cocconeis spp.	++	-	+++	-	++	+	+	-	+	-	++	-
Craticula spp.	+++	-	++	++	-	+	-	+	-	+	-	++
Fragilaria spp.	+	++	++	+++	++	-	+	-	-	-	++	-
Frustulia spp.	+	-	+	-	-	-	++	+	++	+++	++	+
Navicula spp.	+	-	+	+	-	++	++	+	++	++	+++	+
Planothidium spp.	+	-	-	-	+	++	-	+	+++	++	-	++

Remark: + (1-2) = low ++ (3-5) = medium, +++ (6-10) = high (Thamsenanupap and Prommi, 2020)

CHAPTER 4

Discussion

4.1 Diversity and Distribution pattern

The result of this study revealed that eighteen (18) families, fifty-one (51) genera, and two hundred and one (201) species were sampled and identified as species. It further showed that four families of Leptoceridae, Hydropsychidae, Philopotamidae, and Ecnomiidae were the most abundant and made up more than sixty percent (60%) of the total population of insects caught. Family Leptoceridae had the highest number of species of fifty-five (55), followed by the Hydropsychidae family which had forty (40) species. Philopotamidae had twenty-one (21) species and Ecnomidae had seventeen (17) species. Families: Hydroptilidae had sixteen (16) species, Polycentropodidae had eleven (11) species, Psychomyiidae had twelve (12) species, Dipseudopsidae six (6) species, Goeridae had seven (7) species, Helicopsychidae four (4) species, Lepidostomatidae and Calamoceratidae three (3) species each, while Rhyacophilidae, Glossosomatidae, Stenopsychidae, Xiphocentronidae, Brachycentridae, and Odontoceridae had one (1) species each. One new species of Agapetus kaengkrungensis belonging to the Glossosomatidae family was described, added knowledge to sicience and three new records of Polymorphanisus scutellatus BANKS 1939* *Cheumatopsyche opposita* BANKS 1931* and *Cheumatopsyche contexta* ULMER 1951* were also observed and added to the Trichoptera list of Thailand.

This discussion is centered on a comparative analysis of information from this study to other results obtained from the Upper Phuket Mountain range in the north and other parts of the country. The study agreed with the observations of Prommi et al. (2014) who reported that Family Leptoceridae had the largest number of species followed by Hydropsychidae in a study carried out in northern Thailand. This is also in line with the result of Thapanya et al. (2013) in the research on adult caddisfly assemblages from northern Thailand. However, it contrasted with some literature such as Laudee and Prommi (2011) which showed that the greatest number of species observed from the research conducted along the Tapi River, southern Thailand was the Hydropsychidae family. In addition, Prommi and Thani (2014) revealed that the Hydropsychidae family contained the highest number of species in a study conducted in central Thailand. Accordingly, Maneechan and Prommi (2015) also reported that the greatest diversity observed was that of the Hydropsychidae family in the research carried out in the western part of the country. Based on habitat type, Muntakwang et al. (2014) reported that the distribution of *Cheumatopsyche lucida* was habitat-specific to bedrock, boulders, gravel, and sand, in a study conducted in Phayao Province, northern Thailand. However, the distribution of *Cheumatopsyche lucida* in this research does not show a preference for habitat specificity but the named species were common to all the sampling sites regardless of their habitat differences, especially in form of bedrock and boulder underwater structures.

From the foregoing, Families Leptocridae and Hydropsychidae are the most numerous and considerably distributed taxa across the Oriental region MurayStocker et al. (2020) and often an overlap between them. Therefore, details obtained from this work aligned to this pattern of distribution and diversity of Caddisflies species in the Oriental region and even beyond. Interestingly some literature beyond this Mountain range showed a similar orientation of diversity and distribution as seen in other countries within the same biogeographical region such as the studies of Mey and Freitag (2020), who reported that the family Leptoceridae had the highest number of species from a study conducted in central Palawan, the Philippines. Another report from Armitage et al. (2003) supported this pattern of distribution of Trichoptera in the Oriental region with the family Hydropsychidae having the greatest number of species in the research conducted in Vietnam.

The main relevant piece of evidence of Trichoptera distribution in the Oriental region is Atlas for Southeast Asian Trichoptera by Malicky (2010) which showed that the greatest number and diversity of Trichoptera fauna in this region are members of the Families Leptoceridae and Hydropsychidae. The reference, therefore, is made to the hotspots of biodiversity; Doi Suthep-Pui and Doi Inthanon National Parks which contrasted this mode of distribution because of altitudinal differences. Given Malicky (2010) highly pronounced by Morse (2019) some families and species were randomly picked and used to further describe the model of Caddisflies distribution in Thailand and Southeast Asia in general. For example, all the six Families: Rhyacophilidae, Glossosomatidae, Stenopsychidae, Xiphocentronidae, Brachycentridae, and Odontoceridae which were represented by one species each in this study, consequentially every one of them had many species representatives in the hotspots of biodiversity Thapanya et al. (2004) and Bunlue et al. (2012) as well as the Atlas for Southeast Asian Trichoptera. This indicates that many of the species in the mentioned families showed a preference for high altitude. However, *Rhyacophila noebia* in Family Rhyacophilidae is one of the rare species and is endemic to Thailand, it has not been found in the hotspots of Doi Suthep-Pui and Doi Inthanon elevations suggesting that it prefers to live in low elevations. Other members of this genus were observed in the range from 400-2300m elevations (Thapanya et al., 2004). *Stenopsyche siamensis* is the only species widely distributed of all the other species in their genus. They were reported once in Doi Suthep-Pui (400-1200m) and several times in Doi Inthanon (200-2300m) elevation (Thapanya et al., 2004). In Family Xiphocentronidae, *Melanotrachia samaconius* is the only species widely distributed in this genus, it is also present in Doi Inthanon (500-600m) elevation, while the remaining species are endemic to one or two countries in the Southeast Asian region (Malicky, 2010). For Family Brachycentridae, *Micrasema fortiso* is a rare species and endemic to Thailand to date, they are also found in Doi Suthep-Pui (400m) and Doi Inthanon 1200-1300m (Thapanya et al., 2004). At present other members of this family are confined to Thailand, Vietnam, and Borneo countries (Malicky, 2010). *Marilia sumatrana* in the Odontoceridae family is one of the species that are widely distributed across Southeast Asia, they were reported many times in Doi Suthep-Pui (600m) and once in Doi Inthanon 400m (Thapanya et al., 2004). Other species in this family are confined to Laos, Thailand, and Vietnam (Malicky, 2010). However, species in families Rhyacophilidae, Glossosomatidae, and Stenopsychidae were observed throughout the range (400-2300m), this showed they preferred high altitudes whereas all the other species of the three families of Xiphocentridae, Brachycentridae, and Odontoceridae were found between 400-900m altitudes, suggesting that members of these families prefer to live in moderate altitudes less than 1500m above Sea level

