CHAPTER 5

DISCUSSION

5.1 Environmental parameters

The humidity of the terrestrial sites of this study was strongly controlled by the influence of the riparian habitat. The relative humidity in these sites was maintained at over 70% throughout a year. The influence of humidity and canopy shade also played an important role on the regulation of air temperature. The riparian areas on Doi Suthep-Pui and Doi Inthanon had a range of mean air temperatures of 20 - 25 and 18 - 26 °C, respectively. The annual water body temperature ranges were also stabilized at 20 - 22 and 18 - 23 °C on Doi Suthep-Pui and Doi Inthanon, respectively.

The mountain streams in this study were generally in good environmental condition with DO, BOD_5, pH conductivity and TDS of the water bodies in the natural range. Some organic and inorganic contaminants such as nitrates, ammonia, sulfates and phosphates were detected but only in trace amounts.

5.2 Ground dwelling insects from pitfall traps

The community of ground dwelling insects on Doi Suthep-Pui was similar at all 3 study sites with the community dominated by the Entomobryidae and Formicidae. In contrast, all 3 sites on Doi Inthanon contained relatively unique communities as revealed in the ordination scatter. The Doi Inthanon 600 m site differed most from the others because it was dominated by Formicidae alone.

By summary, the pitfall method was most suitable for sampling some ground dwelling insects such as many families of Collembola, Formicidae, some families of Coleoptera and some spiders. Although the pitfall monitoring occupied only 1 night at a time, all traps successfully captured specimens.

5.3 Insects from the beating tray

The beating tray method had a rather low efficiency in the capture of insects in tropical rainforest, because the insects in these areas were extremely active. The effect of the beating generally caused the insects to fly away instead of dropping into the tray. However, this method was reasonably effective for catching Coleoptera families such as Coccinellidae, Endomychidae and Curculionidae.

The communities of insects from Doi Suthep-Pui were grouped because the majority belonged to Arachnida and Formicidae. The site of Doi Inthanon at 600m was similar to that at 1,200m because both contain a high population of Formicidae.

5.4 Insects from the sweeping net

The insect yield from this monitoring method was quite low, because the random 40 times sweep in the riparian sites was relatively insufficient. However, at least 37 insects taxa were captured and identified. This method was suitable for capturing the daytime active insects such as Diptera, Hymenoptera and Cicadellidae.

The communities of arthropods captured by the sweeping net grouped sites at the same elevation; e.g. the grouping of the sites at 1,000 m on both mountains.

5.5 The discussion on Trichoptera

The Trichoptera communities from the upper parts of Doi Inthanon (1,000 and 1,200 m) were distinctive and identifiably of the montane preference (Himalayan-inlier). In contrast, the Trichoptera communities from Doi Suthep-Pui at 1,000 and 1,200 m had closer similarities with the lowland communities at 600 m. The relative isolation of Doi Suthep-Pui has reduced the faunistic influences from the high main mountain ranges (Himalayan) and reinforced the outlier status of Doi Suthep-Pui. The Trichoptera fauna of its upper areas appear to be more strongly influenced by a lowland element as a result. This inlier-outlier hypothesis will require testing using more comparative studies on other types of arthropods.

The diversity of Trichoptera from Doi Suthep-Pui was lower than from Doi Inthanon. The relative differences between the mountains might reflect the effect of habitat size, geographic features and various human activities.

The study stream from Doi Suthep-Pui was shorter than that on Doi Inthanon. The distance between the study site at 600 to 1,200 on Doi Suthep-Pui and Doi Inthanon were 2.5 and 9 km, respectively. Thus the larger extent of habitat on Doi Inthanon is theoretically able to support a higher diversity of Trichoptera.

The second influence on the Trichoptera community was the difference in geological structure of the habitat. The study stream on Doi Suthep-Pui is located over the sedimentary rocks, whereas the study site on Doi Inthanon is located over the igneous rock. The igneous structure is harder than the sediment, then the water current can extract more ions from the sediment structure. Therefore, the stream on Doi Suthep-Pui contained more ions, which can be referred from the higher conductivity and TDS.

The last influence was the human activity on both areas. Although there were the villages and tourism on both mountains, the capacity to eliminate human pollution on Doi Inthanon is relatively stronger. On Doi Inthanon, the self-purification process is better than on Doi Suthep-Pui, because there is a greater volume of water. As a result, the levels of trace pollutants such as ammonia, nitrates and phosphates from Doi Suthep-Pui were higher that those from Doi Inthanon.

