CHAPTER 4

RESULTS

4.1 Environmental parameters

The mean environmental parameters are showed in Table 4.1. The average values of each parameter were compared using Analysis of Variance (ANOVA). The relative humidity, pH of water and phosphate concentration in stream of all sites were not significantly different. The relative humidity of all study sites was around 80%. The pH of water in streams of all sites was around 7-8. The sulfate in water was not detected, only few occasions that it was found but only 1 mg/l.

In the study site, the minimum and maximum temperature were around 18-21 and 24-26 °C, respectively. These air temperatures were performed naturally by gradually decreased along the increasing of altitude. The lowest significantly minimum temperature was found in Doi Inthanon at 1,200 m. On the other hand, the highest maximum temperature was found at Inthanon 600m.

Water temperature was positively correlated with the air temperature by gradually decreased along the elevation. Only the water temperature at 600 m on Doi Inthanon had the significant higher than the other sites. In this site the mean water temperature was around 23 °C, but the other sites were around 18-22 °C.

The mean current velocity of studied streams were around 40-60 m/s, except the Inthanon at 1,200, where the velocity was the highest (~90 m/s). The discharges of water in stream on Doi Inthanon were significantly higher than that of Doi Suthep-Pui.

The conductivity and TDS increased along the distance from head to down stream. The conductivity and TDS were around 30-60 μS/cm and 16-30 mg/l, respectively, except the site at Doi Suthep-Pui at 600m where the mean conductivity and TDS were 150 μS/cm and 75 mg/l, respectively.

The turbidity was specifically highest at Doi Inthanon 600 m for 53 mg/l, whereas the remaining sites were only 5-28 mg/l. The DO of these streams were relatively high, 7.3 – 8.7 mg/l. The study site on Doi Inthanon at 600 and 1,200 were found that contained the significant high of DO. The BOD_5 of these sites were also low, that the values were around 0.7 – 2.7 mg/l.

The trace nutrients were also detected in term of nitrate, ammonia, phosphate and sulfate in relatively low concentration (Table 4.1). These nutrients were relatively high in the site at Doi Suthep-Pui at 600 m. The Alkalinity was also found highest at 600 m on Doi Suthep-Pui.

Finally, soil pH of each site was measured. The soil samples from the study riparian areas were the mild acid, pH ~5-6. Except the mean soil pH from Inthanon at 600 was relatively neutral, pH ~7.

Table 4.1 Mean and standard deviation of some environmental parameters in Doi Suthep-Pui and Doi Inthanon at the elevation 600, 1,000 and 1,200. (* Indicate the significant difference at $p < 0.05$).

	Doi Suthep-Pui			Doi Inthanon		
Elevation	600	1,000	1,200	600	1,000	1,200
Minimum Temperature (°C)	21.5±2.7	20.3±3.6	20.2±3.1	20.4±.3	18.0±4.7	16.0±3.9*
Maximum Temperature (°C)	26.4±1.8	25.8±3.7	24.5±1.8	29.0±6.2*	26.6±4.5	24.8±2.9
Relative humidity (%)	85±12	83±14	80±14	83±13	77±13	80±15
Channel Width (m)	3.0	2.0	2.3	11.0	10.0	4.0
Stream Width (m)	2.3±1.0	1.8±0.7	2.0±0.6	4.1±0.7	6.5±1.7	2.6±0.4
Stream Depth (cm)	10.5±4.0	8.0±4.1	10.0±6.9	24.8±23.4	34.7±10.7	20.1±9.6
pH	7.9±0.4	7.2±0.3	7.3±0.4	7.9±0.5	7.8±0.4	8.0±0.6
Water Temperature (°C)	22.3±1.1	21.0±0.8	20.5±0.6	23.8±4.2*	21.0±3.1	18.3±2.5
Current Velocity (m/s)	0.41±0.07	0.45±0.09	0.42±0.11	0.51±0.10	0.59±0.25	0.89±0.56*
Discharge (m^3/s)	0.1±0.1	0.1±0.1	0.1±0.1	0.6±0.9*	1.2±0.9*	0.7±1.0*

(Table 4.1 Continue)

	Doi Suthep-Pui			Doi Inthanon		
Elevation	600	1,000	1,200	600	1,000	1,200
Conductivity (μS/cm)	150.7±47.0*	62.1±12.2	51.3±4.0	42.9±5.3	49.9±11.8	32.8±11.1
Total Dissolved Solid (mg/l)	75.8±23.5*	32.3±7.8	26.2±3.2	21.4±2.6	24.8±5.9	16.4±5.6
Turbidity (FTU)	28±17	18±8	14±5	53±64*	20±16	5±2
DO (mg/l)	8.0±0.6	7.3±0.6	7.7±0.7	8.7±0.8*	8.4±0.8	8.5±0.9*
BOD_5 (mg/l)	2.5±1.5*	2.7±3.0*	1.8±2.0	1.1±0.8	1.1±0.9	0.7±1.0
Nitrate (mg/l)	1.3±0.9*	2.2±0.8*	0.7±0.7	0.7±0.4	1.3±1.3	1.3±0.3
Ammonia (mg/l)	0.69±1.24*	0.39±0.47	0.36±0.75	0.38±0.29	0.13±0.10	0.49±0.49
Phosphate (mg/l)	0.59±0.23*	0.43±0.11*	0.16±0.05	0.28±0.11	0.21±0.16	0.18±0.14
Sulfate (mg/l)	1±3	0	1±1	0	0	0
Alkalinity (mg/l)	52.7±14.9*	34.1±10.4	24.7±6.9	22.2±2.8	25.5±7.5	19.5±7.9
Soil pH	5.9±0.5	5.4±0.8	6.4±0.5*	7.4±0.7*	5.0±0.8	6.1±1.1

4.2 The riparian insects

4.2.1 Pitfall traps

There were 3,164 specimens of ground dwelling insects were captured and identified. These specimens composed with 107 families. The most abundance family ranks for 15 families, which refer to 90 - 95% of the trapped insects, are showed in Table 4.2. The most abundance insects were Entomobryidae (Collembola) and Formicidae (Hymenoptera). The combination of both families occupied more than

50% of all insects yield from pitfall. The most abundance insect family of Doi Suthep-Pui was Entomobryidea (Collembola) and Doi Inthanon was the Formicidae (Hymenoptera).

Table 4.2 The family and percentage of insect yield captured from pitfall trap from Doi Suthep-Pui and Doi Inthanon at 600, 1,000 and 1,200 m. The results were arranged from the most abundance family to the lower.

Doi Suthep-Pui, 600m	Doi Suthep-Pui, 1000m	Doi Suthep-Pui, 1200m
Entomobryidae (36.1)	Entomobryidae (36.8)	Entomobryidae (34.8)
Formicidae (35.2)	Formicidae (22.6)	Formicidae (30.5)
Arachnida (7.0)	Staphylinidae (6.9)	Phoridae (4.0)
Phoridae (5.6)	Phoridae (5.0)	Staphylinidae (3.6)
Scarabaeidae (2.0)	Arachnida (4.7)	Chironomidae (3.4)
Staphylinidae (2.0)	Chironomidae (3.1)	Endomychidae (3.2)
Chironomidae (2.0)	Tipulidae (2.2)	Arachnida (2.8)
Gryllidae (1.3)	Endomychidae (1.6)	Scarabaeidae (2.7)
Acrididae (1.1)	Chalcidoidae (1.6)	Gryllidae (1.5)
Tipulidae (0.9)	Isotomidae (1.3)	Hypogastruridae (1.1)
Sminthuridae (0.7)	Muscidae (1.3)	Blattellidae (1.1)
Blatidae (0.7)	Carnidae (0.9)	Muscidae (1.1)
Chalcidoidae (0.7)	Cecidomyiidae (0.9)	Psychodidae (0.9)
Cicadellidae (0.4)	Cicadellidae (0.9)	Sminthuridae (0.8)
Rhinotermitidae (0.4)	Gryllacrididae (0.6)	Cercopidae (0.8)

(Table 4.2 Continue)

