

Diversity of freshwater benthos in the ecotourism area at Chiang Dao District in Chiang Mai Province, Thailand

Pongpan Leelahakriengkrai

Biology Section, Department of Science, Faculty of Science and Technology, Chiang Mai Rajabhat University, Thailand; email: bank_2525@hotmail.com

ABSTRACT

The diversity of benthic diatoms and aquatic insects in the ecotourism areas of Mea Lu and Tong Ta Streams at Chiang Dao District in Chiang Mai Province in the north of Thailand were investigated during the months of July and September 2012 and January 2013, from the upper, middle and lower parts of each stream. A total of 53 taxa of benthic diatoms and 46 families of aquatic insects were found. Forty-seven and thirty-one taxa of benthic diatoms were found from the Mea Lu and Tong Ta Streams, respectively. Thirty-eight and twenty-eight families of aquatic insects were found from the Mea Lu and Tong Ta Streams, respectively. The diversity index of benthic diatoms ranged from 1.17 to 2.66, while the aquatic insects ranged from 0 to 2.14. In the upstream sites of this study, a high abundance of benthic diatoms, such as *Navicula cryptotenella*, *Planothidium rostratum* and *Planothidium lanceolatum*, and aquatic insects, such as Caenidae and Elmidae, were found. At the downstream sites, a high abundance of benthic diatoms, such as *Nitzschia palea* and *Mayamaea atomus* and aquatic insects, such as Corixidae, Baetidae, Chironomidae, Simuliidae and Hydropsychidae, were found.

KEY WORDS

Benthic diatoms; Aquatic insects; Diversity index; Ping River.

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INTRODUCTION

At present, ecotourism has become popular in many countries. Nevertheless, no further detailed studies have been conducted on the biodiversity of freshwater benthos in the ecotourism areas around the world. This is true for Thailand too, with the exception of several studies dealing with a few groups of animals and plants (Hvenegaard & Dearden, 1998; Chettamart & Emphandhu, 2002; Lyndon & Yongvanit, 2005; Chayamarit & Puff, 2007a,b; Jaroensutasinee et al., 2011; Krailas et al., 2012).

Thailand has many ecotourism areas, such as Doi Inthanon National Park, Phukradung National Park, Khao Yai National Park and Kaeng Krachen

National Park, as well as Doi Chiang Dao National Park (also called Doi Luang) at Chiang Dao District in Chiang Mai Province. This district comprises the area in which Ping River originates, which is the main river of Thailand and was first awarded with the title of "ecotourism district" in the Northern Thailand in the year 2011.

The aim of the study was to determine the diversity of freshwater benthos in the ecotourism area at Chiang Dao District in Chiang Mai Province, comprising Mea Lu (ML) and Tong Ta (TT) Streams. In addition, this research study presents the first report of diversity of freshwater benthos, including benthic diatoms and aquatic insects, in the ecotourism area in the north of Thailand.

MATERIALS AND METHODS

The samples were collected from two streams at the ecotourism areas, including Mea Lu (ML) and Tong Ta (TT) Streams, which are located in the upstream area of Ping River at Chiang Dao District in Chiang Mai Province, Thailand. The benthos samples, including benthic diatoms and aquatic insects, were collected in July and September 2012 and January 2013 from the upper, middle and lower parts of each stream (Fig. 1 and Table 1).

Benthic diatom samples were scraped off from 5 stones (or other hard substrates) at each site. In the laboratory, the samples were cleaned by the concentrated acid digestion method and prepared on permanent slides (Renberg, 1990; Kelly et al., 1998; Leelahakriengkrai & Peerapornpisal, 2011). The samples were identified and counted according to Krammer & Lange-Bertalot (1986, 1988, 1991a,b), Lange-Bertalot (2001), and Kelly & Haworth (2002).

Aquatic insects samples were collected by the kick sampling method with a D-frame net (800 µm meshes) and preserved in 70% ethanol (Furse et al.,

1981; Arimoro & Ikomi, 2009). In the laboratory, only the aquatic insects were separated, identified and counted according to McCafferty (1983), Merritt et al. (2009), Stehr (1991), Dudgeon (1992), Wiggins (1996) and Sangpradub & Boonsoong (2006).

Sampling site	GPS (Lat-Long)	Altitude (m)
ML1	N 19°25'31.178" E 098°56'48.618"	489
ML2	N 19°25'07.819" E 098°56'53.287"	478
ML3	N 19°24'36.048" E 098°57'07.377"	463
TT1	N 19°5'31.261" E 098°56'49.058"	491
TT2	N 19°24'56.805" E 098°57'06.718"	460
TT3	N 19°24'42.124" E 098°57'15.150"	452

Table 1. Sampling sites and their topography.

