Diversity and seasonality of caddisflies (Insecta: Trichoptera) at Champathong waterfall, northern Thailand

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Abstract

The adult caddisfly fauna of Champathong waterfall in northern Thailand was sampled monthly using portable black light traps from February to October 2009. All specimens were identified according to species. A total of 762 male individuals were caught, belonging to 72 species of 14 families. The most common species were *Chimarra monorum* Chantaramongkol and Malicky, 1989, *Cheumatopsyche copia* Malicky and Chantaramongkol, 1997, and *Hydromanicus serubabel* Malicky and Chantaramongkol, 1993. Furthermore, the air temperature and precipitation parameters of area data were analyzed. Flight activity is clearly associated with seasonal climatic conditions. Overall Trichoptera species was highest in richness and abundance during February through to April, which coincides with the end of the dry season in the region.

Keywords: Light traps, caddisflies, biodiversity, seasonality

I. Introduction

Biodiversity can be broadly defined as the number, variety, and variability of living organisms, and it is often simply defined the number of different species in a given geographic area. Baseline organismal biodiversity research is necessary for an understanding of ecosystem, ecology and organism conservation. The conservation aspect of this type of research is becoming increasingly important due to a measured decline in worldwide organismal biodiversity and concern over the potential ecological implications of this decline.

The caddisflies (Trichoptera) are an order of holometabolous insect found on every continent except Antarctica. They are potentially useful indicators of river and stream health (Chantaramongkol, 1983; Resh, 1992). They are relatively easy to identify to species level in the adult stage and show a diverse range of ecological, behavioral and functional feeding modes as larvae. Furthermore, they are good indicators of environmental perturbation, and because they are distributed along the stream continuum, they constitute one of the most interesting groups for studying the ecology of organisms in running water (de Moor, 1999).

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Light traps have been used extensively by various workers to survey caddisfly populations. Light traps are the sampling tools that are used to collect insect from both terrestrial and aquatic systems. The methods applied in light traps, which are catching tools in aquatic insects, have been of benefit especially in sampling the Trichoptera species (Waringer, 2003). Although they are selective and affected by the meteorological parameters, the light traps remain used commonly (Schmera and Kiss, 2004). Adult Trichoptera seasonality in Thailand is poorly known, although several investigations in the northern region at Doi Suthep-Pui have been conducted e.g., Chantaramongkol *et al*. (1999), and Prommi and Chantaramongkol (2003). The abundance of Trichoptera adults was related to the three seasons in that region. Whereas, the study of adult Trichoptera seasonal activity patterns for the two seasons: dry (December-April) and wet (May-November) were obtained in southern Thailand (Prommi *et al.*, 2005).

Aquatic insect emergence is strongly influenced by season. Most of Asian countries are affected by the monsoon and seasonal rainfall, and monsoon behavior is nearly unpredictable (Gopal 2002). Moreover, most tropical rivers have an annual cycle, which is governed by the pattern of rainfall (Payne, 1986). Precipitation plays a major role in changing the benthic community (Robinson and Minshall, 1986) in the tropical rivers (Silveira et al., 2006). In this study, the diversity and seasonal distribution of caddisflies of a stream at Champathong waterfall in northern Thailand were described. Adult caddisflies were identified to the species level and their species richness evaluated for conservation value in a stream. Factors that could influence the temporal distribution of adults were investigated.

II. Materials and Methods

Study area. This research was conducted at a stream from Champathong waterfall (Figure 1), in the Doi Lueng National Park, Phayao Province, the northern part of Thailand. The study area is located at 19°13'N, 99°44'E and is 620 m above sea-level. The substrate consisted of large exposed rocks with little movable intervening substrate. The climate is the monsoonal, with a mean annual rainfall of about 1158.3 mm; the rainy season is from May to October; the cool-dry season is from November to January (minimum temperatures 10.5°C); and the hot-dry season is from February to April, (maximum temperatures 38.2°C) (Figure 2) (Source: Muang Phayao Station, 2009).

A B

Figure 1. Location of sampling site (A: upper part of stream; B: lower part of stream) in stream from Champathong waterfall**,** northern Thailand.