Doi Inthanon, 600	Doi Inthanon, 1000	Doi Inthanon, 1200
Formicidae (79.7)	Formicidae (37.3)	Formicidae (26.3)
Entomobryidae (8.5)	Entomobryidae (22.3)	Entomobryidae (22.7)
Staphylinidae (1.8)	Arachnida (8.3)	Phoridae (13.1)
Arachnida (1.7)	Staphylinidae (4.7)	Staphylinidae (7.5)
Gryllidae (0.7)	Phoridae (3.7)	Chironomidae (3.7)
Cucujidae (0.7)	Byturidae (2.3)	Arachnida (3.2)
Scarabaeidae (0.7)	Muscidae (2.3)	Muscidae (3.1)
Scolytidae (0.7)	Tipulidae (2.3)	Endomychidae (2.9)
Phoridae (0.7)	Scarabaeidae (2.0)	Tipulidae (2.4)
Endomychidae (0.6)	Scolytidae (2.0)	Cucujidae (1.5)
Chironomidae (0.4)	Gryllidae (1.7)	Scarabaeidae (1.4)
Brachycera (0.4)	Cucujidae (1.7)	Aradidae (1.0)
Phlaeothripidae (0.3)	Lepismatidae (1.0)	Cicadellidae (0.8)
Byturidae (0.3)	Tephritidae (1.0)	Chalcidoidae (0.8)
Acrididae (0.2)	Hypogastruridae (0.7)	Isotomidae (0.7)

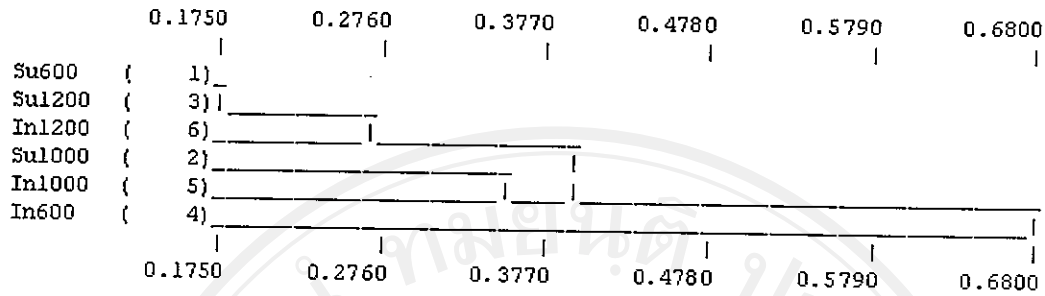

Fig 4.1 Cluster analysis (Flexible UPGMA) shows the classification of study sites based on the community of insect family captured from Pitfall traps. Su600 is Doi Suthep-Pui at 600 m; In600 is Doi Inthanon at 600 m.

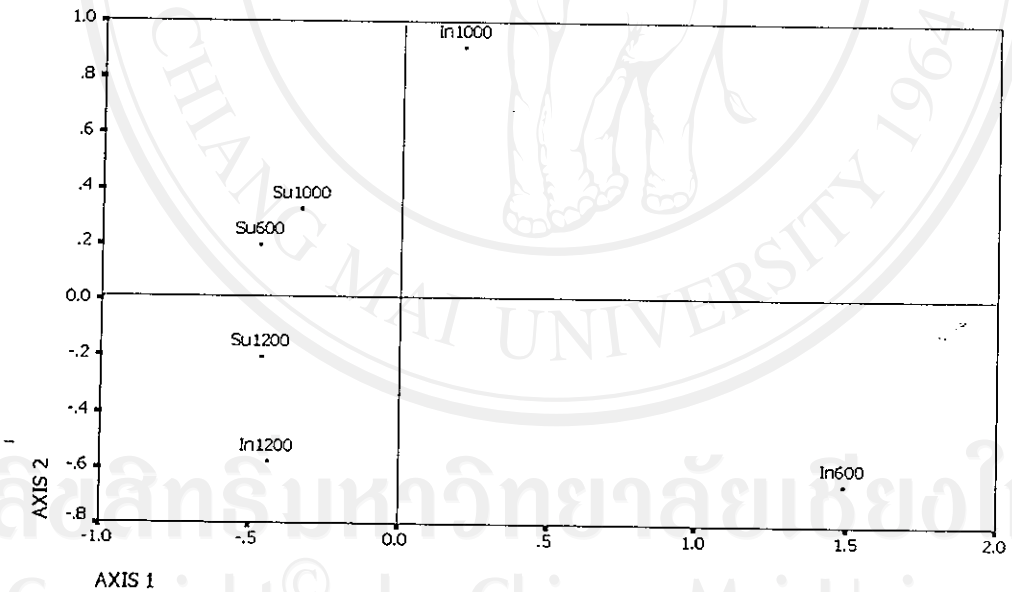

Fig 4.2 Ordination (semi-strong hybrid multidimensional scaling) shows the relationship of study sites based on their insect community from pitfall trap. Stress = 0.74 X 10^{-1}.

The analysis of the ground dwelling insect community using cluster analysis (Fig 4.1) and ordination (Fig 4.2) show the grouping of the study site located on the same mountain. The most similar community belonged to the insects from Doi Suthep-Pui. The cluster analysis and ordination shows the grouping between Doi Suthep-Pui at 600, 1,000 and 1,200 m.

The community of insects from Doi Inthanon were relatively different. The result from ordination (Fig 4.2) is clearly shows the relatively scatter of each study site from Doi Inthanon in ordination space. The ground dwelling insects from Doi Inthanon at 1200 m had the tendency to resemble with the community from Doi Suthep-Pui. Both multivariate analysis show the relatively difference of insects community from Doi Inthanon 600 m compared with the other sites.

4.2.2 Beating tray method

The insects and closely relative arthropod for 334 specimens cover 48 taxa were captured under the beating tray method. This most abundance arthropod that were caught using this method were the spider (Arachnida). Especially, all of the sites on Doi Suthep-Pui, the most abundance taxa were Arachnida, which cover around 25% of the yield. Some insects captured under this method were Formicidae (Hymenoptera), Cocinellidae (Coleoptera), Pentatomidae (Hemiptera), Endomychidae (Coleoptera) for example. The list the most abundance for the top 10 ranks of Arthropod taxa from each site are show in Table 4.3.

In each study site contained the unique arthropod community living around the lower reach canopy. The arthropod communities were analyzed and the results are presented by cluster analysis (Fig 4.3) and ordination (Fig 4.4). These results show

that the arthropod community at Doi Suthep-Pui 600 m was rather similar with those from Doi Suthep-Pui 1,200 m and the Doi Inthanon at 600 m also performed the similarity with Doi Inthanon 1,200m. Whereas, the community from Doi Suthep-Pui and Doi Intannon at 1,000 m contained the relatively unique Arthropod community.

Table 4.3 The Arthropod taxa and their percentage yield that were captured by beating tray method from the lower reach canopy in riparian forest on Doi Suthep-Pui and Doi Inthanon at 600, 1,000 and 1,200 m.

Doi Suthep-Pui, 600m	Doi Suthep-Pui, 1000m	Doi Suthep-Pui, 1200m
Arachnida (29.7)	Arachnida (22.7)	Arachnida (21.8)
Formicidae (21.6)	Formicidae (16.7)	Formicidae (18.2)
Pentatomidae (10.8)	Cocinellidae (10.6)	Thripidae (9.1)
Lepidoptera (Larva) (8.1)	Endomychidae (7.6)	Cicadellidae (5.5)
Endomychidae (5.4)	Culicidae (6.1)	Lepidoptera (Larva) (5.5)
Diplopoda (5.4)	Chironomidae (4.5)	Corylophidae (3.6)
Entomobryidae (2.7)	Chalcidoidae (4.5)	Curculionidae (3.6)
Blattellidae (2.7)	Rhizophagidae (3.0)	Diplopoda (3.6)
Acrididae (2.7)	Scolytidae (3.0)	Entomobryidae (1.8)
Corixidae (2.7)	Lepidoptera (Larva) (3.0)	Sminthuridae (1.8)

(Table 4.3 Continue)

Doi Inthanon, 600	Doi Inthanon, 1000	Doi Inthanon, 1200
Formicidae (34.1)	Arachnida (26.7)	Formicidae (33.3)
Kalotermitidae (20.5)	Formicidae (16.7)	Arachnida (17.6)
Cocinellidae (9.1)	Diplopoda (13.3)	Entomobryidae (11.8)
Arachnida (9.1)	Cocinellidae (6.7)	Carabidae (9.8)
Lepidoptera (Larva) (6.8)	Curculionidae (6.7)	Lepidoptera (Larva) (5.9)
Entomobryidae (4.5)	Entomobryidae (3.3)	Cucujidae (3.9)
Chelisochidae (2.3)	Gryliidae (3.3)	Cicadellidae (2.0)
Tingidae (2.3)	Reduvildae (3.3)	Cerambycidae (2.0)
Curculionidae (2.3)	Tingidae (3.3)	Cocinellidae (2.0)
Scarabaeidae (2.3)	Carabidae (3.3)	Curculionidae (2.0)

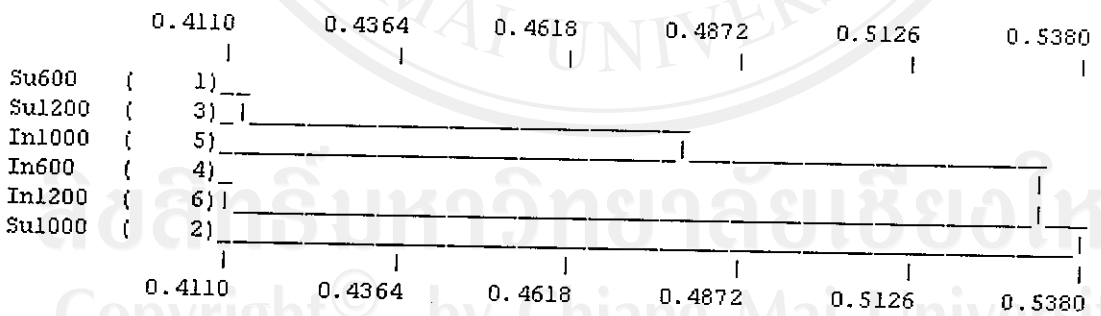

Fig 4.3 Cluster analysis (Flexible UPGMA) shows the classification of study sites based on the community of Arthropod taxa captured from Beating tray method.