(Thapanya et al., 2004). In Family Leptoceridae, *Oecetis tripunctata* is one of the widespread species in the Southeast Asian region Malicky (2010) but has not been reported at Doi Suthep-Pui, while in Doi Inthanon it was reported once, at 1000m altitude as a rare species Thapanya et al. (2004), this showed that it prefers to live in lowland forests. The results of this study showed that it has been observed in all the sampling periods, therefore, it has a nonseasonal life cycle. *Cheumatopsyche lucida* in the Hydropsychidae family is one of the most widely distributed across the Oriental region but has not been found in the hot spots of biodiversity Thapanya et al. (2004) this also confirmed that it prefers to live in low elevation forest areas. It showed a nonseasonal life cycle.

The results of this study also revealed that about fifty percent (50%) of the species found were earlier reported by (Prommi, 2007). There is also evidence of the existence of common species with the result of Laudee and Prommi (2011) in the research carried out along the Tapi River. This showed that some of the species observed can be regarded as Potamon species because they were found in rivers (Laudee and Prommi, 2011), while other species were referred to as Rhitom species found in freshwater streams and lakes.

Considering the photographs of the sample sites (Figures 2.2-21) presented, showed that there is a great variation in the flow bed habitat type in the sampling sites in terms of bedrock, boulder, cobble, sand, and mud. These underwater structures primarily affect the diversity of Trichoptera larvae because they are the basic substrates for attachment, retreats, or adaptation for their survival as benthic macroinvertebrates. The over roll interaction of the physical environment (climate, topography, water) and the biotic components are responsible for the high composition of Trichoptera fauna in the Oriental region because they provide a conducive environment for breeding, growth, and survival for both larvae and adults of the insect species. This is an indication that the physical environment has a direct impact on the distribution and abundance of species in each habitat, and may also directly or indirectly be affected by the food resources available for them. To further explain this association, Bouchard (2004) showed that Leptoceridae caddisfly larvae are generally common in all freshwater types, but they prefer standing waters such as marshes, ponds, and lakes or slow-flowing streams. On the contrary, the larvae of Hydropsychidae are confined to fast-flowing freshwaters from small spring streams to large rivers. They favor streams with bedrock, boulder, cobble, and sand substrates, thus where big solid structures are available on the flow bed to protect them from water currents and serve as sites for attachment of their cases and nets. They can also be found on submerged vegetation like large woody surfaces. The presence of this array of habitat types in the Oriental region is a major attribute for the extensive populations of aquatic insects' larvae and their terrestrial adults in this region.

4.2 Correlation of water quality parameters and Trichoptera species

The result of this analysis showed that *Diplectrona gombak* and *Setodes larva* had a moderate positive correlation with temperature. This is contrary to the report of Prommi and Thamsenanupap (2015), who showed that some *Hydropsyche* spp. and *Macrostemum fenestratum* correlated negatively with water temperature. However, *Setodes neleus* displayed a very high negative correlation with water temperature. This implies that *S. neleus* prefers to live in the water at lower temperatures. *Diplectrona gombak* and *Dipseudopsis nebulosa* responded moderately to the pH condition in their habitats, it can therefore be inferred that they preferred neutral Potential Hydrogen (pH) levels. This agreed with the study of Prommi and Thamsenanupap (2015), which showed that Diplectrona spp. had a low positive correction with alkalinity or pH. Accordingly, Prommi and Thani (2014) reported that some Caddisflies species responded positively to water temperature, water potential Hydrogen, and electrical conductivity in the water habitat, in central Thailand. The relationship between *Setodes minotauros* and electrical conductivity demonstrated a moderate correlation between the species and the water environment, this suggests that the larvae are more comfortable in water habitats of optimum electrical conductivity. *Macrostemum floridum* and *Amphipsyche gratiosa* exhibited a very high positive correlation with water velocity, which implies that they prefer to live in fast-flowing freshwater streams of high velocity, nevertheless, *Cheumatopsyche charites* and *S. larva* displayed a moderate positive correlation to water velocity. Payyaka and

Prommi (2014), supported that aquatic insect diversity is highly correlated to water environmental variables such as dissolved oxygen and alkalinity. Generally, therefore, it can be deduced that the relationship between water quality parameters and the diversity of Trichopteran larvae in the various sites indicated that there has been a positive or negative response of the larvae to environmental factors. This study indicated that Caddisflies larvae prefer conducive environmental factors in terms of Dissolved Oxygen, Temperature, pH, Electrical Conductivity, Water velocity, etc. for optimum growth and succession in aquatic ecosystems.

4.3 Life cycle and feeding habits of *Macrostemum floridum*

The life cycle of *M. floridum* was studied, and the result obtained showed that it has a nonseasonal life cycle with five (V) distinct larval instar developmental stages. This is in line with the study of Kondratieff et al. (1997) on *Cheumatopsyche pettiti* who reported that it has five larval instars. Yoga et al. (2014) reported that *Cheumatopsyche species* pass through five larval instars before reaching the pupal stage. The study supported the report of Prommi and Khamrak (2020) on the life cycle and larval feeding habits of *Macrostemum indistinctum* Banks 1911 which revealed that it has five larval instars. The result also revealed that the body length of fifth larval instars ranges from 11.60-14.00mm, in contrast to the length of *M. brasiliense* fifth larval instars body length which ranges from 19.6-21.2mm Pes et al. (2019), the latter is almost two times longer than the former. In terms of abdominal color, *M. floridum* has a yellow coloration while *M. brasiliense* has a yellowish-brown abdominal coloration. In addition, *M. floridum* fifth larval instars head capsule width ranges from 1.40-1.50mm compared to the fifth larval instars head capsule width of *M. indistinctum* which ranges from 1.38-1.98mm Prommi and Khamrak (2020) and was much broader. Generally, Caddisflies larvae exhibit various feeding habits in their habitats, however, *M. floridum* in the Hydropsychidae family belongs to the group of filter-collector feeders (Holzenthal and Thomson, 2015). Further to this, a quantitative assessment of the gut content of *M. floridum* was conducted, and this showed that the main food items found were blue-green algae, green algae, and diatoms, this agreed with the report of Prommi and Khamrak (2020) on the life cycle and larval feeding habits of *Macrostemum indistinctum* Banks 1911.