Specimen collection. Adults were collected using portable black-light traps (10-W fluorescent tube, 12-Volt DC battery) suspended across a white pan containing a detergent solution. Light traps started at various times between an hour before sunset and 1.5 hours after sunset near the stream margin and left overnight. Light trapping was conducted on a clear sky night and avoided the full moon that might interrupt light trap catches. Insects attracted to the black light were collected in the detergent solution and transferred into 80% ethyl alcohol the next morning and transported to the laboratory. All collected specimens in one night were considered as one sample for that particular month. Adults were collected one day in a month for 9 month from February to October 2009. The specimens in the month of July were stolen, therefore data of that month was unavailable.

Specimen identification. Specimens were sorted and examined under a dissecting stereomicroscope. For most caddisfly species, adult males primarily were used for making species determinations. The last two abdominal segments of adult male genitalia were removed and cleared by heating in 10% NaOH at 70 °C for 30 minutes. Specimen identification was carried out on the species level using Malicky (2010). For each species, specimen counts from collections at each month were summed.

Analyses. Correlations between the Trichoptera species community structure and local climate data were tested by Pearson product-moment correlation coefficient using SPSS v. 13.0 (http://www.spss.com/).

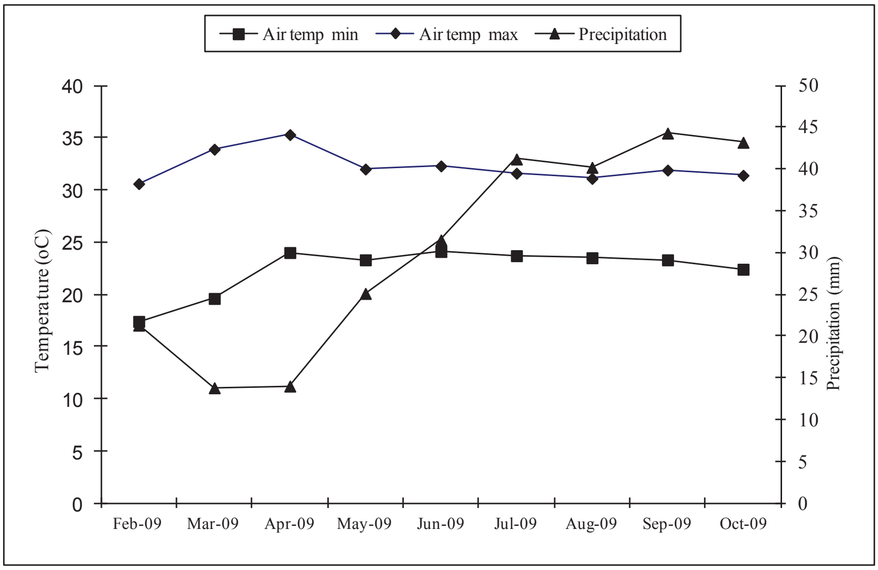

Figure 2. Total monthly rainfall and air temperature in Champathong waterfall (February-October 2009) (source: Muang Station Records for 2009).

III. Results

In this study, the diversity of adult Trichoptera varied widely over the months. A total of 762 male individuals were caught belonging to 72 species of 14 families (Table 1). The distribution of families (Figure 3) and the flight graphics of the 10 most common species in terms of individuals, and time of collection of 72 species, were based on the monthly count of specimens in the traps (Figure 4).

Adult Trichoptera were present at all times of the year in a stream. The highest abundance of adult caddisflies were collected in the dry season (February to April) while the lowest was recorded in the wet and cold season (June to October) (Table 1).