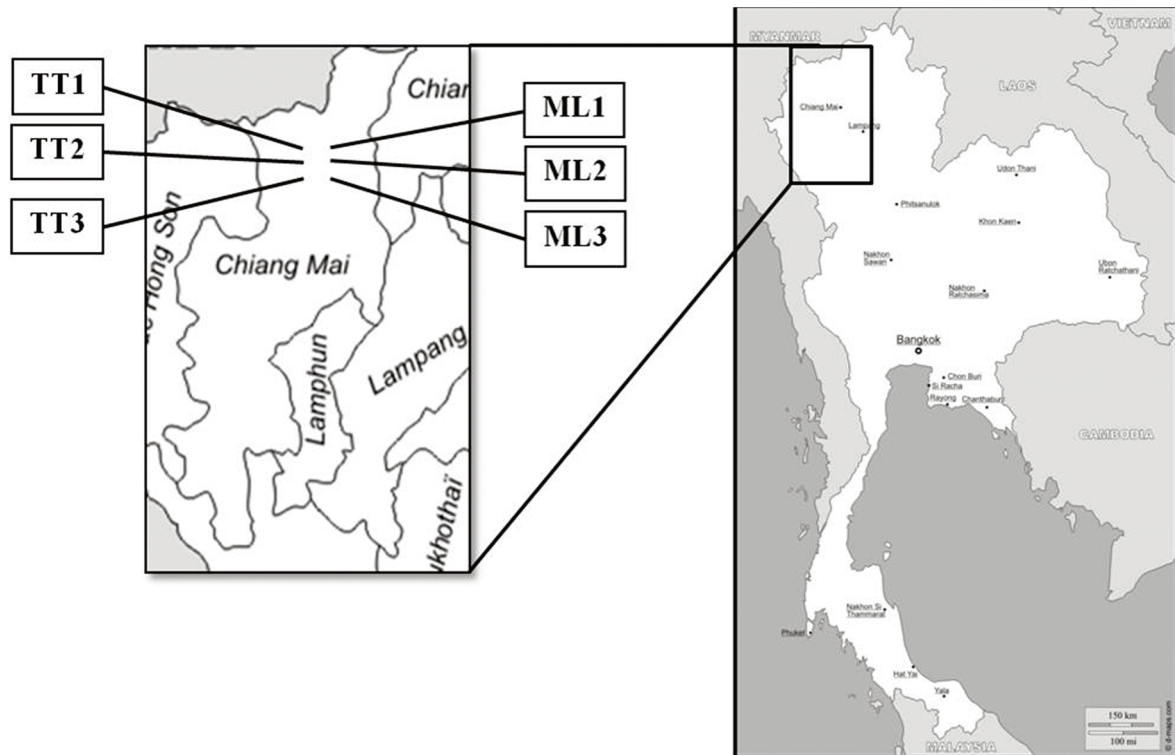


Figure 1. Map showing location of the six sampling sites in Mea Lu (ML) and Tong Ta (TT) streams at Chiang Dao district, Chiang Mai province, Thailand.

The species diversity index (H') and evenness (E) of benthic diatoms and aquatic insects were calculated following the Shannon Diversity Index (Odum, 2005).

RESULTS AND DISCUSSION

A total of nineteen families and fifty-three taxa of benthic diatoms from the Mea Lu and Tong Ta Streams were classified into 2 classes, according to Round et al. (1990), Coscinodiscophyceae, and

Bacillariophyceae in Division Bacillariophyta. Forty-seven taxa of benthic diatoms were found from the Mea Lu Stream and thirty-one species were collected from the Tong Ta Stream (Table 2). In the upstream sites of this study, a high abundance of *Navicula cryptotenella*, *Planothidium rostratum* and *Planothidium lanceolatum* was found, similarly to what reported in Asia by Tien (2004), Atazadeh et al. (2007) and Suphan & Peerapornpisal (2010), who found the same dominant species in Erh-Jen River (China), Gharasou River (Iran) and Mekong River and its tributaries. It appears that the species