4.4 Morphology of *Macrotemum floridum*

The larvae of *M. floridum* in the Hydropsychidae Family bear many of the general morphological characteristics common to all members of the *Macrostemum* genus (Dudgeon, 1999). These primary characteristics include a flattened head with a conspicuous U-shaped carina, a pair of stridulating ridges, discrete sclerites at the base of the labrum, unusual dense fringe setae on the fore tibiae, and tarsi, a prominent process at the base of the femur, abdominal segments lack scale hairs among others (Wiggins, 1996; Dudgeon, 1999). However, from the observable morphological characteristics of *M. floridum* species in this study, certain morphological features appear to be peculiar for this species. There exist some apparent differences between *M. floridum* and two species of *M. fastosum* and *M. brasiliense,* for example, the foretrochantin of the foreleg is well forked and sclerotized in *M. floridum*, but never forked and non-sclerotized in *M. fastosum* and *M. brasiliense* (Dudgeon, 1999; Pes et al., 2019). Other prominent morphological differences between the mentioned species include the following: there are more long hairs on the carinal ridges in *M. floridum* than in *M. fastosum* and *M. brasiliense, M. floridum* and *M. fastosum* have unusual dense setae on tibiae and tarsi of the forelegs while *M. brasiliense* has a medium-sized slender seta on the dorsal margins of tibiae and tarsi. In *M. floridum* the right mandible has two apical teeth and three mesal teeth, the left mandible has two apical teeth and five mesal teeth while in *M. brasiliense* the right mandible has one apical tooth and three mesal teeth, the left mandible has one apical tooth and five mesal teeth, however, the shape of the mesal teeth of both mandibles differs from those of *M. floridum*. A pair of sclerites are found on the ventral side of segment IX in *M. floridum,* but there is no such pair of sclerites on the venter of segments VIII or IX in *M. fastosum* which is a common characteristic feature of the *Macrostemum* genus (Dudgeon, 1999). However, in the case of *M. brasiliense,* two small sclerites are found on the ventral side of segment VIII Pes et al. (2019) in contrast to *M. floridum*. The aforementioned morphological characteristics represent some structural differences observed among the three species mentioned in this genus.

4.5 Larval identification

The identification of Hydropsychid larvae was based on certain keys and diagnostic features (Wiggins, 1996). Identification of *M. floridum* NAVAS 1929 larva was centered on these diagnostic features and keys exerted on the fifth larval instar. This final larval instar was associated with the pupa, thereafter the pupal genitalic characters were also associated with the described adult insect genitals. In general, the subterminal instars are unsuitable for this technique because the morphological features would not have been fully developed, making recognition difficult. Diagnostic characters or keys are designed to eliminate taxa resemblances in the larva, for accurate identification.

The earlier description of some Hydropsychidae larvae in Thailand was reported by Laudee and Prommi (2016) in the description of the larva of *Cheumatopsyche lucida*; Prommi et al. (2006) on the description of the larva and pupa of *Potamyia phaidra*; Prommi and Peumwarunyoo (2013) on larvae of Amphipsyche species; Prommi (2016) on the description of larvae of four species of Hydropsychidae. The diagnosis of the Hydropchidae larvae rests upon some diagnostic keys and features to differentiate larvae of one species from the other. Even though hydropsychid larvae of different genera and species have different diagnostic features of identification, there exist some similarities between them which may be found across the species.

CHAPTER 5

Conclusion and Suggestion

5.1 Conclusion

The results of this study showed that a total of fourteen thousand three hundred and eighteen (14, 318) adult Trichoptera insects were caught using UV-pan light traps from March-December 2019. Eighteen (18) families, fifty-one (51) genera, and two hundred and one (201) instant species were identified. Family Leptoceridae had the largest number of fifty-five (55) species, followed by Hydropsychidae with forty (40) species, Philopotamidae had twenty-one (21), Ecnomiidae with seventeen (17) species. Families: Hydroptilidae had sixteen (16) species, Polycentropodidae had eleven (11) species and Psychomyiidae had twelve (12) species, Dipseudopsidae had six (6) species, Goeridae seven (7) species, Helicopsychidae four (4) species, Lepidostomatidae and Calamoceratidae, three (3) species each, while Rhyacophilidae, Glossosomatidae, Stenopsychidae, Xiphocentronidae, Brachycentridae, and Odontoceridae had one (1) species each. One new species of Agapetus kaengkrungensis belonging to the Glossosomatidae family was described and added to science, three new records of Polymorphanisus scutellatus BANKS 1939* *Cheumatopsyche opposita* BANKS 1931* and *Cheumatopsyche contexta* ULMER 1951* were observed and added to the Trichoptera list of Thailand. It can be inferred from this result that there exists great diversity and abundance of Caddisflies species in the study area and their distribution supports the pattern of distribution of Trichoptera fauna in Southeast Asian countries.

There have been both positive and negative responses from some species to water environmental variables, this confirmed that Trichoptera species diversity can be affected by water environmental conditions.

Larval identification of *Macrostemum floridum* was based on the use of the metamorphotype technique.

The culture or life cycle of *Macrostemum floridum* was studied, and the result showed that it has a nonseasonal life cycle with five (V) distinct larval instar developmental stages. The gut content was quantitatively analyzed, this revealed that about eighty percent of the food consumed was made up of blue-green algae, green algae, and diatoms.