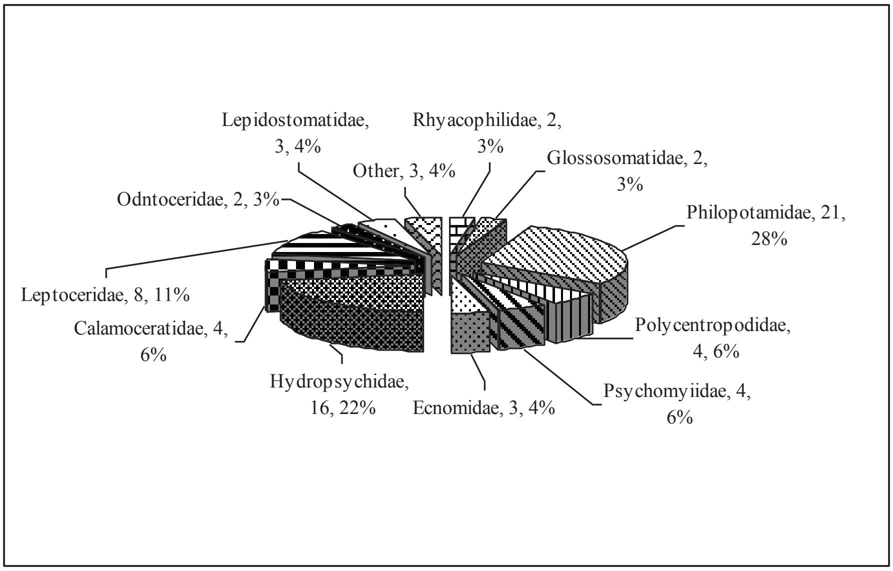

Figure 3. Percentage of caddisflies species collected in each family in a stream from Champathong waterfall during February to October 2009.

Taxa represented by fewer specimens and found a single time were in family Philopotamidae (*Chimarra meorum*, *C. rama*, *C. shiva*, *C. schwendingeri*, *Gunungiella traiafiazga*, *G. fiarafiazga*, *Kisaura verecunda*); family Stenopsychidae *(Stenopsyche siamensis*); family Polycentropodidae (*Polyplectropus anakgugus*); family Psychomyiidae (*Psychomyia kuni*, *Tinodes ragu*); famliy Dipseudopsidae (*Dipseudopsis robustior*); family Ecnomidae (*Ecnomus mammus*, *E. venimar*); family Hydropsychidae (*Cheumatopsyche globosa*, *Hydropsyche dolosa*, *Macrostemum dohrni*); family Goeridae (*Goera matuilla*); family Calamoceratidae (*Anisocentropus brevipennis*, *Ganonema extensum*, *G. fuscipenne*); family Leptoceridae (*Adicella evadne*, *A. hero*, *Oecetis miletos*, *Setodes endymion*, *S. sarapis*, *Tagalopsyche orisis*, *Triaenodes dusra*); family Odontoceridae (*Marilia sumatrana*); family Lepidostomatidae (*Dinarthrum pratetaiensis*).

Taxa collected twice were in family Glossosomatidae (*Agapetus lalus*); family Philopotamidae (*Chimarra bimbltona*, *C. lannaensis*, *C. suthepensis*, *C. suadulla*, *Kisaura surasa*); family Polycentropodidae (*Polyplectropus nahor*, *Pseudoneureclipsis philemon*); family Hydropsychidae

(*Cheumatopsyche carna*, *C. chrysothemis*, *Diplectrona eurydike*); family Leptoceridae (*Adicella koronis*); family Lepidostomatidae (*Georodes doligung*).

Taxa collected three times included family Rhyacophilidae (*Rhyacophila suthepensis*, *R. tosagan*); family Glossosomatidae (*Agapetus dangorum*); family Philopotamidae (*Chimarra atnia*, *C. chiangmaiensis*, *C. devva*); family Polycentropodidae (*Polyplectropus admin*); family psychomyiidae (*Psychomyia lak*); family Ecnomidae (*Ecnomus tinco*); family Hydropsychidae (*Diplectrona aurovittata*, *Hydatomanicus klanklini*, *Hydromanicus truncatus*, *Hydropsyche camillus*, *Pseudoleptonema supalak*); family Calamoceratidae (*Anisocentropus pan*); family Lepidostomatidae (*Adinarthrum moulmina*). Only one species, *Psychomyia lak*, in family Psychomyiidae, were presented four times.