Family	Species	ML1	ML2	ML3	TT1	TT2	TT3
Stephanodiscaceae	<i>Cyclotella meneghiniana</i>	-	-/-+	-	-	-	-
	<i>Cyclotella pseudostelligera</i>	-	-	-/-+	-	-	-
Achnantheaceae	<i>Achnanthes oblongella</i>	-/++	+/-+	-	+/-	+/+/+	+/+/+
	<i>Achnanthes brevipes</i>	-	-	-	+/-	+/-+	+/+/-
	<i>Planothidium lanceolata</i>	+/*+/*	+/+/+	+/+/+*	+*-/+	+/+/+*	+/+/+
	<i>Planothidium rostratum</i>	+/*+/*	+/+/+	+/-+	+*-/	-/-+	-/++
	<i>Planothidium</i> sp.	-	-/-+	-	-	-	-
Cocconeidaceae	<i>Cocconeis placentula</i>	+/+/+	+/-+	+/-+	-/-+	-/-+	-/++
Cymbellaceae	<i>Cymbella turgidula</i>	-	-	-/++	-	+/+/+	+/-
	<i>Cymbella tumida</i>	+/-	-	-/+	+/-	+/-+	+/-
	<i>Encyonema</i> sp.	-	+/-	-	-	-/-+	-
Eunotiaceae	<i>Eunotia bilunaris</i>	-	+/-	-	-	-	-/+
Gomphonemataceae	<i>Gomphonema gracile</i>	+/-	-	-	-	-	-
	<i>Gomphonema lagenula</i>	-	+*-/+	+/+/+	+/-+	+/+/+	+/-+
	<i>Gomphonema parvulum</i>	-	-	-	+/-+	-/-+	-/++
Diadesmidaceae	<i>Luticola goeppertiana</i>	-	-/+*	-	-	-/+*	+/+/+
Amphipleuraceae	<i>Frustulia vulgaris</i>	-/+	-	-	-	-	-
Brachysiraceae	<i>Brachysira neoexilis</i>	-	-/+	-	-	-	-
Sellaphoraceae	<i>Sellaphora pupula</i>	-/+	-/+	+/-+	-	-	-
Pinnulariaceae	<i>Pinnularia divergens</i>	-/+	-	-/+	-	-	-
	<i>Pinnularia mesolepta</i>	-	-	-/+	-	-	-
	<i>Pinnularia</i> sp.1	-	-	+/+	-	-	-
	<i>Pinnularia</i> sp.2	-	-	-/+	-	-	-
Diploneidaceae	<i>Diploneis oblongella</i>	+/+/+	-/++	-	+/+/+	-/-+	+/+/+

Table 2. Species list of benthic diatoms in the Mea Lu and Tong Ta streams (+ = present; - = absent in July 2012/September 2012/January 2013/ respectively; * = dominant).

FAMILY	SPECIES	ML1	ML2	ML3	TT1	TT2	TT3
Naviculaceae	<i>Adlafia</i> sp.		-/+	-/+			
	<i>Mayamaea atomus</i>	-/+	+*/+*/+*	+*/+*/+*	-	-	-
	<i>Navicula viridula</i>	-/+	-/+	+/+	+/+	+/-	-/+
	<i>Navicula cryptocephala</i>	-	-	-	+/-	+/+*	+/+
	<i>Navicula cryptotenella</i>	+*/+*	+*/+*	+*/-	+*/-	+/+*	+*/+
	<i>Navicula germainii</i>	-/+	-/+	+/+*	-/+	-/+	-/+
	<i>Navicula phyllepta</i>	+/+	+/-	-/+	-/+	-/+	-/+
	<i>Navicula capitatoradiata</i>	+/-	-/+	-/+*	+/-	-/+	-/+
	<i>Navicula symmetrica</i>	-	-	-	-	-/+	-/+
	<i>Navicula rostellata</i>	-	+/-	+/+*	-	-/+	-/+
	<i>Navicula tridentula</i>	+/-	-/+	-	-	-	-
	<i>Navicula erifuga</i>	-/+	-/+	-/+	-	-	-
Neidiaceae	<i>Neidium binodis</i>	-/+	-	-	-	-	-
Pleurosigmataceae	<i>Gyrosigma spencerii</i>	-/+	-	+/+	-/+	-	-/+
	<i>Gyrosigma scalproides</i>	-/+	-	-/+	-/+	-	-/+
Stauroneidaceae	<i>Craticula molestiformis</i>	-	-	-	+/+	+/-	-/+
	<i>Stauroneis smithii</i>	-/+	-	-	-/+	-	+/+
	<i>Stauroneis kriegeri</i>	-	-	-	+/-	-/+	-/+
Catenulaceae	<i>Amphora montana</i>	-	-	+/-		+/-	+/-
Bacillariaceae	<i>Nitzschia amphibia</i>	-/+	+/-	+/-	-	-	-
	<i>Nitzschia clausii</i>	-	-/+	+/-	-	-	-
	<i>Nitzschia coarctata</i>	-/+	-	-	-	-	-
	<i>Nitzschia levidensis</i>	-/+	-	+/-	-	-	-
	<i>Nitzschia palea</i>	+/+	+/+	+*/+*/+*	+/-	+/+	+*/+*/+*
	<i>Nitzschia dissipata</i>	-	-	+/-	+/-	-	-/+
	<i>Nitzschia</i> sp.	-/+	-	+/-	+/-	-	-
Surirellaceae	<i>Surirella angusta</i>	-	-/+	+/-	+/-	-/+	
	<i>Surirella splendida</i>	-	-	+/-	-	-	-
	<i>Surirella</i> sp.	-/+	-	+/-	-	-	-