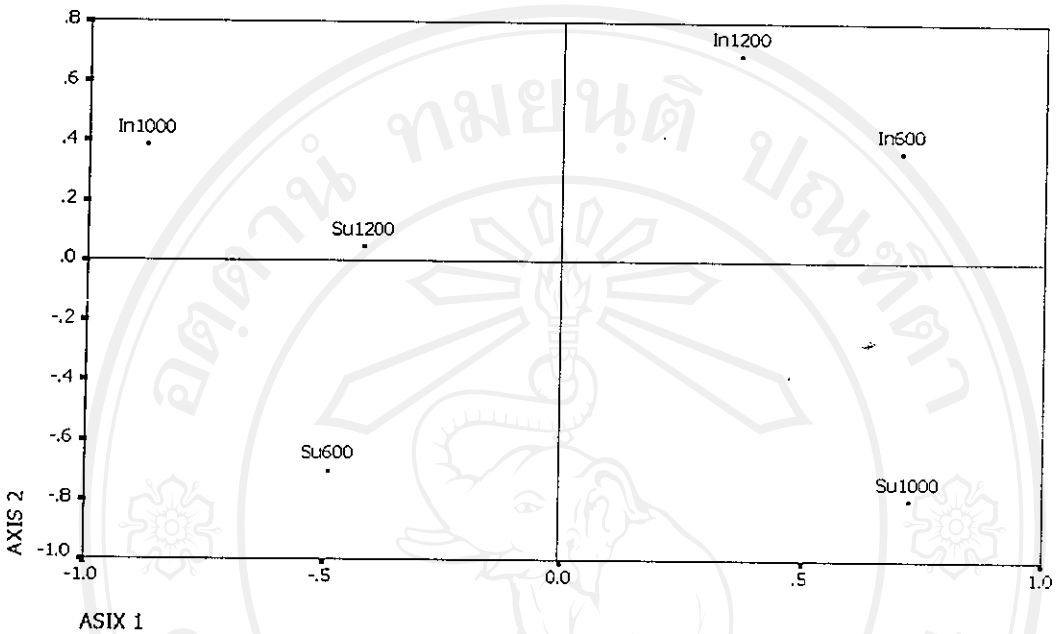

Fig 4.4 Ordination (semi-strong hybrid multidimensional scaling) shows the relationship of study sites based on their insect community from beating tray method. Stress = 0.11.

4.2.3. Sweeping net

The arthropod for 37 taxa were captures using sweeping net. Diptera; Brachycera, Nematocera, Chironomidae, were the most abundance captured insects. This detail of each taxa in the study sites are show in Table 4.4.

The analysis of the community of arthropod show the grouping of the site at the same elevation. The cluster analysis (Fig 4.5) shows the closely grouping between mountain at the elevation 600 and 1,000. The result from Ordination (Fig 4.6) also shows the grouping between Doi Suthep-Pui and Doi Intanon at 1,000m.

Table 4.4 The Arthropod taxa and their percentage yield that were captured by sweeping net from the shrub in riparian forest at Doi Suthep-Pui and Doi Inthanon at 600, 1,000 and 1,200.

Doi Suthep-Pui, 600m	Doi Suthep-Pui, 1000m	Doi Suthep-Pui, 1200m
Formicidae (28.9)	Brachycera (25.0)	Cicadellidae (20.7)
Brachycera (17.8)	Nematocera (12.5)	Phoridae (17.2)
Cicadellidae (11.1)	Chironomidae (10.7)	Chalcidoidae (13.8)
MinorHymenoptera (6.7)	Phoridae (10.7)	Arachnida (13.8)
Arachnida (6.7)	Chalcidoidae (8.9)	Formicidae (10.3)
Entomobryidae (4.4)	Arachnida (8.9)	Brachycera (6.9)
Lepidoptera (4.4)	Formicidae (5.4)	Entomobryidae (3.4)
Chironomidae (4.4)	Acrididae (3.6)	Ephemeroptera (3.4)
Phoridae (4.4)	MinorColeoptera (3.6)	Mantidae (3.4)
Acrididae (2.2)	MinorLepidoptera (3.6)	Lepidoptera (3.4)

Doi Inthanon, 600	Doi Inthanon, 1000	Doi Inthanon, 1200
Cicadellidae (20.4)	Brachycera (47.7)	Cicadellidae (16.2)
Formicidae (14.8)	Arachnida (11.4)	Acrididae (13.5)
Brachycera (9.3)	Formicidae (9.1)	Brachycera (13.5)
Phoridae (5.6)	Cicadellidae (6.8)	Arachnida (13.5)
Chalcidoidae (5.6)	Chironomidae (6.8)	MinorColeoptera (8.1)
Acrididae (3.7)	Cocinellidae (4.5)	Chironomidae (8.1)

(Table 4.4 Continue)

Asteiidae (3.7)	Phoridae (4.5)	Grylidae (5.4)
Dolichopodidae (3.7)	Nematocera (4.5)	Curculionidae (5.4)
Arachnida (3.7)	Acrididae (2.3)	Elateridae (5.4)
Entomobryidae (1.9)	Curculionidae (2.3)	Reduviidae (2.7)

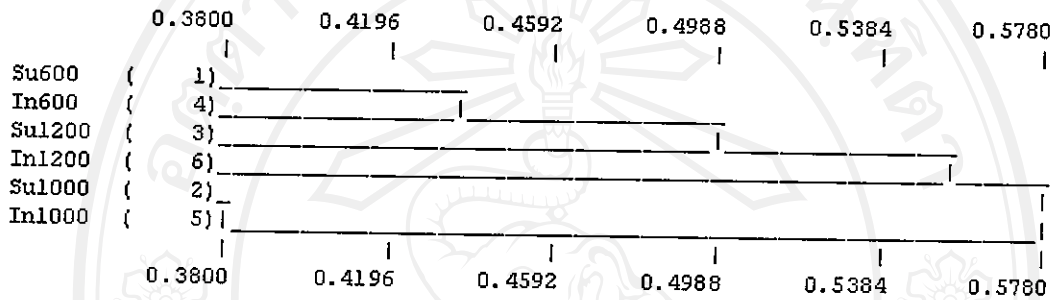

Fig 4.5 Cluster analysis (Flexible UPGMA) shows the classification of study sites based on the community of insects taxa captured from sweeping net.

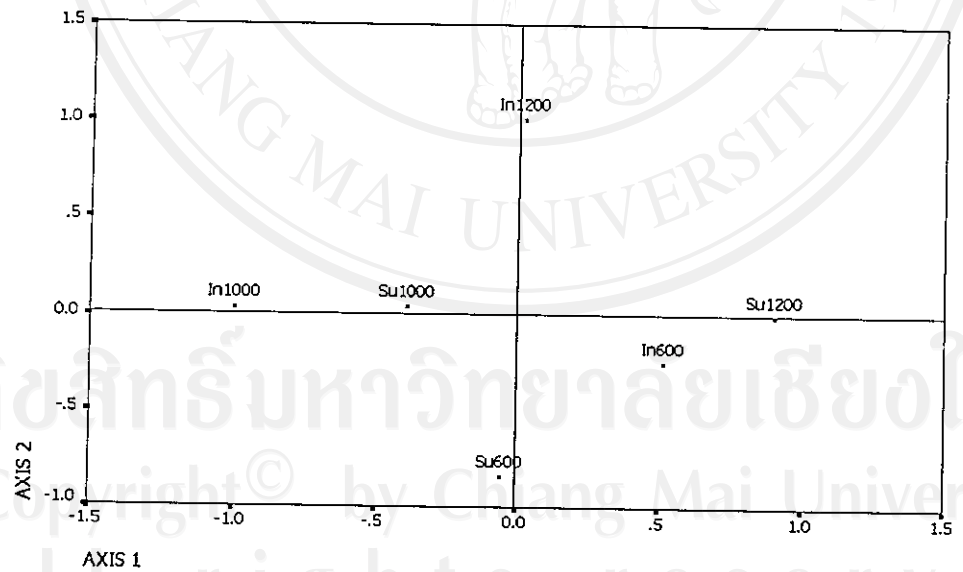

Fig 4.6 Ordination (semi-strong hybrid multidimensional scaling) shows the relationship of study sites based on their insect community from sweeping net. Stress = 0.91 $X10^{-1}$.