Taxa collected five times were Philopotamidae- *Dolophilodes truncata*, *Gunungiella segsafiazga*. Taxa present six times were Philopotamidae- *Chimarra akkaorum*, *C. spinifera*; Hydropsychidae- *Hydropsyche pallipenne*, *Macrostemum fastosum*; Odontoceridae- *Phraepsyche danaos*. Only one species found seven times was *Chimarra pipake* in famlity Philopotamidae . the. The philopotamid species (*Chimarra monorum*) and the hydropsychid species (*Cheumatopsyche copia*, and *Hydromanicus serubabel*) were dominant and distributed at all collecting times.

Of the 72 species collected, 18 were represented by only a single specimen over collecting periods due to exceptional rarity of these species in the study area. Therefore, phenological data of species represented by relatively few specimens over the collecting date can be misleading.

The local climate in the area i.e. minimum and maximum air temperatures and rainfall was evaluated by Pearson's correlation test. Many species of Trichoptera were significantly related to the effects of local climate according to the data (Table 2).

IV. Discussion

Naturally, the caddisflies are highly represented in the tropics (Dudgeon, 1999). Riparian area around stream from Champathong waterfall provides a relatively suitable habitat for trichopteran adults as they were highly abundant (Petersen et al., 1999). Survival of Trichoptera adults is influenced by dense vegetation in riparian areas (Collier et al., 1997) to provide refuges (Anderson 1992). Studies by Meehan (1996), Hawkins et al. (1982) and Newbold et al. (1994) showed that streams in forested area had higher production of certain insect groups compared with open canopies.

Table 1. Total number of specimens and 72 species of adult Trichoptera from light traps collected (male only) from Champathong waterfall during February to October 2009 (relative abundance as%).

Taxa	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	%RA
Rhyacophilidae									
Rhyacophila suthepensis Malicky 1987			1		1			1	0.39
R. tosagan Malicky&Chantamongkol 1993	3	1				2			0.79
Glossosomatidae									
Agapetus dangorum Olah 1942	1	1	1						0.39
A. lalus Malicky&Chantamongkol 1992		1	1						0.26
Philopotamidae									
Chimarra akkaorum Malicky&Chantamongkol 1989	1	4	9	1	1	2			2.36
C. atnia Malicky&Chantamongkol 1993	1	1	1						0.39
C. bimbltona Malicky 1979						1	1		0.26
C. chiangmaiensis Chantaramongkol&Malicky 1989			2		3	2			0.92
C. devva Malicky&Chantamongkol 1993	3	5					2		1.31
C. lannaensis Chantaramongkol&Malicky 1989						4	8		1.57
C. meorum Chantaramongkol&Malicky 1989	1								0.13
C. monorum Chantaramongkol&Malicky 1989	2	14	5	2	5	1	10	1	5.25
C. pipake Malicky&Chantamongkol 1993	6	3	1	1	2	5	5		3.02
C. rama Malicky&Chantamongkol 1993							2		0.26
C. shiva Malicky&Chantamongkol 1993		2							0.26
C. spinifera Kimmins 1957	26	33	4		5	10	2		10.5
C. suthepensis Chantaramongkol&Malicky 1989		3	1						0.52
C. schwendingeri Chantaramongkol&Malicky 1989		11							1.44
C. suadulla Malicky&Chantamongkol 1993	2	4							0.79
Dolophilodes truncata Kimmins 1955	2	1	1	1				1	0.79
Gunungiella segsafiazga Malicky&Chantamongkol 1993	1		2	3	1	3			1.31
G. traiafiazga Malicky&Chantamongkol 1993		2							0.26
G. fiarafiazga Malicky&Chantamongkol 1993		3							0.39
Kisaura surasa Malicky&Chantamongkol 1993			3					1	0.52
K. verecunda Malicky&Chantamongkol 1993		12							1.57
Stenopsychidae									
Stenopsyche siamensis Martynov 1931		2							0.26
Polycentropodidae									
Polyplectropus anakgugus Malicky 1995				1					0.13
P. admin Malicky&Chantamongkol 1993		4		2			1		0.92
P. nahor Malicky&Chantamongkol 1993			1		1				0.26
Pseudoneureclipsis philemon Malicky&Prommi 2000		1	1						0.26
Psychomyiidae									
Lype atnia Malicky&Chantamongkol 1993			1		2	2	1		0.79
P. lak Malicky&Chantamongkol 1993			2	1		2			0.66
P. kuni Malicky&Chantamongkol 1993		1							0.13
Tinodes ragu Malicky&Chantamongkol 1993						1			0.13

Table 1. Continued.