5.2 Suggestions

Studies have shown that intensive research has been carried out on the diversity and distribution of Trichoptera fauna in the Southeast Asian region with emphasis on Thailand, but not much was done in the aspects of life cycle and ecology. It could be recalled that Caddisflies larvae are an important source of food for fish, carry out vital ecological roles in energy transfer, and are used as bioindicators, these have been confirmed globally. In addition, they have high crude protein levels enough to supplement or even replace fishmeal in animal feed composition. However, despite Trichoptera fauna's greatest diversity as well as being a good source of food for freshwater fish in the Oriental region, no attention is given to developing it as an aquaculture source of protein.

I, therefore, suggest that researchers focus attention on the possibility to convert these diversities and abundance of Caddisflies fauna in Southeast Asia to be a means of livelihood that could generate employment and income for people.

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Khao Sok National Park Water Quality Parameter values

Temperature^{0}C			Sites		
Season	1	2	3	4	5
1	25.35	25.30	25.58	27.38	26.85
2	20.80	22.20	21.40	21.90	22.20
3	22.00	20.10	22.20	22;80	23.00
Total	68.15	67.60	69.18	72.08	72.05
Mean	22.72	22.53	23.06	24.03	24.02
SD	±0.55	±0.74	±0.21	±0.76	±0.75

pH			Sites		
Season	1	2	3	4	5
1	9.54	9.43	9.29	8.39	7.63
2	6.75	8.82	6.68	6.68	8.33
3	7.52	7.08	7.38	7.16	7.31
Total	23.81	25.33	23.35	22.23	23.27
Mean	7.93	8.44	7.78	7.41	7.76
SD	±0.07	±0.58	±0.08	±0.45	±0.10

Dissolved Oxygen mg/l	Sites				
Season	1	2	3	4	5
1	6.97	6.97	7.57	7.26	6.20
2	8.23	7.99	7.83	7.72	7.85
3	7.82	7.67	7.68	8.02	7.85
Total	23.02	22.63	23.08	23.00	21.83
Mean	7.67	7.54	7.69	7.67	7.28
SD	±0.10	±0.03	±0.12	±0.10	±0.29

Electrical Conductivity µS/cm	Sites				
Season	1	2	3	4	5
1	63	58	102	103	116
2	34.86	34.22	34.60	48.56	68.31
3	44.07	35.85	34.35	54.05	58.55
Total	141.93	128.07	170.95	205,61	242,86
Mean	47.31	42.69	56.98	68.54	80.95
SD	±11.98	±16.60	±2.31	±9.25	±21.66

Khlong Phanom National Park water quality parameter values

Temperature ^{0}C	Sites				
Season	1	2	3	4	5
1	29.13	27.98	26.25	27.70	28.90
2	25.15	24.90	25.10	25.20	25.70
3	21.20	21.94	24.03	23.15	23.10
Total	75.50	74.82	75.38	76.05	77.70
Mean	25.17	24.94	25.13	25.35	25.90
SD	±0.13	±0.36	±0.17	±0.05	±0.6o

pH	Sites				
Season	1	2	3	4	5
1	8.23	8.37	8.75	8.70	8.43
2	7.20	7.25	8.04	7.42	7.34
3	6.24	6.22	7.20	6.37	6.30
Total	21.67	21.84	23.99	22.49	22.07
Mean	7.22	7.28	8.00	7.50	7.36
SD	±0.25	±0.19	±0.53	±0.03	±0.11

Dissolved Oxygen mg/l	Sites				
Season	1	2	3	4	5
1	7.11	7.73	8.09	7.06	9,30
2	7.50	7.76	8.30	8.01	8.55
3	8.12	7.79	8.53	8.96	7.85
Total	22.73	23.28	24.92	24.03	25.70
Mean	7.58	7.76	8.31	8.01	8.57
SD	±0.47	±0.29	±0.26	±0.04	±0.52

Electrical Conductivity µS/cm	Sites				
Season	1	2	3	4	5
1	292.00	280.00	128.00	118.00	128.00
2	236.00	233.25	118.80	93.82	126.30
3	180.60	186.50	111.25	69.89	130.60
Total	708.60	699.75	358.05	281.71	384.90
Mean	236.20	233.25	119.35	93.90	128.30
SD	±74	±71.05	±42.85	±68.30	±33.90

Kaengkrung National Park water quality parameter values

Temperature^{0}C	Sites				
Season	1	2	3	4	5
1	29.10	28.70	27.33	31.20	32.60
2	22.60	22.90	21.78	22.70	21.40
3	23.30	21.10	20.70	23.60	23.20
Total	75.00	72.70	69.81	77.50	77.20
Mean	25.00	24.23	23.27	25.83	25.73
SD	±0.19	±0.58	±1.54	±1.02	±0.92

pH	Sites				
Season	1	2	3	4	5
1	9.08	8.03	7.89	8.42	8.40
2	6.53	6.70	6.75	7.90	6.71
3	6.71	7.21	6.14	6.27	7.18
Total	22.32	21.94	20.78	22.59	22.29
Mean	7.44	7.31	6.93	7.53	7.43
SD	±0.11	±0.02	±0.40	±0.20	±0.10

Dissolved Oxygen mg/l	Sites				
Season	1	2	3	4	5
1	7.22	6.23	6.71	7.85	7.31
2	8.00	7.65	7.73	7.85	8.43
3	7.87	7.21	6.70	8.14	7.94
Total	23.09	21.09	21.14	23.84	23.68
Mean	7.70	7.03	7.05	7.95	7.89
SD	±0.18	±0.49	±0.47	±0.43	±0.37

Electrical Conductivity µS/cm	Sites				
Season	1	2	3	4	5
1	151	113	166	116	153
2	105.50	185.40	203.30	115.90	175.80
3	76.80	100.70	127.60	84.24	117.90
Total	333.30	399.03	496.90	316.14	446.70
Mean	111.10	133.03	165.63	105.38	148.90
SD	±21.71	±0.22	±32.82	±27.43	±16.09