Table 2 (continued). Species list of benthic diatoms in the Mea Lu and Tong Ta streams
(+ = present; - = absent in July 2012/September 2012/January 2013/ respectively; * = dominant).

in moderate water quality could be considered as mesotrophic species. At the downstream sites, *Nitzschia palea* and *Mayamaea atomus* were found to be the dominant species, as in Jüttner et al. (2003), Stenger-Kovács et al. (2007), Duong et al.

(2007) and García et al. (2008). They all reported the finding of these species in the downstream sites, which indicates tolerance to organic pollution.

A total of forty-six families of aquatic insects from the Mea Lu and Tong Ta Streams were classi-

ORDER	FAMILY	ML1	ML2	ML3	TT1	TT2	TT3
Odonata	Gomphidae	+/-/-	-	-	+/-/-	-	-
	Corduliidae	-/+/+	-/-/+	-	+/-/-	-	-
	Coenagrionidae	-	+/-/-	+/+/+	+/-/-	+/-/-	+/-/-
	Macromiidae	-	-	-	-	-	+/-/-
	Protoneuridae	-	+/-/-	-/+/-	-	+/-/-	-/-/+
	Libellulidae	-	--	+/-/-	-	+/-/+	+/-/-
	Aeshnidae	+/-/-	+/-/-	-	-	-	+/-/-
	Chlorocyphidae	-	-	+/-/+	-/+/+	-/+/+	-/+/+
	Platystictidae	-	-	-/+/-	-	-	-/+/+
	Euphaeidae	-/+/+	-	-	-	-	-
	Calopterygidae	-	+/-/+	-	-	-	-
	Coleoptera	Elminthidae	-	-	-	+/-/-	-/+/-
Scirtidae		+/-/-	-	-	+/-/-	-	-
Dytiscidae		-	-	-	-	-	-/+/+
Dryopidae		+/-/-	-	-	-	-	-
Psephenidae		+/-/-	-	-	-	-	-
Elmidae		+*/+/*	-/+/-	+/-/-	-	-	-
Gyrinidae		-	+/-/-	+/-/-	-	-	-
Hydrophilidae		-	-/+/-	-/+/-	-	-	-
Diptera	Chironomidae	-/+/-	+/*+/*	+/*+/*	+/+/-	+/+/+	-/+/-
	Athericidae	+/-/+	-	-	+/-/+	-	-
	Simuliidae	-/+/-	-/+/-	-	-/+/+	+/*+/*	-
	Tipulidae	-/+/+	-	-	-	-/+/-	-
	Stratiomyidae	-/+/-	+/-/-	+/-/-	-	-	-
	Ceratopogonidae	-	-/+/-	-	-	-	-
Ephemeroptera	Ephemeridae	+/-/-	-	-/+/+	+/-/+	-	-/+/+
	Caenidae	+*/-/+	-/+/+	+/*+/*	+*/-/+	+/-/+	+/+/+
	Beatidae	-/+/+	-/+/+	+/*+/*	-/+/+	+/*+/*+*	-/+/*+*
	Leptophlebiidae	-	-	-	-	-	-/+/+
	Neophemeridae	+/-/-	-	-/+/+	-	-	-
	Heptageniidae	-/+/+	-	-	-	-	-
Trichoptera	Odontoceridae	+/-/-	-/+/-	-	+/-/-	-	-
	Hydropsychidae	+/+/+	-/+/-	-/+/+	-/+/+	-/+/*/-	-/+/+
	Hydroptilidae	-	-	-	-	-	-/+/-
	Ecnomidae	-	-	-	-	-	-/+/+
	Molannidae	+/-/-	-	-	-	-	-
	Calamoceratidae	+/-/-	-	-	-	-	-
	Brachycentridae	-/+/+	-	-	-	-	-
	Leptoceridae	-	+/*+/*	-	-	-	-
	Limnephilidae	-	-/+/-	-	-	-	-
Hemiptera	Gerridae	+/-/+	-/+/+	-/+/+	-	+/-/-	+/*+/*
	Nepidae	-	-	-	-	-	+/-/-
	Veliidae	-	-/+/*	-	-/+/+	-/+/+	-
	Mesoveliidae	-	-	-	-	-/+/+	-
	Naucoridae	-/+/-	-	-	-	-	-
	Corixidae	-	+*/-/+	+/*+/*	-	-	-