Taxa	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	%RA
Dipseudopsidae									
Dipseudopsis robustior Ulmer 1929			1						0.13
Ecnomidae									
Ecnomus mammus Malicky&Chantamongkol 1993			1						0.13
E. venimar Malicky&Chantamongkol 1993				1					0.13
E. tinco Malicky&Chantamongkol 1993	1	4					1		0.79
Hydropsychidae									
Cheumatopsyche carna Malicky&Chantamongkol 1997	4	1							0.66
C. chryseis Malicky&Chantamongkol 1997			4		1	4	5	4	2.36
C. chrysothemis Malicky&Chantamongkol 1997					1	4			0.66
C. copia Malicky&Chantamongkol 1997	37	13	8	3	5	12	5	2	11.2
C. globosa Ulmer 1910		1							0.13
Diplectrona aurovittata Ulmer 1906			5	1				2	1.05
D. eurydike Malicky&Chantamongkol 2002						1		1	0.26
Hydromanicus klanklini Malicky&Chantamongkol 1993		2				1	1		0.52
H. serubabel Malicky&Chantamongkol 1993	28	60	26	9	4	12	9	2	19.7
H. truncatus Betten 1909	4	3	3						1.31
Hydropsyche camillus Malicky&Chantamongkol 2000	5	36	12						6.96
H. dolosa Banks 1939		1							0.13
H. pallipenne Banks 1939		9	3	2	4	1		1	2.62
Macrostemum dohrni Ulmer 1905						1			0.13
M. fastosum Walker 1952	4	9	1	1	1	4			2.62
Pseudoleptonema supalak Malicky&Chantamongkol 1998	1	3	2						0.79
Goeridae									
Goera matuilla Malicky&Chantamongkol 1992		3							0.39
Calamoceratidae									
Anisocentropus pan Malicky&Chantamongkol 1994	1	3			1				0.66
A. brevipennis Ulmer 1906			1						0.13
Ganonema extensum Martynov 1935					1				0.13
G. fuscipenne Albarda 1881		1							0.13
Leptoceridae									
Adicella evadne Schmid 1994		1							0.13
A. koronis Malicky&Thani 2002		1				1			0.26
A. hero Malicky&Chantamongkol 2002		1							0.13
Oecetis miletos Malicky&Naewvong 2005		1							0.13
Setodes endymion Malicky&Chibu 2000			1						0.13
S. sarapis Malicky 2005			3						0.39
Tagalopsyche orisis Malicky 2005	1								0.13
Triaenodes dusra Malicky 2005		2							0.26
Odontoceridae									
Marilia sumatrana Ulmer 1951			2						0.26
Phraepsyche danaos Malicky&Sompong 2000	1	1		4	6	4	2		2.36

Table 1. Continued.

Taxa	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	%RA
Lepidostomatidae									
Adinarthrum moulmina Mosely 1949	1	6				4			1.44
Dinarthrum pratetaiensis Malicky&Chantamongkol 1994		7							0.92
Georodes doligung Malicky 1979		3			1				0.52
Total number of individual	137	281	110	33	46	84	55	16	
Number of species	24	45	32	15	19	24	15	10	

This is probably due to air temperature in forested sections is lower compared with open areas due to variation in shaded areas. Most Trichoptera are nocturnal flies and prefer lower air temperature (Collier et al., 1997). In addition, higher number of Hydropsychidae (Trichoptera) adults is probably associated with availability of algal biomass (Quinn et al., 1997). The larvae are often attached to rocks, facing the water flow, and feed on particles caught in their nets (Triplehorn and Johnson 2005). Other caddisfly larvae such as Philopotamidae and Leptoceridae fasten their cases to rocks, wood debris and other small objects in the stream (Triplehorn and Johnson 2005). Generally, substrate diversity indirected affects the distribution of aquatic insects as it offers a favourable place for oviposition in several groups of aquatic insects. Badcock (1953) reported that some caddisfly females appeared to be selective in term of particular substrates to lay their eggs. In the present study, a sufficient number of oviposition sites at stream from Champathong Waterfall was observed, including plenty of protruding rocks as well as trees scattered along the stream banks, which could explain the high abundance of caddisfly in the present study.