4.2.4 Malaise Trap

These method was relatively high efficient for captive flying insects in the forest. A lot of insects in various orders were trapped and still preserved for further identification. The Diptera was the most abundance insects order captured. The Homoptera and Hymenoptera were the second and third rank of the insect orders captured by the traps. In the riparian zone, there were the aquatic insects group; Trichoptera, Plecoptera, Ephemeroptera, Odonata, that were trapped. The lists of each order with the percentage found in trap contain in Table 4.5.

Table 4.5 The insects order and their abundance calculated in percentage that captured with Malaise trap from Doi Suthep-Pui and Doi Inthanon.

Doi Suthep-Pui	Doi Inthanon
Diptera (31.6)	Diptera (50.2)
Homoptera (27.4)	Hymenoptera (16.5)
Hymenoptera (13.6)	Homoptera (15.3)
Lepidoptera (6.8)	Trichoptera (10.8)
Trichoptera (5.6)	Coleoptera (3.0)
Coleoptera (5.3)	Plecoptera (2.0)
Ephemeroptera (4.4)	Ephemeroptera (1.4)
Orthoptera (3.2)	Orthoptera (0.4)
Plecoptera (1.7)	Odonata (0.2)
Odonata (0.2)	Hemiptera (0.2)

4.2.5 Trichoptera

There were 960 individuals and 72 species of Trichoptera captured over the study period. The species diversity on Doi Suthep-Pui (10 families and 22 species) was lower than on Doi Inthanon, (18 families and 56 species). The names of the captured species are shown in Table 4.6. Both mountains provided unique species of Trichoptera and each site had a different Trichoptera community. Cluster analysis shows the grouping of study sites on each mountain in terms of their Trichoptera community rather than grouping the sites at the same elevation (Fig 4.7).

Table 4.6 Trichoptera from Light trap from Doi Suthep-Pui and Doi Inthanon at 600, 1,000 and 1,200 m

Species	Doi Suthep-Pui			Doi Inthanon		
	600	1000	1200	600	1000	1200
Family Hydropsychidae						
Hydropsyche kankini M&C, 1993	x					
Hydropsyche bootes M&C, 2000	x					x
Hydropsyche palipenne Banks, 1938		x				
Hydropsyche uvana Mey, 1995				x	x	x
Hydropsyche adratos M&C, 1996				x	x	x
Hydropsyche bacchus M&C, 2000				x		
Hydropsyche briareus M&C, 2000				x		
Hydromanicus serubabel M&C, 1993	x	x		x		
Hydromanicus inferior C&M, 1995					x	
Hydromanicus eliakim M&C, 1993						x

(Table 4.6 Continue)

Species	Doi Suthep-Pui			Doi Inthanon		
	600	1000	1200	600	1000	1200
Hydromanicus truncatus Betten, 1909						x
Hydromanicus punctusalis Mey, 1996						x
Diplectrona obscura Ulmer, 1930		x		x		x
Diplectrona ungaranica Ulmer, 1951						x
Diplectrona T6		x	x			
Diplectrona T7					x	
Dipectrona spp.			x	x		x
Cheumatopsyche ceres M&C, 1997		x				
Cheumatopsyche cocles M&C, 1997	x					
Cheumatopsyche dubitans Mosely, 1942	x					
Cheumatopsyche gaia Malicky, 1997					x	
Trichomacronema paniae M&C, 1991						x
Marcrostemum midus M&C, 1998				x		
Family Lepidostomatidae						
Dinarthrum longipenis	x					
Dinarthrum tungyawensis M&C, 1994	x	x	x			
Dinarthrum inthanon M&C, 1994						x
Dinarthrum februarius M&C, 1994						x
Dinarthrum fischeri M&C, 1994						x
Dinarthrum brueckmanni M&C, 1994						x
Crunoeciella hirta Navas, 1932				x	x	x

(Table 4.6 Continue)

Species	Doi Suthep-Pui			Doi Inthanon		
	600	1000	1200	600	1000	1200
Lepidostoma ganesa M&C, 1994						x
Family Odontoceridae						
Lannapsyche chantaramongkolae Malickly, 1989	x			x		x
Mariia sumatrana Ulmer, 1951	x			x		
Inthanopsyche trimeresuri Malickly, 1989						x
Psiloteta abudeb						x
Family Philopotamidae						
Chimarra lannaensis M&C, 1989	x					
Chimarra suthepensis M&C, 1989		x				
Chimarra khamuorum M&C, 1989				x		
Chimarra toga M&C, 1993				x		
Chimarra nahesson M&C, 1993						x
Chimarra htinorum C&M, 1989						x
Chimarra okuihorum Mey, 1998				x		
Kisaura surasa M&C, 1993		x	x			
Kisaura intermidia Kimmins, 1955						x
Family Ecnomidae						
Ecnomus jojachin M&C, 1993					x	
Family Psychomiidae						
Psychomyia chomu M&C, 1993					x	
Tinodes acheron M&C, 1996						x

(Table 4.6 Continue)

Species	Doi Suthep-Pui			Doi Inthanon		
	600	1000	1200	600	1000	1200
Family Rhyacophilidae						
Rhyacophila petersorum Schmid and Denning, 1971	x					
Rhyacophila suthepensis Malickly, 1987	x					
Rhyacophila verugia M&C, 1993				x		
Rhyacophila scissoides Kimmins, 1953						x
Himalopsyche acharai M&C, 1989						x
Family Calamoceratidae						
Anisocentropus janus M&C, 1994		x				
Anisocentropus pan M&C, 1994			x			
Anisocentropus magnus Banks, 1931					x	
Anisocentropus pandora M&C, 1994						x
Ganonema fuscipenne Albaarda, 1881				x		
Ganonema extemsum Martynov, 1935						x
Family Goeridae						
Goera schmidi Denning, 1982				x	x	
Family Arctopsychidae						
Arctopsyche hynreck M&C, 1991						x
Family Hydroptilidae						
Ugandatrichia maliwan M&C, 1991					x	x
Family Stenopsychidae						
Stenopsyche haimavatika Schmid, 1969					x	

(Table 4.6 Continue)

Species	Doi Suthep-Pui			Doi Inthanon		
	600	1000	1200	600	1000	1200
Family Brachycentridae						
Micrasema asuro M&C, 1992					x	
Family Leptoceridae						
Adicella tongicerca Kimmins, 1963						x
Oecetis hades M&C, 2003				x		
Oecetis tripunctata Fabricius, 1793					x	x
Setodea akrura Gordon & Schmid, 1987				x	x	

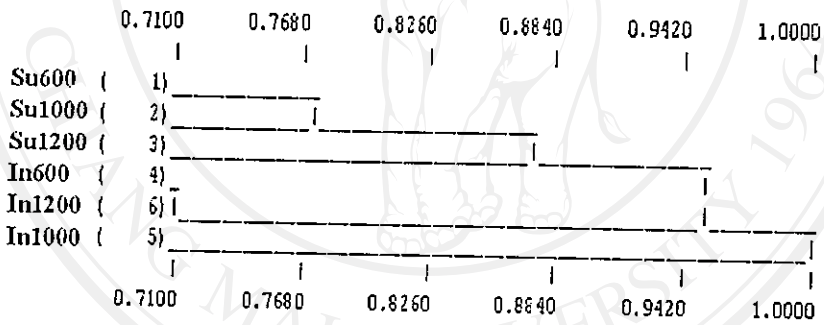

Fig 4.7 Cluster analysis (Flexible UPGMA) shows the classification of study sites based on the presence-absence of Trichoptera species. Su600 is Doi Suthep-Pui at 600 m; In600 is Doi Inthanon at 600 m.