This study was introduced to study under the nature of the continuity to the main range. It was demonstrated that aspects of the continuity with the main range, Thanon Thong Chai, of Doi Suthep-Pui and Doi Inthanon are different. Doi Suthep-Pui shows some separation from the main range but Doi Inthanon is located exactly on the main range. In addition, the Thanon Thong Chai range is closely related to the greater Himalaya. Therefore it is useful to consider Doi Suthep-Pui and Doi Inthanon as Himalayan-outlier and -inlier, respectively.

The results from the multivariate analysis support the recognition of different Trichoptera communities from both mountains. The analysis showed the Trichoptera communities from Doi Inthanon at 1,000 and 1,200 m were different from the other sites and these species can be nominated as typical Himalayan-inlier species. In contrast, the Trichoptera communities from Doi Suthep-Pui at 1,000 and 1,200 were closely similar with the lowland species from 600 m. The separate location of Doi Suthep-Pui from the Himalayan inlier group, has reduced the influence of theHimalayan fauna on this mountain.

The idea of Himalayan inlier and outlier is proposed as an hypothesis worthy of further testing of its validity. The study of other flora and fauna distributions between the Himalayan and Thanon Tong Chai are needed in the future. Monitoring

along the range from Mae Hong Son, Chiang Mai, Lampoon and Tak will be undertaken in the future to test the idea.

5.6 The discussion on Geometridae

The overview study found 17 and 14 species, respectively of Geometridae from Doi Suthep-Pui and Doi Inthanon. Both mountains contain different Geometridae communities, with a low Sorensen Similarity Index between the mountains of only 0.42. However, the number of unidentified species of Geometridae was equal with the identified. Obviously for the early exploration of biodiversity in Thailand, an important obstacle is the taxonomic problem.

The pilot multivariate study using the distribution pattern of 180 species of Geometrid moths in Thailand from literature sources generated 3 groups of localities.

The first group included highland areas (Doi Suthep-Pui and Doi Inthanon). These localities cover the major part of northern Thailand and some part of western Thailand (upper Kanchanaburi), with many localities on the Thanon Thong Chai range. On this range are various areas above 1,500 m such as, Pha Hom Pok 2,288m (Chiang Rai), Chiang Dao peak 2,225 m (Chiang Mai), Suthep-Pui 1,685 m (Chiang Mai), Inthanon 2,565 m (the highest in Thailand, Chiang Mai) and Mon Jong 1,929 m (Chiang Mai). There are additional higher peaks, but these are not as well known or as accessible. The previously listed peaks are commonly referred to in many researches on the fauna of northern Thailand.

The Thanon Thong Chai range lies continuously with the Himalayan range. Therefore it has a capacity to support the typically Himalayan geometrid species such

as *Chorodna similis*, *Uliura combustaria*, *Uliura dierli*, *Dalima truncataria*, *Arichanna peniculifera*, *Arichanna flavimedia* (Stüning, 2000).

The second proposed group of localities comprises areas located between 800 - 1,500 m and mostly situated on the eastern-most mountain ranges, Luang Pra Bang, Phetchabun, Dong Praya Yen and the San Kam Pang mountain range. These mountains lay across from the east of northern Thailand to the area of eastern Thailand. This range differs from the Thanon Thong Chai range in term of geological structures (Baum *et al.*, 1981). These ranges occupy various Changwat e.g. Nan, Uttaradit, Phitsanulok, Phetchabun, Loei, Chaiyapum, Nakhon Ratchasima, Nakhon Nayok, Sa Kaew and Prachin Buri. The geometrid localities in these ranges include Phu Kha (Nan), Phu Luang (Loei), Phu Rua (Loei) and Khao Yai (Nakhon Nayok). Moreover, these geometrid communities were similar to communities from other mountains e.g. Khao Soi Dow (Chanthaburi), Erawan Nation Park (Kanchanaburi), Khong Nahka (Ranong), Khao Luang (Nakhon Sri Thammarat). The relationships of these geometrid communities might be explained by historical events when the southern part of Thailand approached central Thailand in the Middle Oligocene (30 Ma). After that time, southern Thailand gradually shifted southwest to its present configuration (Hall 1998) (Fig 5.1). This model could explain the previous relationship between the central and southern species. However, many localities in this group have been fragmented by human activities. Khao Yai and the closest Khao Soi Dow have been isolated by development in eastern Thailand. In this group 3 minor groups can be seen. Firstly, the upperpart of Phu Kha, Phu Luang, Phu Rua are under the influence of the Luang Pra Bang and Phetchabun corridor. Secondly, the remnants in eastern Thailand; Khao Yai and Khao Soi Dow, still have a previous

influence from the distance factor. Finally, the Thailand-Burma boundary corridor (Ta Nao Sri mountain range); Erawan, Klong Nakha, Khao Luang, the forest patch between Thailand and Burma continues to play a role as the corridor among them. However, these localities still share similar geometrid communities. Some exclusive geometrid species in this group are apparent in the result.