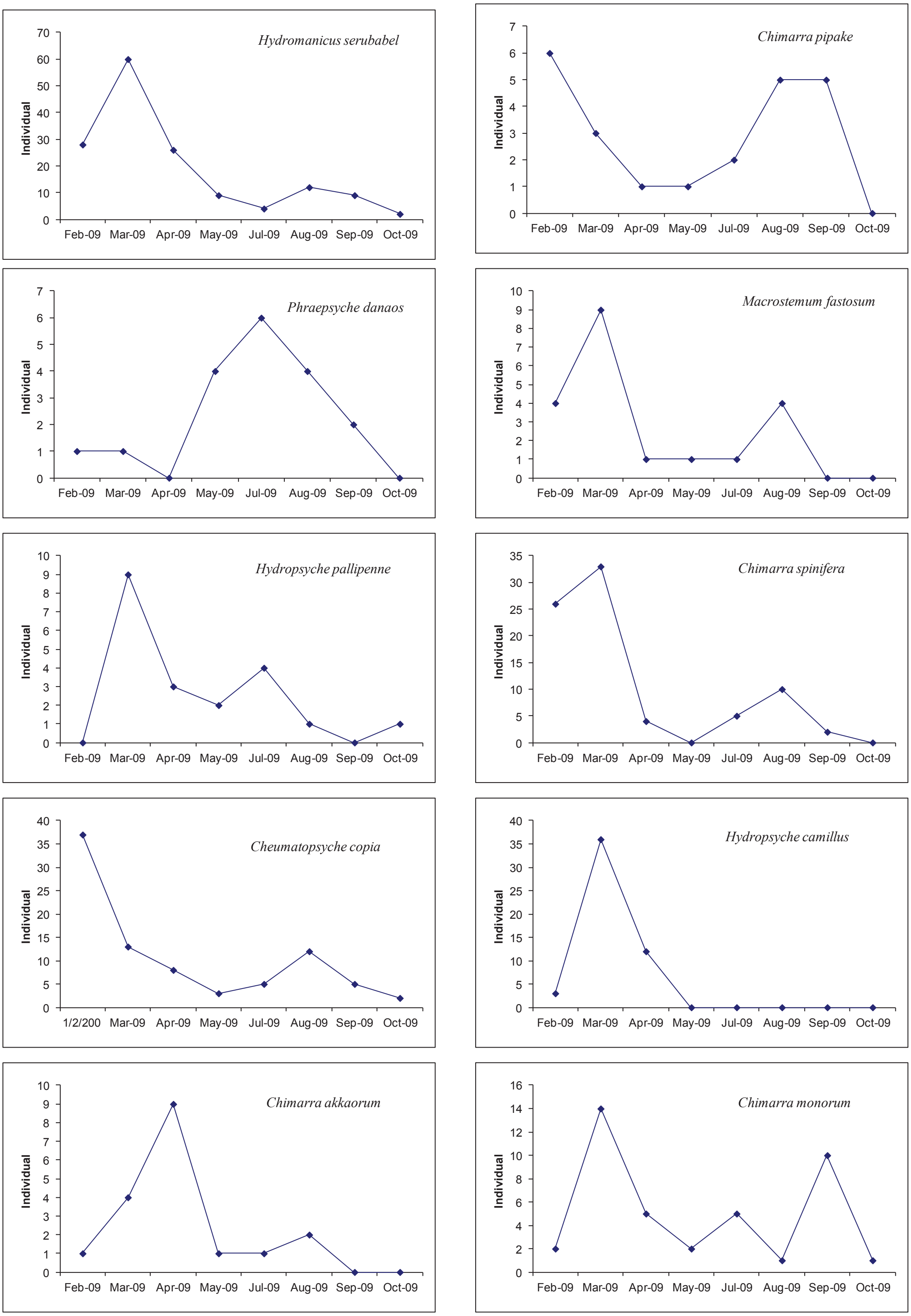

Figure 4. The seasonal flight distribution of the 10 most common species of 72 Trichoptera species in a stream from Champathong waterfall.