Khlong Saeng Wildlife Sanctuary water quality parameters values

Temperature^{0}C			Sites		
Season	1	2	3	4	5
1	28.80	28.80	27.78	27.15	26.58
2	20.80	20.80	21.00	20.20	20.80
3	22.60	22.50	23.00	21.80	22.70
Total	72.20	72.10	71.78	69.15	70.08
Mean	24.07	23.03	23.93	23.05	23.36
SD	±0.40	±0.36	±0.26	±0.62	±0.31

pH			Sites		
Season	1	2	3	4	5
1	6.80	6.90	6.96	7.53	7.57
2	6.75	6.76	7.14	6.75	7.88
3	7.23	7.10	6.75	7.56	7,26
Total	20.78	20.76	20.85	21.84	22.71
Mean	6.93	6.92	6.95	7.28	7.57
SD	±0.20	±0.21	±0.18	±0.15	±0.44

Dissolved Oxygen mg/l	Sites				
Season	1	2	3	4	5
1	6.40	6.36	6.28	6.35	6.11
2	7.91	8.14	8.23	8.40	8.33
3	7.82	7.91	8.61	8.34	7.99
Total	22.13	22.41	23.12	23.09	22.43
Mean	7.38	7.47	7.71	7.70	7.48
SD	±0.17	±0.08	±0.16	±0.15	±0.07

Electrical Conductivity µS/cm	Sites				
Season	1	2	3	4	5
1	60.00	61.00	64.00	166.00	73.00
2	78.66	78.32	89.95	89.39	70.63
3	41.35	44.83	46.84	94.16	35.18
Total	180.01	184.15	200.79	349.55	178.81
Mean	60.00	61.38	66.93	116.52	59.60
SD	±12.87	±11.49	±5.94	±43.65	±13.27

Correlations

		Temp	pH	DO	EC	WV	D.nebulo	D.robust	M.florid	A.gratio	D.gomba	C.lucida	C.charit	O.tripun	T.pales	L.dirgha	S.opora	S.minota	S.neleus	S.larva	S.okyrrh
Temp	Pearson Correlation	1	-.220	.578**	.560*	.351	.021	-.316	.162	.218	-.547*	-.021	.214	.320	.185	.059	-.057	.404	-.565**	.547*	-.072
	Sig. (2-tailed)		.351	.008	.010	.129	.931	.175	.494	.356	.013	.931	.364	.169	.435	.805	.812	.077	.009	.013	.763
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
pH	Pearson Correlation	-.220	1	.248	-.302	-.078	-.500*	-.306	.034	-.026	.556*	.112	-.144	.022	.155	.161	.190	-.161	.147	.076	.115
	Sig. (2-tailed)	.351		.291	.196	.743	.025	.189	.885	.912	.011	.637	.546	.926	.515	.497	.423	.497	.535	.751	.628
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
DO	Pearson Correlation	.578**	.248	1	.067	.078	.009	.003	.028	.032	-.137	-.024	.030	.118	.102	.015	-.244	-.083	-.125	.285	-.168
	Sig. (2-tailed)	.008	.291		.780	.745	.969	.992	.906	.894	.564	.919	.899	.621	.670	.951	.300	.729	.598	.223	.478
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
EC	Pearson Correlation	.560*	-.302	.067	1	-.086	-.345	-.337	-.014	.039	-.372	-.168	-.263	.013	-.097	-.208	-.103	.474*	-.395	.033	-.180
	Sig. (2-tailed)	.010	.196	.780		.718	.137	.147	.953	.871	.107	.478	.263	.956	.685	.378	.665	.035	.085	.890	.448
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
WV	Pearson Correlation	.351	-.078	.078	-.086	1	.147	-.197	.610**	.621**	-.016	-.044	.487*	.177	-.040	-.010	-.125	.440	-.137	.474*	-.110
	Sig. (2-tailed)	.129	.743	.745	.718		.537	.405	.004	.003	.948	.853	.029	.456	.868	.967	.600	.052	.566	.035	.646
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
D.nebulo	Pearson Correlation	.021	-.500*	.009	-.345	.147	1	.551*	-.106	-.087	-.289	-.235	.262	.073	-.177	.057	-.154	-.217	-.040	.108	-.218
	Sig. (2-tailed)	.931	.025	.969	.137	.537		.012	.658	.714	.217	.319	.265	.760	.456	.811	.518	.359	.867	.651	.357
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
D.robust	Pearson Correlation	-.316	-.306	.003	-.337	-.197	.551*	1	-.111	-.144	-.181	-.166	-.199	-.222	-.263	.117	-.121	-.222	.476*	-.279	-.155
	Sig. (2-tailed)	.175	.189	.992	.147	.405	.012		.642	.546	.445	.485	.400	.347	.262	.624	.610	.347	.034	.234	.514
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
M.florid	Pearson Correlation	.162	.034	.028	-.014	.610**	-.106	-.111	1	.990**	-.039	-.034	.158	-.042	-.124	-.014	-.056	.541*	-.158	.356	-.094
	Sig. (2-tailed)	.494	.885	.906	.953	.004	.658	.642		.000	.869	.887	.505	.861	.602	.954	.815	.014	.506	.123	.694
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
A.gratio	Pearson Correlation	.218	-.026	.032	.039	.621**	-.087	-.144	.990**	1	-.093	-.034	.173	-.029	-.113	-.084	-.070	.593**	-.177	.360	-.100
	Sig. (2-tailed)	.356	.912	.894	.871	.003	.714	.546	.000		.696	.888	.465	.903	.634	.724	.768	.006	.456	.118	.675
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
D.gomba	Pearson Correlation	-.547*	.556*	-.137	-.372	-.016	-.289	-.181	-.039	-.093	1	.117	.068	.022	.045	.017	-.053	-.238	.390	-.136	.090
	Sig. (2-tailed)	.013	.011	.564	.107	.948	.217	.445	.869	.696		.625	.776	.925	.851	.944	.826	.313	.089	.567	.705
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
C.lucida	Pearson Correlation	-.021	.112	-.024	-.168	-.044	-.235	-.166	-.034	-.034	.117	1	.576**	-.057	.848**	.167	.352	-.140	-.007	.041	.910**
	Sig. (2-tailed)	.931	.637	.919	.478	.853	.319	.485	.887	.888	.625		.008	.810	.000	.482	.129	.557	.977	.864	.000
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
C.charit	Pearson Correlation	.214	-.144	.030	-.263	.487*	.262	-.199	.158	.173	.068	.576**	1	.266	.557*	.145	-.002	-.090	-.123	.574**	.468*
	Sig. (2-tailed)	.364	.546	.899	.263	.029	.265	.400	.505	.465	.776	.008		.257	.011	.542	.994	.706	.606	.008	.038
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
O.tripun	Pearson Correlation	.320	.022	.118	.013	.177	.073	-.222	-.042	-.029	.022	-.057	.266	1	.411	.562**	-.111	-.057	-.199	.734**	-.068
	Sig. (2-tailed)	.169	.926	.621	.956	.456	.760	.347	.861	.903	.925	.810	.257		.071	.010	.642	.811	.401	.000	.775
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
T.pales	Pearson Correlation	.185	.155	.102	-.097	-.040	-.177	-.263	-.124	-.113	.045	.848**	.557*	.411	1	.439	.400	-.204	-.082	.367	.815**
	Sig. (2-tailed)	.435	.515	.670	.685	.868	.456	.262	.602	.634	.851	.000	.011	.071		.053	.081	.388	.733	.111	.000
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
L.dirgha	Pearson Correlation	.059	.161	.015	-.208	-.010	.057	.117	-.014	-.084	.017	.167	.145	.562**	.439	1	.150	-.233	-.202	.395	.199
	Sig. (2-tailed)	.805	.497	.951	.378	.967	.811	.624	.954	.724	.944	.482	.542	.010	.053		.529	.323	.393	.085	.400
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
S.opora	Pearson Correlation	-.057	.190	-.244	-.103	-.125	-.154	-.121	-.056	-.070	-.053	.352	-.002	-.111	.400	.150	1	-.137	.129	-.032	.680**
	Sig. (2-tailed)	.812	.423	.300	.665	.600	.518	.610	.815	.768	.826	.129	.994	.642	.081	.529		.565	.589	.895	.001
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
S.minota	Pearson Correlation	.404	-.161	-.083	.474*	.440	-.217	-.222	.541*	.593**	-.238	-.140	-.090	-.057	-.204	-.233	-.137	1	-.306	.117	-.193
	Sig. (2-tailed)	.077	.497	.729	.035	.052	.359	.347	.014	.006	.313	.557	.706	.811	.388	.323	.565		.190	.625	.415
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
S.neleus	Pearson Correlation	-.565**	.147	-.125	-.395	-.137	-.040	.476*	-.158	-.177	.390	-.007	-.123	-.199	-.082	-.202	.129	-.306	1	-.289	.072
	Sig. (2-tailed)	.009	.535	.598	.085	.566	.867	.034	.506	.456	.089	.977	.606	.401	.733	.393	.589	.190		.217	.764
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
S.larva	Pearson Correlation	.547*	.076	.285	.033	.474*	.108	-.279	.356	.360	-.136	.041	.574**	.734**	.367	.395	-.032	.117	-.289	1	.011
	Sig. (2-tailed)	.013	.751	.223	.890	.035	.651	.234	.123	.118	.567	.864	.008	.000	.111	.085	.895	.625	.217		.965
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
S.okyrrh	Pearson Correlation	-.072	.115	-.168	-.180	-.110	-.218	-.155	-.094	-.100	.090	.910**	.468*	-.068	.815**	.199	.680**	-.193	.072	.011	1
	Sig. (2-tailed)	.763	.628	.478	.448	.646	.357	.514	.694	.675	.705	.000	.038	.775	.000	.400	.001	.415	.764	.965	