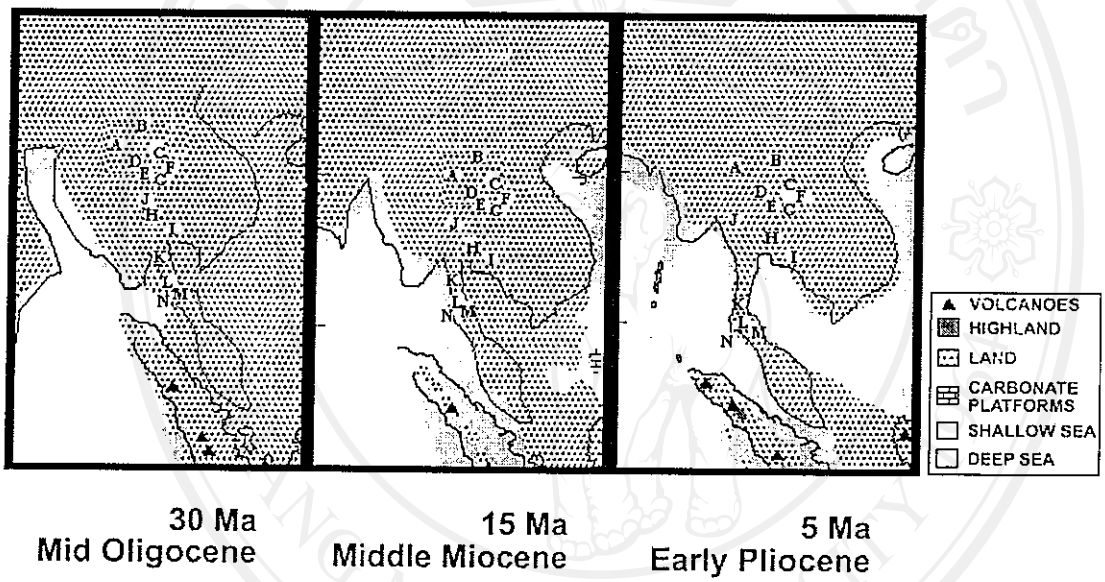

Fig 5.1 Model shows the simulation of the Geometrid locality positions on the plate tectonic movement of Southeast Asia since 30 Ma (Million years ago) until 5 Ma. The plate tectonic movement simulation model was created by Hall, 1998.

The third group of localities occur in the lowlands or in forest patches below than 800 m. These areas support some typicaly lowland geometrid species e.g. *Abraxas illuminata*, *Hypomecis transcissa*, *Hypomecis separata*, *Xandrames latiferaria*. Some of them can be found in the second group, but have never been found in the first group. The main localities are Phu Hin Rongkla and Thung Salaeng

Luang (Phitsanulok), Nam Nao National Park (Phetchabun), both remnant forest patches in the upper part of central Thailand. Nam Proam Dam (Khon Kaen) and Chulabhone Dam (Chaiyaphum) are also lowland forests, which are influenced by the water supply from dams. Khao Sok (Surat Thani) and Num Tok Ton Sai (Phuket) are also forest patches in southern Thailand. It is interesting that Phuket island shares some species of the mainland, but it still contains an endemic subspecies, *Cleora contiguata brooski*.

5.7 Discussion on Trichoptera and Geometridae

Trichoptera and Geometridae have relatively good taxonomic coverage in Thailand compared with other insect groups. Trichoptera taxonomic information in Thailand is available from studies generated since 1987 by Prof. Hans Malicky and Dr. Porntip Chataramongkol. The Geometridae taxonomic knowledge can be extracted from the literature from nearby countries such as from Malaysia, Indonesia and Nepal.