Table 2. Pearson's correlations between local climate datas on adult caddisflies in stream from Champathong waterfall.

Taxa/parameters	Minimum air temperature (oC)	Maximum air temperature (oC)	Rainfall mm
Rhyacophila tosagan	-0.779*		
Agapetus dangorum			-0.878**
Agapetus lalus		0.930**	-0.769*
Chimarra akkaorum		0.892**	-0.709*
Chimarra devva	-0.779*		
Chimarra meorum	-0.809*		
Chimarra spinifera	-0.845**		
Chimarra suadulla	-0.797*		
Dolophilodes truncata	-0.749*		
Pseudoneureclipsis philemon		0.930**	-0.769*
Dipseudopsis robustior		0.788*	
Ecnomus mammus		0.788*	
Cheumatopsyche carna	-0.921**		
Cheumatopsyche copia	-0.849**		
Pseudoleptonema supalak		0.743*	-0.849**
Anisocentropus brevipennis		0.788*	
Setodes endymion		0.788*	
Setodes sarapis		0.788*	
Tagalopsyche orisis	-0.809*		
Marilia sumatrana		0.788*	

**p<0.05, *p<0.01

Chantaramongkol et al. (1999) noted that the differences of number and species of Trichoptera depending on the nature of the habitat that is designated by the environment.

In the present study, a high individuals adult caddisfly were collected during dry season (February to April) rather than during the wet and cold-dry season (May to October). The dry season in the tropics is characterized by high temperature and low precipitation rate. In New Zealand, it was reported that peak emergence of aquatic insects generally occurs over summer and that their flight activity is related to air temperature (Collier et al., 1997). In addition, DeWalt and Donald (1998) stated that lower richness of adult Trichoptera taxa was due to lower water temperature, which could delay their emergence. This is due to the fact that warmer water temperature usually increase metabolism rate in organism bodies and may lead to earlier emergence (Voshell and Reese, 2002). Seasonal precipitation has been suggested as another important factor influencing the composition and temporal abundance of aquatic insects in tropical streams (Masteller and Buzby, 1993). Meanwhile, Corbet (1964) conclude that adult aquatic insects are highly variable in terms of emergence time because in tropical regions emergence can be continuous in wet or dry weather.

At stream of Champathong Waterfall, a higher number of Trichoptera, especially hydropsychids, was recorded during the dry season. Emergence of adult insects at any stream is dependent on the stability and consistency of surrounding riparian environment (Chan et al., 2004). The dry season merely provides a stable environment for insects to emerge, mate and oviposit (Paetzold and Tockner, 2005). During the wet season, however, flight activity of caddisflies is challenging, as their wings will be drenched and therefore more energy will be needed to heat up their bodies (Collier et al., 1997). Furthermore, prior to emergence, the Trichoptera pupa needs to free its body from the cocoon before flying off (Flannagan and Lawler, 1972). In this regard, the rainy season might be less favorable for Trichoptera emergence at tropical streams.

V. Conclusion

The present study suggests that tropical forest stream supported high diversity and abundance of Trichoptera adults. The dry season condition was favorable to trichopteran individuals as their abundance and family diversity were high during the dry season (February to April). Microclimatic conditions experienced during the adult phase have an impact on survival and longevity. Air temperature and relative humidity are of particular importance, with higher temperatures and lower humidity reducing the adult lifespan of aquatic groups. Microclimate also influences the flight activity of aquatic species. In common with terrestrial groups, the flight activity of aquatic adults appears to be affected primarily by air temperature, but humidity also influences flight in some groups.

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