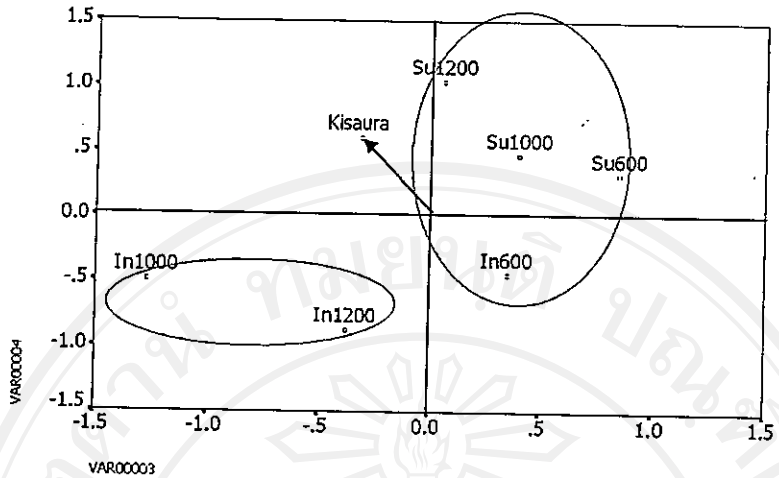

Fig 4.8 Ordination (semi-strong hybrid multidimensional scaling) shows the relationship of study sites based on their Trichoptera community. *Kisasura surasa* (Philopotamidae) was identified by PCC as the most highly correlated species to the ordination. Stress = 0.3 X 10^{-5}.

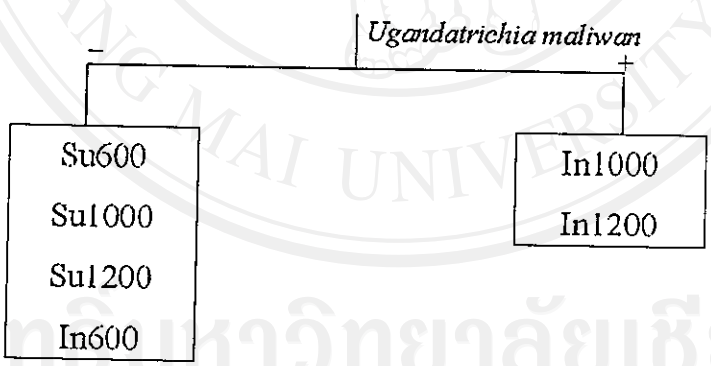

Fig 4.9 TWINSPAN summary shows the classification of study sites based on their Trichoptera community. The significant indicator species is *Ugandatrichia maliwan* (Hydroptilidae).

The upper part of Doi Inthanon (1,000 and 1,200 m) were identified by ordination (Fig 4.8) and TWINSPAN (Fig 4.9) as the sites where contained the different Trichoptera communities. TWINSPAN classified the Trichoptera community from Doi Inthanon at 600 m with the Doi Suthep-Pui communities rather than with the other Doi Inthanon sites at 1,000 and 1,200 m. Population count data supported this finding and showed that all the sites on Doi suthep plus Doi Inthanon at 600 m were dominated by Hydropsychidae and Philopotamidae, whereas on Doi Inthanon at 1,000 and 1,200 m, the abundant families were Hydropsychidae, Hydroptilidae and Lepidostomatidae.

The PCC module (Fig 4.8) identified *Kisaura surasa* (Philopotamidae) as the most strongly positively correlated species with the ordination result. This species were only found exclusively on Doi Suthep-Pui at 1,000 and 1,200 m.

Classification of the sites using TWINSPAN identified *Ugandatrichia maliwan* (Hydroptilidae) as an indicator species that separated the six sites into two major 2 groups. During this study, *Ugandatrichia maliwan* was found only on Doi Inthanon at 1,000 and 1,200 m.

From the raw date, the site specific Trichoptera species were identified and show in Table 4.7. Some of them were the reality site specific but some did not such as; *Chimarra lannaensis, Rhyacophila petersorum* that were captured from Doi Suthep-Pui at 600 during the monitoring but these species might be found from Doi Inthanon.

Table 4.7 The site specific species of Trichoptera distribute in each study site on Doi Suthep-Pui and Doi Inthanon.

Study sites	The site specific Trichoptera species
Doi Suthep-Pui, 600m (98°55′55″E, 18°47′50″N)	*Cheumatopsyche cocles, Cheumatopsyche dubitans, Dinarthrum longipenis, Chimarra lannaensis*, Rhyacophila petersorum*, Rhyacophila suthepensis**
Doi Suthep-Pui, 1000m (98°55′13″E,18°48′12″N)	*Cheumatopsyche ceres, Chimarra suthepensis*, Anisocentropus janus**
Doi Suthep-Pui, 1200m (98°54′40″E, 18°48′13″N)	*Anisocentropus pan*
Doi Inthanon, 600m (98°36′38″E, 18°32′34″N)	*Hydropsyche bacchus, Hydropsyche briareus, Chimarra toga**, Chimarra nahesson**, Ganonema fuscipenne*
Doi Inthanon, 1000m (98°34′56″E, 18°32′15″N)	*Hydromanicus inferior**, Ecnomus jojachin**, Psychomyia chompu**, Stenopsyche haimavatika, Micrasema asuro*
Doi Inthanon, 1200m (98°31′11″E, 18°31′20″N)	*Hydromanicus truncatus, Dinarthrum fischeri**, Dinarthrum brueckmanni, Inthanopsyche trimeresuri, Chimarra nahesson**, Chimarra htinorum**, Kisaura intermidia**, Tinodes acheron, Ganonema extemsum, Arctopsyche hynreck***

Note: * species found on Doi Inthanon, ** species found on Doi Suthep-Pui (Malicky and Chantaramongkol 1993, Chantaramongkol and Malicky 1997).

The updated survey of caddisfly fauna on two mountains in northern Thailand, Doi Suthep-Pui and Doi Inthanon National Parks were reviewed. A total of 345 species is recorded, with 199 species known from Doi Suthep-Pui, and 249 species from Doi Inthanon (Table 4.8). The names of these species with their altitudinal distribution, phenology and some noted are show in the Appendix B.

Hydropsychidae, Philopotamidae, Leptoceridea, Lepidostomatidae, Rhyacophilidae were the most diverse species group on Doi Suthep-Pui. Hydropsychidae, Philopotamidae, Rhyacophilidae Lepidostomatidae Polycentropodidae were the most diverse species on Doi Inthanon.

Phryganeidae, Limnocentropodidae and Uenoidae have never been found on Doi Suthep-Pui. Dipseudopsidae also never been discovered on Doi Inthanon.

Table 4.8 Species of Trichoptera family, found on Doi Suthep-Pui and Doi Inthanon with the number of total and sheared species.

Family	Doi Suthep-Pui	Doi Inthanon	Total	Shared species
Rhyacophilidae	14	25	27	12
Glossosomatidae	9	12	16	5
Hydroptilidae	4	5	7	2
Philopotamidae	31	41	55	17
Stenopsychidae	1	4	4	1
Polycentropodidae	13	16	25	4
Dipseudopsidae	3	0	3	0

(Table 4.8 Continue)

Family	Doi Suthep-Pui	Doi Inthanon	Total	Shared species
Ecnomidae	5	3	8	0
Psychomyiidae	11	14	19	6
Xiphocentronidae	4	3	7	0
Arctopsychidae	1	3	3	1
Hydropsychidae	42	44	61	25
Phryganeidae	0	1	1	0
Brachycentridae	2	3	4	1
Limnocentropodidae	0	4	4	0
Goeridae	6	5	11	0
Limnephilidae	2	4	4	2
Uenoidae	0	2	2	0
Lepidostomatidae	14	24	30	8
Helicopsychidae	5	3	6	2
Odontoceridae	4	9	9	4
Leptoceridea	18	13	24	7
Sericostomatidae	1	1	1	1
Calamoceratidae	6	8	10	4
Molanidae	3	2	4	1
Total	199	249	345	103

4.2.6 Geometridae; Lepidoptera

The research found Geometridae in Doi Suthep-Pui and Doi Inthanon for 17 and 14 species, respectively. Only 7 species such as *Cusiala boarmoides, Ectropis longiscapia, Hyposidra talaca* were found on both mountains (Table 4.9). Totally geometrid species for 24 were identified from both areas and there were 21 species cannot be identified.

This researches reviewed the Geometridae for 224 taxa and their names are listed in Appendix C. Their distributions are also presented in term of 14 localities (Fig 4.10). The Geometridae (134 taxa), that were popularly studied, carried out from Locality A (Doi Suthep-Pui, Doi Inthanon and the areas around Chiang Mai). The second popular rank was the Locality H; Khao Yai (Nakhon Nayok) (Table 4.10). Altogether, there were 180 taxa of Geometrid moths found in Thailand including that their distribution, that can be exactly presented (Appendix C).

The position of localities in ordination and grouping formation on dendrogram were analyzed from the different member of the geometrid moths of each locality. The proximate point in ordination or branch of cluster indicated the similarity between geometrid communities. The result from the ordination (Fig 4.11) was explained by dendrogram (Fig 4.12). The result shows the classification of the localities using the geometrid communities in Thailand into 3 groups.