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A new species, *Agapetus kaengkrungensis* (Trichoptera: Glossosomatidae) from Kaeng Krung National Park, southern Thailand with the distribution map of the genus in Thailand

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Abstract

The male of a new species of caddisfly, *Agapetus kaengkrungensis* n. sp. (Glossosomatidae) is described and illustrated from Kaeng Krung National Park, Surat Thani Province, southern Thailand. *Agapetus kaengkrungensis* n. sp. is distinguished from other species by the characters of segment IX and inferior appendages. The distributions of the *Agapetus* spp. of Thailand are mapped and discussed.

Key words: diversity, Oriental Region, caddisfly

Introduction

Three genera of Glossosomatidae are known from Thailand including *Glossosoma* Curtis 1834, *Agapetus* Curtis 1834, and *Padunia* Martynov 1910. A fourth genus *Cariboptila* Flint 1964 has also been reported in Thailand, but its occurrence outside of the Caribbean region is disputed (Robertson & Holzenthal 2013).

With at least 187 extant species, the genus *Agapetus* is the most diverse in the family Glossosomatidae and subfamily Agapetinae and is reported from all continents other than Africa, South America, and Antarctica (Morse 2020). At least 47 species have been reported from the Oriental region (Morse 2020), with 15 of those species recorded from Thailand (Malicky 2010; Malicky & Chantaramongkol 1992, 2009; Malicky et al. 2006; Mey 1996). They include *A. abdeel* Malicky & Chantaramongkol 2009, *A. atuus* Malicky & Chantaramongkol 1992, *A. cenomarus* Malicky & Chantaramongkol 1992, *A. dangorum* Oláh 1988, *A. esinertus* Malicky & Chantaramongkol 1992, *A. gonophorus* Mey 1996, *A. gotgian* Oláh 1988, *A. halong* Oláh 1988, *A. lalus* Malicky & Chantaramongkol 1992, *A. phorkys* Malicky & Nuntakwang 2006 (in Malicky et al. 2006), *A. quordus* Malicky & Chantaramongkol 1992, *A. seheliel* Malicky 2012, *A. vercondarius* Malicky &

Chantaramongkol 1992, *A. viricatus* Malicky & Chantaramongkol 1992, and *A. voccus* Malicky & Chantaramongkol 1992.

Most of the *Agapetus* spp. in Thailand were described from northern Thailand, with only one species (*A. cenomarus*) described from northeastern Thailand. The genus *Agapetus* has not been reported previously from southern Thailand (Prommi 2007, Laudee & Malicky 2014).