Table 3. Families list of aquatic insects in the Mea Lu and Tong Ta streams (+ = present; - = absent in July 2012/September 2012/January 2013/ respectively; * = dominant).

BENTHIC DIATOMS					AQUATIC INSECTS		
Month	Sampling site	Diversity Index	Evenness	Species number	Diversity Index	Evenness	Family number
July 2012	ML1	1.80	0.75	11	1.89	0.70	15
	ML2	1.17	0.41	17	1.94	0.84	10
	ML3	1.87	0.59	24	2.14	0.89	11
	TT1	2.55	0.81	23	2.06	0.89	10
	TT2	2.03	0.82	12	0	0	1
	TT3	2.62	0.94	16	1.92	0.87	9
September 2012	ML1	2.14	0.77	16	0.15	0.07	9
	ML2	1.53	0.73	8	1.78	0.72	12
	ML3	2.14	0.69	22	1.56	0.71	9
	TT1	1.54	0.86	6	1.35	0.65	8
	TT2	1.93	0.78	12	0.92	0.52	6
	TT3	2.54	0.76	28	1.25	0.6	8
January 2013	ML1	2.1	0.64	26	1.44	0.62	10
	ML2	2.12	0.68	22	1.75	0.80	9
	ML3	2.15	0.76	17	0.99	0.45	9
	TT1	2.63	0.93	17	1.3	0.67	7
	TT2	2.66	0.78	31	0.92	0.51	6
	TT3	2.53	0.79	25	1.66	0.67	12

Table 4. Shannon's diversity index, evenness and the number of benthic diatoms in Mea Lu (ML) and Tong Ta (TT) streams.

fied into 6 orders; Ephemeroptera, Hemiptera, Diptera, Coleoptera, Odonata and Trichoptera. Thirty-eight families of aquatic insects were collected from the Mea Lu Stream and twenty-eight families from the Tong Ta Stream (Table 3). In the upstream sites, a high abundance of Caenidae and Elmidae was found, which are known to be sensitive to organic pollution and commonly found in locations under high dissolved oxygen conditions. Moreover, at the downstream sites, Corixidae, Baetidae, Chironomidae, Simuliidae and Hydropsychidae were found, which are known to possess tolerance to organic pollution and are commonly found in locations under low dissolved oxygen conditions (Mustow, 2002; Sharma et al, 2005; Mary & Macrina, 2012).

Shannon's diversity index, evenness and the number of benthic diatoms and aquatic insects in

the Mea Lu and Tong Ta Streams are shown in Table 4. The diversity index of benthic diatoms ranged from 1.17 to 2.66 and the evenness ranged from 0.41 to 0.94 and number of species varied from 6 to 31. In TT2, where a total of 31 species were present, the highest diversity index of 2.66 (evenness 0.78) was recorded on January 2013. Also in other sampling sites a high diversity rate was recorded in January 2013, during the cool dry season. The sampling sites which reflected a low rate of diversity index were mostly found in the ML2. The diversity index of aquatic insects ranged from 0 to 2.14 and the evenness ranged from 0 to 0.89, while the number of families varied from 1 to 15. In ML3, where a total of 11 families were present, the highest diversity index of 2.14 (evenness 0.89) was recorded on July 2012; in TT1, a high rate of the diversity index was recorded on July 2012 (diversity index 2.06, evenness 0.89).

In conclusion, the diversity of benthos in the ecotourism area including the Mea Lu and Tong Ta Streams, revealed very little difference compared to the diversity reports from Europe and Asia. In addition, this study revealed the sensitivity and tolerance of benthos to organic pollution in the upstream and downstream areas, respectively. Finally, this research study represents the first report of the diversity of freshwater benthos, including benthic diatoms and aquatic insects, in the ecotourism areas in the north of Thailand to produce the database collection that can be used for other study areas.

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