The first group is geometrid community in the locality A (Doi Suthep-Pui, Inthanon and the areas around Chiang Mai), in northern of Thailand. In this locality contain the difference species of geometrid moths comparing with the remaining localities. These areas composed with the highland Geometridae species such as; all

member of *Alcis*, *Arichanna*, *Biston*, *Catoria*, *Darisa*, *Hyposidra*, and some of *Ourapteryx*, *Abraxas*.

Table 4.9 The Geometridae (Order Lepidoptera) from Doi Suthep-Pui and Doi Inthanon.

SubFamily	Tribe	Species	Doi Suthep-Pui	Doi Inthanon
Ennominae	Boarmiini	*Alcis chiangmaiensis* Sato, 1991		X
Ennominae	Boarmiini	*Alcis periphracta* (Prout, 1926)		X
Ennominae	Boarmiini	*Biston pustulata* (Warren, 1896)	X	
Ennominae	Boarmiini	*Catoria olivescens* Moore, 1888	X	
Ennominae	Boarmiini	*Chorodna similis* (Moore, 1888)	X	
Ennominae	Boarmiini	*Cleora alienaria* (Walker, 1860)	X	
Ennominae	Boarmiini	*Cusiala boarmoides* Moore, 1887	X	X
Larentiinae	Cidariini	*Ecliptopera rectilinea* Warren, 1894		X
Ennominae	Boarmiini	*Ectropis longiscapia* Prout, 1926	X	X
Ennominae	Hypochrosini	*Fascellina albicordis* Prout, 1932		X
Ennominae	Boarmiini	*Gasterocome pannosaria* (Moore, 1867)	X	
Ennominae	Hypochrosini	*Hypochrosis hyadaria* Guenée, 1857		X
Ennominae	Boarmiini	*Hypomecis cineracea* (Moore, 1888)	X	
Ennominae	Boarmiini	*Hypomecis tetragonota* (Walker, 1862)	X	
Ennominae	Boarmiini	*Hyposidra aquilaria* (Walker, 1862)	X	X
Ennominae	Boarmiini	*Hyposidra talaca* (Walker, 1860)	X	X
Ennominae	Boarmiini	*Hyposidra violescens* Hampson, 1895	X	
Ennominae	Eutoeini	*Luxiaria emphatica* Prout, 1925	X	X
Ennominae	Eutoeini	*Luxiaria mitorrhaphes* Prout, 1925		X
Ennominae	Boarmiini	*Menophra subpilosa* (Warren, 1894)	X	X
Ennominae	-	*Metabraxas atrogrisea* Inoue, 1992	X	
Ennominae	-	*Metapercnia ductaria* Walker	X	X
Ennominae	Ourapterygini	*Ourapteryx clara* Butler, 1880		X
Ennominae	Plutodini	*Plutodes flavescens* Butler, 1880	X	

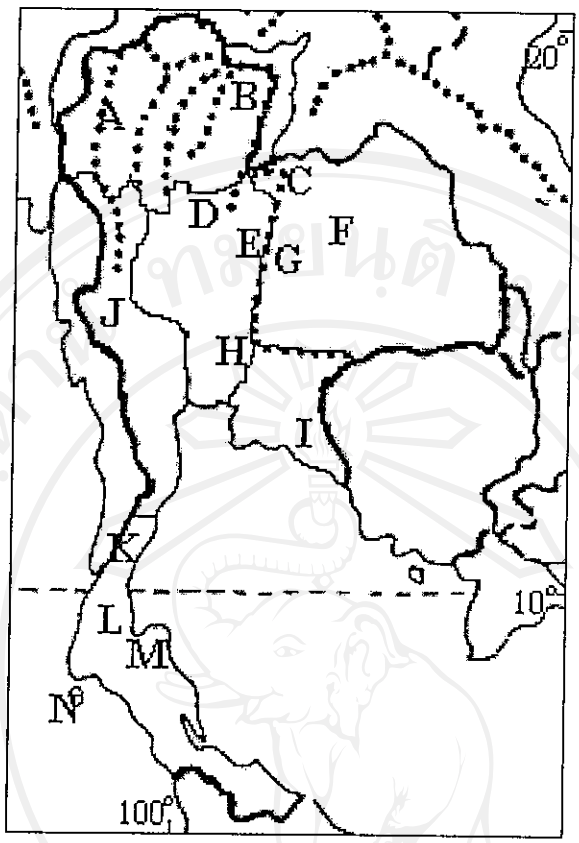

Fig 4.10 The locality record of Geometridae in Thailand; A = Doi Inthanon Doi Suthep-Pui (Chiang Mai), B= Doi Phukha (Nan), C = Phu Luang and Phu Rua (Loei), D = Phu Hin Rongkla and Thung Salaeng Luang (Phitsanulok), E = Nam Nao National Park (Phetchabun), F = Nam Proam Dam (Khon Kaen), G = Chulabhone Dam (Chaiyaphum), H = Khao Yai (Nakhon Nayok), I = Khao Soi Dao (Chanthaburi), J = Earawan and Tum Than Lod (Kanchanaburi), K = Khong Nahka (Ranong), L = Khao Sok (Surat Thani), M = Khao Luang (Nakhon Sri Thammarat) and N = Nam Tok Ton Sai (Phuket).

Table 4.10 Number of taxa present at particular localities, addressed in the Fig 4.10 "Z" mean Thailand recorded species, but unspecified the site.

Locality	Site	Changwat	Taxa
A	Doi Inthanon Doi Suthep-Pui	Chiang Mai	134
B	Doi Phukha	Nan	5
C	Phu Lunag and Phu Rua	Loei	13
D	Phu Hin Rongkla and Thung Salaeng Luang	Phitsanulok	4
E	Nam Nao National Park	Phetchabun	5
F	Nam Proam Dam	Khon Kaen	2
G	Chulabhone Dam	Chaiyaphum	6
H	Khao Yai	Nakhon Nayok	34
I	Khao Soi Dao	Chanthaburi	18
J	Earawan and Tum Than Lod	Kanchanaburi	7
K	Khong Nahka	Ranong	6
L	Khao Sok	Surat Thani	2
M	Khao Luang	Nakhon Sri Thammarat	11
N	Nam Tok Ton Sai	Phuket	3
Z	Unspecified	-	41
Southern Thailand	Unspecified	-	3
Northern Thailand	Unspecified	-	8

The second (H, I, J, M, C, K, B,) and third groups (D, G, N, L, E, F) are also composed of the specified geometrid moths, that have not been found in the first group such as, *Hypomecis separata*, *Hypomecis costaria*, *Cleora pupillata pupillata*, *Cleora determinata*. The second and third are also separated because the member of the second group are specifically with *Arichanna flavimedia*, *Arichanna peniculifera*, *Ourapteryx fulvinervis*, *Amblychia angeronaria*, *Dindica polyphaenaria*, *Dindica olivacea e.g.* While, the third group is exclusively composed with, *Cleora contiguata brooski*, *Abraxas illuminata*, *Rikiosatoa fucatariodes*, *Biston panternaria exanthemata e.g.*

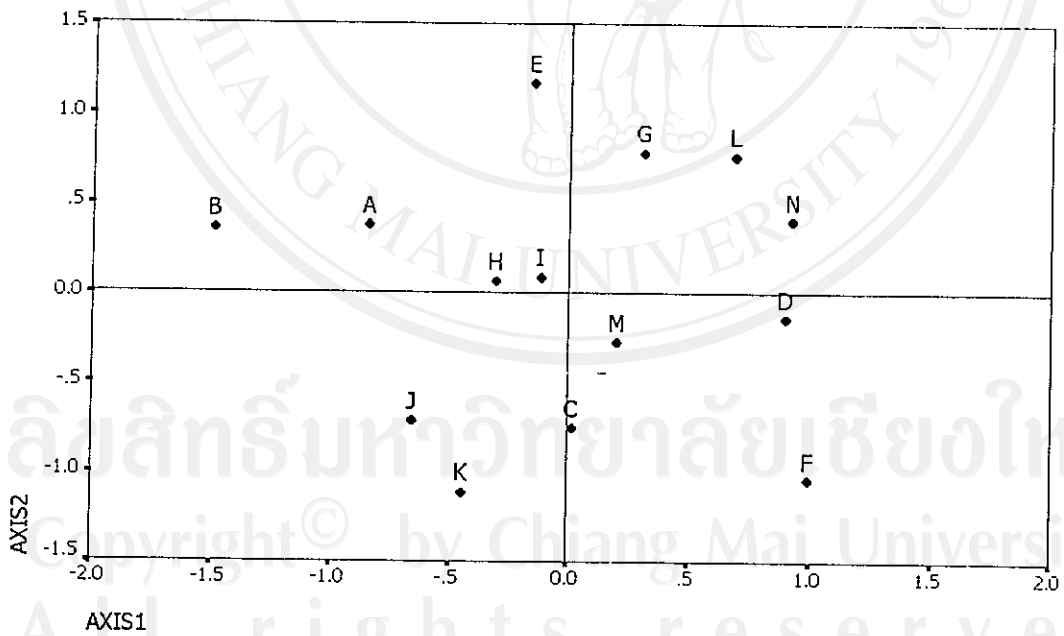

Fig 4.11 Ordination of localities evaluated by geometrid moths 180 species. The meaning of each locality is showed on the Fig 4.6.