This article describes a new species of *Agapetus* from southern Thailand, bringing the total number of known species of the genus in Thailand to 16. The distributions of *Agapetus* species in Thailand are discussed and mapped.

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Materials and Methods

The collecting site is in Kaeng Krung National Park which is in the Phuket Range, part of the Tenasserim Ranges. The forest type is tropical evergreen forest subtype moist evergreen forest. The study site is a first-order stream with substrate dominated by cobble and sand.

Caddisfly specimens were collected with a UV pan light trap (12 V, 10 W) set beside the stream overnight at the location and the time indicated below. Samples were preserved in 70% ethanol, then manually sorted from other insects. Male genitalia of the new species were excised and muscle tissue was macerated by heating in 10% KOH at 60°C for 30 minutes. Pencil templates of the male genitalia of the new species were drawn using a compound microscope equipped with a drawing tube, then final vector-graphics were prepared from the templates with Adobe Illustrator© software.

The holotype is stored in 70% ethanol and deposited in the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai Campus, Hat Yai District, Songkhla Province, Thailand (PSUNHM). Terminology for genitalic structures follows that of Etnier et al. (2010). Data for *Agapetus* spp. from Thailand were compiled from publications referenced above and the Trichoptera collections of Dr. Pongsak Laudee and Prof. Dr. Hans Malicky. The distributions of Agapetus spp. were plotted on a map of Thailand.

Taxonomy

Glossosomatidae

Agapetus **Curtis 1834 [Type species** *Agapetus fuscipes* **Curtis 1834, by subsequent designation of Westwood (1840)].**

***Agapetus kaengkrungensis* n. sp.**
Figs 1A–1D

Diagnosis. The male genitalia of the new species are similar to those of *A. abbreviatus* Ulmer 1931 found in Java, Indonesia, but can be distinguished from them by characters of segment IX and the inferior appendages. In *A. abbreviatus*, the posterodorsal end of segment IX is truncate in lateral view, but it is slightly downcurved and acute apically in the new species. The inferior appendages of *A. abbreviatus* are oval in lateral view, but those of the new species are long and rectangular, each with a short, apically rounded process apicoventrally. In ventral view, each inferior appendage of the new species has a pointed spine ventromedially and two stout spines apically, but has no spine ventromedially and is pointed apically in *A. abbreviatus*.
Description. Length of each male forewing 3.0 mm. Specimens in alcohol with head, thorax, abdomen, legs, and forewings dark brown.

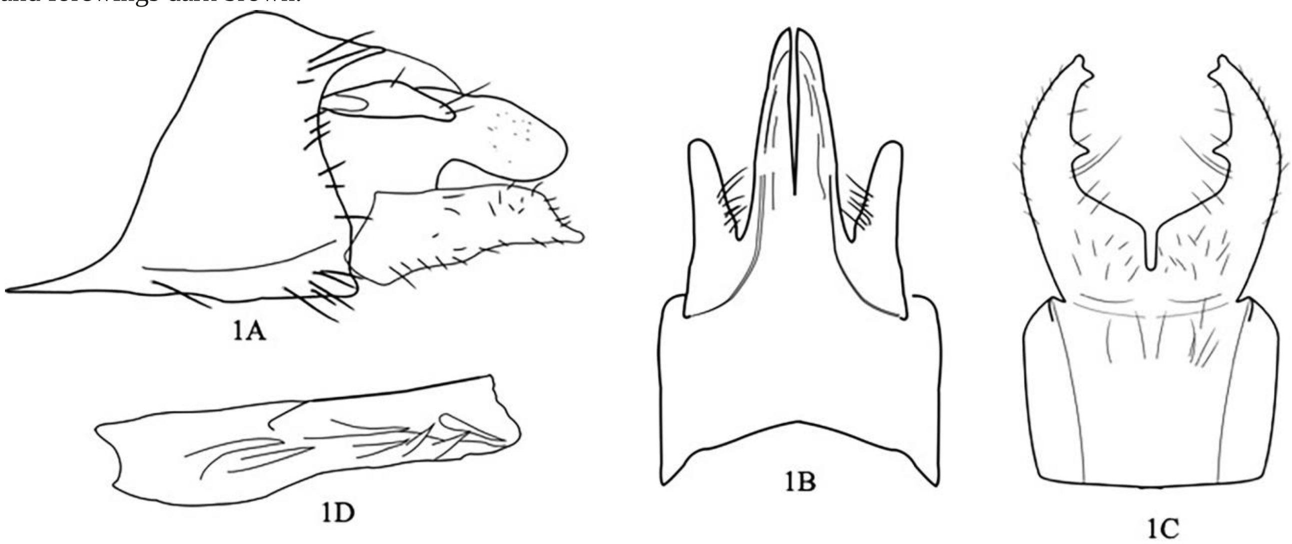
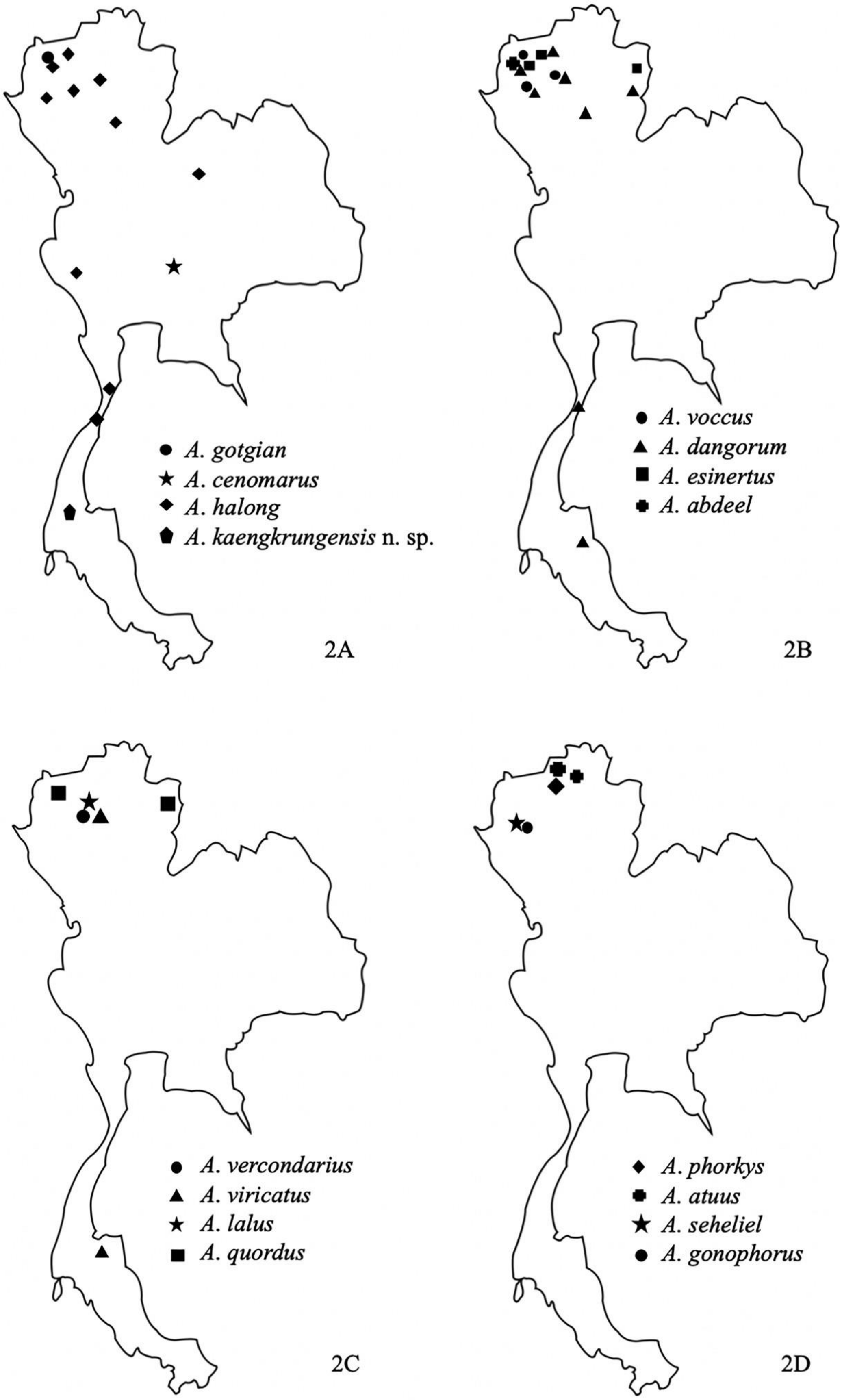