The ordination and dendrogram reveal the clue of the factor that influence on the grouping of geometrid communities. They show the highly similarity of geometrid communities between the closely locality such as, H (Khao Yai, Nakhon Nayok) and I (Khao Soi Dao, Chanthaburi) in the second group or L (Khao Sok, Surat Thani) and N (Nam Tok Ton Sai, Phuket) in the third group. In contrast, the geometrid community in locality M (Khao Luang, Nakhon Sri Thammarat) was grouping with H and I rather than L and N. It was because of the geometrid community from H were mostly from higher altitude in Khao Luang mountain, whereas the communities from L and N came from the lower areas.

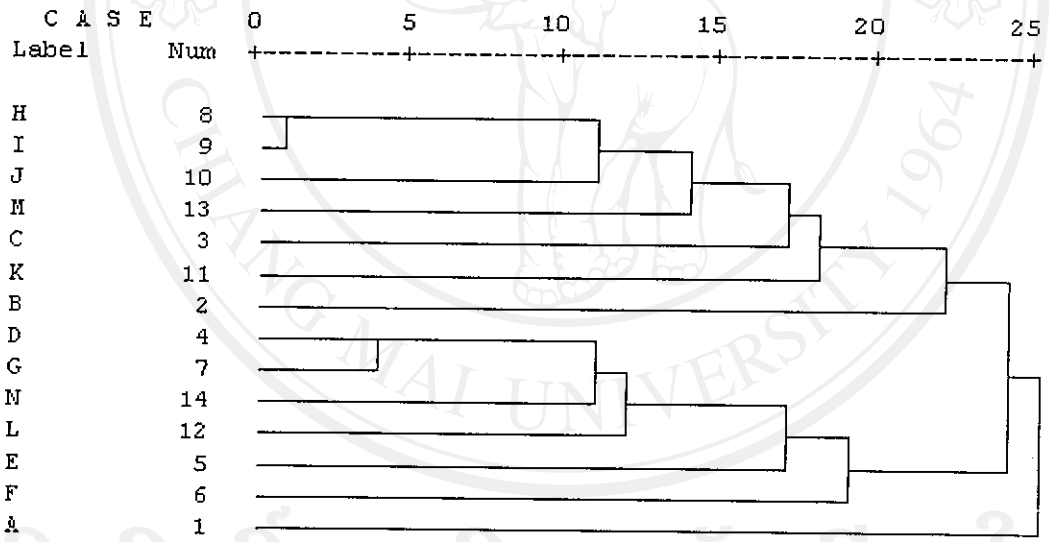

Fig 4.12 Dendrogram shows the classification of major localities on Geometridae in Thailand (180 species).

4.3 Temporal pattern of Trichoptera

The results from the intensive studies on Trichoptera since 1987 can be evaluated in terms of species richness and occurrence in each month with Fig 4.13. The change in Trichoptera species richness tends to respond to the cycle of the monsoons. The highest peak adult Trichoptera was in the pre-southwestern monsoon period (April) when around 140 species were found on Doi Suthep-Pui and around 170 species on Doi Inthanon. During the southwestern monsoon, July and August, the species richness declined but recovered again in the post-southwestern monsoon period. The species richness was stabilized during the northeastern monsoon period. Both Trichoptera communities from Doi Suthep-Pui and Doi Inthanon displayed this pattern.

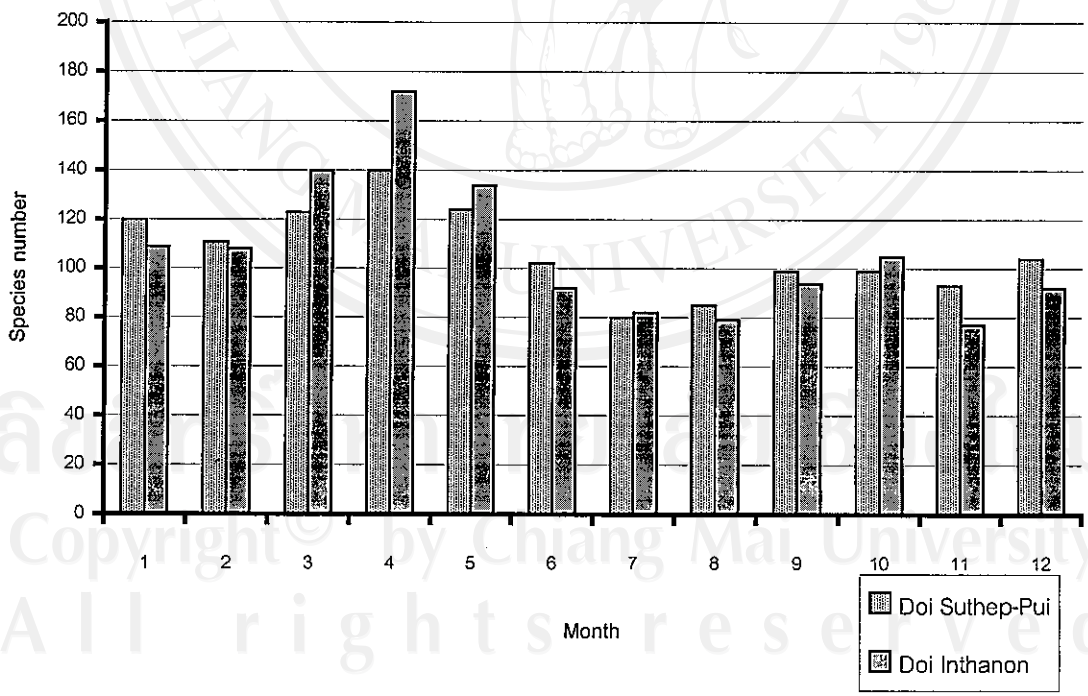

Fig 4.13 The species richness of Trichoptera in each month. The data includes species from Doi Suthep-Pui and Doi Inthanon National Park.

Trichoptera of 338 species from Doi Suthep-Pui and Doi Inthanon were evaluated for their emergence period under the criteria of the monsoonal cycle. They were categorized into 4 groups *viz*, species that can be found throughout a year, the species present during the period of the southwestern or northeastern monsoon and the species which strictly emerge during the pre and/or post monsoon period.

The first group was the species that can be found through a year. This group was composed of 72 species (21.3 %). Within this number, there were 42 species active every month such as *Himalopsyche acharai, Rhyacophila petersorum, Rhyacophila suthepensis, Ugandatrichia maliwan.* The remaining 30 species were missing in a few months, but they had a tendency to be found throughout a year such as *Rhyacophila drokpa, Chimarra chiangmaiensis.* Table 4.11 shows 20 examples of the species that can be found throughout a year.

In the second group, there were 25 species (7.4%) that can be categorized as those found in the period of southwestern monsoon (May to September) such as *Chimarra aneca, Psychomyia monto, Macrostemum fastosum, Goera uniformis.* Twenty species of this group are showed in Table 4.12.

The third group composed the major members of Trichoptera in this area. There are 116 species (34.3%) that were categorized as a species emerging during northeastern monsoon (January to March and November to December). They are listed in Table 4.13.

The Fourth group comprised 86 species (25.4%). They had a tendency of emerging synchronously with the monsoons by emerging in the period of pre and/or post southwestern monsoon (Table 4.14).

Table 4.11 Trichoptera that can be found throughout the year on Doi Suthep-Pui and Doi Inthanon National Park. The shaded cells indicate occurrence.

Monsoon period	NE			T1	SW					T2	NE	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Himalopsyche acharai	■	■	■	■	■	■	■	■	■	■	■	■
Rhyacophila drokpa	■				■	■	■	■	■	■	■	
Rhyacophila petersorum	■	■	■	■	■	■	■	■	■	■	■	■
Rhyacophila quana	■	■	■	■	■	■	■	■	■	■	■	■
Rhyacophila suthepensis	■	■	■	■	■	■	■	■	■	■	■	■
Ugandatrichia maliwan	■	■	■	■	■	■	■	■	■	■	■	■
Chimarra chiangmaiensis	■	■	■	■	■	■	■	■		■	■	■
Chimarra htinorum	■	■	■	■	■	■	■	■	■	■	■	■
Chimarra lannaensis	■	■	■	■	■	■	■	■	■	■	■	■
Chimarra suthepensis	■	■	■	■	■	■	■	■	■	■	■	■
Kisaura consagia	■	■	■	■	■	■	■	■	■	■	■	■
Kisaura sura	■	■	■	■	■	■	■	■	■	■	■	■
Nyctiophylax suthepensis	■	■	■	■	■	■	■	■	■	■	■	■
Melanotrichia attia		■	■	■	■	■	■	■	■	■	■	■
Arctopsyche hynreck	■	■	■	■	■	■	■	■	■	■	■	■
Cheumatopsyche ceres	■	■	■	■	■	■	■	■	■	■	■	■
Hydropsyche camillus	■	■	■	■	■	■	■	■	■	■	■	■
Crunoeciella hirta	■	■	■	■	■	■	■	■	■	■	■	■
Goerodes doligung	■	■	■	■	■	■		■	■	■	■	■
Anisocentropus pan	■	■	■	■	■	■	■	■	■	■	■	■
Molanna oglamar	■	■	■	■	■	■	■	■	■	■	■	■

Table 4.12 Trichoptera presenting during the southwestern moonsoon period on Doi Suthep-Pui and Doi Inthanon National Park. The shaded cells indicate occurrence.

Monsoon period	NE			T1	SW					T2	NE	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rhyacophila blenda												
Rhyacophila drosampa												
Rhyacophila mayestril												
Rhyacophila scissa												
Glossosoma atitto												
Chimarra aneca												
Chimarra burmana												
Psychomyia monto												
Cheumatopsyche caieta												
Macrostemum fastosum												
Macrostemum floridum												
Micrasema fortiso												
Micrasema turbo												
Limnocentropus hysbald												
Goera ilo												
Goera uniformis												
Dinarthrum brueckmanni												
Helicopsyche rodschana												
Setodes tcharurupa												
Limnocentropus hysbald												

Table 4.13 Trichoptera presenting during the northeastern moonsoon period on Doi Suthep-Pui and Doi Inthanon National Park. The shaded cells indicate occurrence.

Monsoon period	NE			T1	SW					T2	NE	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rhyacophila gyamo	■	■	■	■		■						■
Rhyacophila manna	■	■	■	■								■
Rhyacophila murhu		■	■	■								
Glossosoma elvisso	■	■		■	■							■
Glossosoma malayanum	■	■	■	■	■							
Nepaloptila kanikar	■			■								■
Padunia karaked	■	■		■								■
Chimarra bimbltona	■	■		■						■		■
Chimarra lavuaorum	■	■	■	■					■			■
Chimarra monorum	■	■	■	■	■					■	■	■
Womaldia serrata	■	■	■	■								
Pseudoneureclipsis achim		■	■	■								
Hydatomanicus adonis	■		■	■							■	■
Hydropsyche briareus	■	■	■	■	■							■
Hydropsyche pallipenne	■	■	■	■					■	■	■	■
Potamyia baenzigeri	■	■	■	■								■
Dinarthrum inthanon	■	■	■	■	■							■
Lepidostoma montatan	■	■								■	■	
Inthanopsyche trimeresuri		■	■	■	■							
Adicella koronis		■	■	■								■

Table 4.14 Trichoptera presenting on the pre and/or post southwestern moonsoon period on Doi Suthep-Pui and Doi Inthanon National Park. The shaded cells indicate occurrence.

Monsoon period	NE			T1	SW					T2	NE	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rhyacophila muktepa			■						■			
Rhyacophila voccia			■	■					■	■		■
Chimarra cumata				■	■	■						
Chimarra exapia	■		■							■		
Chimarra momma		■	■	■	■	■			■	■		
Chimarra pipake	■		■	■					■	■	■	
Kisaura longispina			■	■						■		
Kambaitipsyche hykrion			■	■					■			
Nyctiophylax zadok				■						■		
Pahamuyana jihmita					■	■			■	■	■	
Plectrocnemia eber			■							■		
Polyplectropus arni				■	■	■						
Pseudoneureclipsis saccheda					■	■				■	■	■
Pseudoneureclipsis sukrip				■	■	■						
Ecnomus suadrus		■	■	■	■			■	■	■	■	
Paduniella sampati		■		■	■	■				■		
Tinodes mogetius			■	■	■	■			■	■		
Abaria ateduna								■	■	■		
Cheumatopsyche banksi	■	■	■						■	■		
Hydropsyche baubo				■	■					■		

The remaining Trichoptera for 39 species (11.5%) were cannot be clearly evaluated using the criteria of the pattern of monsoon.

4.4 The endemic Trichoptera

The riparian zones on Doi Suthep-Pui and Doi Inthanon play a role as the habitat for some endemic species. Many Caddisflies were discovered only in these areas and some of therm were recognized as endemic species on these mountains. Doi Suthep-Pui and Doi Inthanon contain 42 and 60 species of Trichoptera that might be the endemic. Their names are presented in Table 4.15 and 4.16 for the species on Doi Suthep-Pui and Doi Inthanon, respectively.

Table 4.15 The 42 species of Trichoptera from Doi Suthep-Pui National Park that were evaluated as the endemic species on the mountain.

Rhyacophila manna	*Rhyacophila wanichacheewai*	*Agapetus lalus*
Agapetus vercondarius	*Agapetus viricatus*	*Orthotrichia deukalion*
Chimarra argeia	*Chimarra dirke*	*Chimarra exapia*
Chimarra lavuaorum	*Chimarra noebia*	*Chimarra toga*
Dolophilodes bullu	*Kisaura surasa*	*Pahamuyana jihmita*
Polyplectropus ibykos	*Pseudoneureclipsis achim*	*Pseudoneureclipsis philemon*
Pseudoneureclipsis saccheda	*Pseudoneureclipsis usia*	*Ecnomus eurytos*
Ecnomus venimar	*Psychomyia barata*	*Tinodes acheron*
Abaria guatila	*Cnodocentron brogimarus*	*Cheumatopsyche admetos*
Micrasema helveio	*Goera matuilla*	*Goera schmidi*
Larcasia lannaensis	*Dinarthrum daidalion*	*Dinarthrum martius*
Lepidostoma montatan	*Helicopsyche ategenta*	*Helicopsyche namtok*
Helicopsyche siama	*Ceraclea iambe*	*Leptocerus demophon*
Leptocerus euros	*Ganonema delios*	*Molannodes hydorn*

Table 4.16 The 60 species of Trichoptera from Doi Inthanon National Park that were evaluated as the endemic species on this mountain.

Rhyacophila bicolor doiangka	*Rhyacophila blenda*	*Rhyacophila mayestril*
Rhyacophila murhu	*Rhyacophila verugia*	*Rhyacophila xayide*
Nepaloptila jisunted	*Nepaloptila ruangjog*	*Chimarra cumata*
Chimarra devva	*Chimarra inthanonensis*	*Chimarra karenorum*
Chimarra lahuorum	*Chimarra litugena*	*Chimarra matura*
Wormaldia inthanonensis	*Kambaitipsyche hykrion*	*Nyctiophylax archemoros*
Nyctiophylax aristaios	*Plectrocnemia arphachad*	*Plectrocnemia eccingoma*
Polyplectropus apsyrtos	*Polyplectropus arni*	*Pseudoneureclipsis sukrip*
Ecnomus alkestis	*Ecnomus alkinoos*	*Paduniella dendrobia*
Paduniella maeklangensis	*Tinodes cincibilus*	*Tinodes mogetius*
Abaria ateduna	*Melanotrichia attia*	*Cheumatopsyche chione*
Parapsyche intawitschajanon	*Diplectrona harpyia*	*Macrostemum bellerophon*
Limnocentropus siribhumensis	*Limnocentropus apollon*	*Limnocentropus hysbald*
Limnocentropus inthanonensis	*Micrasema turbo*	*Goera solicur*
Nothopsyche muqua	*Dinarthrum augustus*	*Dinarthrum baenzigeri*
Dinarthrum inthanon	*Dinarthrum lannaensis*	*Dinarthrum octobrius*
Dinarthrum septembrius	*Dinarthrum siribhum*	*Lepidostoma ratanapruksi*
Lepidostoma varithi	*Zephyropsyche weaveri*	*Cochliophylax admata*
Psilotreta abudeb	*Psilotreta quin*	*Psilotreta watananikorni*
Adicella klytaimestra	*Ceraclea iuno*	*Oecetis hades*