FIGure 1. Male genitalia of *Agapetus kaengkrungensis* n. sp. 1A, left lateral. 1B, dorsal. 1C, ventral. 1D, phallus, left lateral



A. gotgian
A. cenomarus
A. halong
A. kaengkrungensis n. sp.
2A
A. voccus
A. dangorum
A. esinertus
A. abdeel
2B
A. vercondarius
A. viricatus
A. lalus
A. quordus
2C
A. phorkys
A. atuus
A. seheliel
A. gonophorus
2D

FIGure 2. Distribution map of *Agapetus* spp. in Thailand. (Data on the map are from the references and the collections of Dr.
Pongsak Laudee and Prof. Dr. Hans Malicky)

Male genitalia (Figs. 1A–1D). Segment IX in lateral view subrectangular with very long process anteroventrally and long process posterodorsally (Fig. 1A); in dorsal view, quadrate with broad and shallow concavity anteriorly (Fig. 1B); nearly square in ventral view (Fig. 1C). Preanal appendages long, finger-like, rounded apically in lateral view (Fig. 1A); in dorsal view, finger-like with tuft of setae dorsolaterally, rounded apically (Fig. 1B). Segment X in lateral view, subrectangular basally, large and bulbous subapically (Fig. 1A); in dorsal view, long, subtriangular with narrow mesal incision 3/4 of its length (Fig. 1B). Inferior appendages in lateral view, long, subrectangular, entirely setose, each with short, apically rounded process apicoventrally (Fig. 1A); in ventral view, claw-like with pointed projection ventromesally and two stout and acute projections apically (Fig. 1C). Phallus long, regular, blunt apically with seven sclerotized spines on the retracted subphallic membranes. (Fig. 1D).

Type material. Holotype male (PSUNHM). Thailand: Surat Thani Province, Kaeng Krung National Park, Khlong Yan River, 9°19’13”N, 103°49’54”E, ca. 59 m a.s.l., 28.ix.2019, leg. Solomon Boga Valdon.

Etymology. The species is named for the type locality, Kaeng Krung National Park.

Distribution of *Agapetus* spp. in Thailand

Sixteen species of *Agapetus* including the new species are now recorded from Thailand (Figs 2A–2D). Most of our country’s *Agapetus* spp. have been reported from northern Thailand. *Agapetus halong* is a widespread species which is found from northern Thailand through western Thailand, northeastern Thailand, and the Thai Peninsula, and this species is recorded also from Vietnam, which is in the same Indochinese sub-region of the Oriental Region (Armitage et al. 2005; Malicky 2010). *Agapetus dangorum* is also a widespread species which is found from northern Thailand through the Thai Peninsula and also has been recorded from Vietnam (Armitage et al. 2005; Malicky 2010). However, this species has not been recorded from the Malay Peninsula (Malicky 2010). *Agapetus gotgian* and *A. gonophorus* also inhabit both northern Thailand and Vietnam (Malicky 2010; Armitage et al. 2005). Recently a collection of caddisflies from hill evergreen forest in Tai Rom Yen National Park demonstrated that *A. viricatus*, previously known only from northern Thailand, was found in southern Thailand where the elevation is 900–1200 m a.s.l. Nine species of *Agapetus* spp. are endemic, having been reported from only northern Thailand (Indochinese sub-region), including *A. abdeel*, *A. atuus*, *A. esinertus*, *A. lalus*, *A. phorkys*, *A. quordus*, *A. seheliel*, *A. vercondarius*, and *A. voccus*. Insofar as we know, the new species *A. kaengkrungensis* is endemic to southern Thailand which is in the Sundaic sub-region of the Oriental Region.

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