Both insect groups show similar patterns of altitudinal distribution. Some of them have limited altitudinal range, but around 25% of them were found to have a broad distribution from the foothills to the summit. Trichoptera such as; *Hydropsyche uvana, H. adratos Himalopsyche acharai, Rhyacophila petersorum, Trichomacronema paniae* and *Dinarthrum brueckmanni* were found from the foothills to the top of Doi Inthanon, as found in the study of Malicky and Chantaramonkol, (1993). For the Geometridae, many species of *Biston, Chorodna, Cleora Hypomecis* and *Ourapteryx* also have broad range distributions.

The broad range altitudinal distribution of these insects group might be explained by the influence of the riparian zone. The forests below 800 m are the deciduous forest type, except along the riparian zone, where the evergreen vegetation penetrates to lower levels. These corridors are able to stabilize the humidity and temperature as already discussed. The remaining 75% of these insects were found to be more limited in their altitudinal range. Some of them have been sampled from only 1-2 specimens, that might be narrowly endemic species. The knowledge of the ecology and conservation needs of these species needs to be improved in the future.

5.8 The temporal pattern of Trichoptera

The dynamics of macroinvertebrate communities during the monsoon period is a challenge for studying in the Oriental region. The aquatic invertebrate density and richness declined in the period of southwestern monsoon when the water load in rivers rapidly increased and the stream become more turbulant in Nepal (Brewin *et al.*, 2000). However, study of disturbance of benthic macroinvertebrates in the monsoon in he Orient is poorly developed because of the difficulties in the identification on these fauna.

From this study, an overview of temporal dynamics of Trichoptera was revealed. Their species richness was synchronized with the monsoon period. The pre southwestern monsoon (April) is the time that many of Tricoptera emerge but they rapidly declined during the southwestern monsoon period (May to September) and recovered again after the southwestern monsoon. This is the survival strategy of these organisms to evade the turbulence during the southwestern period. However, the responses to this disturbance by each species are particular.

The overview results show around 30% of the Trichoptera in this area can tolerate the southeastern monsoon and can emerge during this period. The species that can be found throughout the year and those that can be found during southeastern monsoon period are shown in Tables 4.11 and 4.12.

On the other hand, around 60% of the Trichoptera seem to avoid the turbulence of the southwestern monsoon by emerging during the northeastern monsoon or before and/or after the southwestern monsoon (Table 4.13 and 4.14, respectively).

Thus an idea is gained of monsoon dynamics on some of the aquatic macroinvertebrates in the oriental area. The monsoons dynamic is an essential driver of the observed seasonal pattern in the fauna. Further study on this approach will be required.

5.9 Riparian zone, the habitat of endemic species

Doi Suthep-Pui and Doi Inthanon National Parks are regard as unsuitable to naturally conserve the large mammals because, these areas are relatively small and are also occupied by humans. Moreover well constructed roads pass through these national parks. However, these lands still preserve a fascinating diversity and endemism of insects.

This thesis documents the role of riparian forest areas as habitat for both terrestrial and aquatic insects. Some of them are recognized as endemic species (endemic Trichoptera in Tables 4.15 and 4.16). The limitation of size and altitude of Doi Suthep-Pui compared with Doi Inthanon, means that there is lower diversity and endemism on Doi Suthep-Pui.

These riparian areas should be conserved as areas containing a high diversity of insects that will be the food for the other terrestrial consumers such as birds and spiders. They are also the areas for rearing a large number of aquatic insects that will be an important part of the nutrient and energy flux in the ecosystem. For the deforested areas, the riparian zone should be firstly restored to an ecologically functional state.

5.10 Further studies of insects in Thailand

Thailand contains relatively high biodiversity. It appears that this country supports about 5% of Oriental geometrid moths (233 from 4,150 species (Scoble, 1999)). However, this is certainly a serious underestimation of the fauna and we would expect that 800 or more species to occur in the country with more careful sampling. Thailand is strategically located in Asia to support the species of Palaearctic origin by the Himalayan corridor, Australasian elements though Peninsular Malaysia and the Oriental fauna itself. As well there are endemic species such as; *Alcis chiangmaiensis chiangmaiensis*, *Cleora contiguata brooski*, *Herochroma flavibasalis thaiensis*, *Parectropis siamensis*, *Pseudobiston pinratanai*, *Shangrilana paradisea* are found in Thailand. Further studies on the endemism and the biogeographical distribution of geometrid moths are a significant challenge for research in the future.

The studies on insects in Thailand can further develop along 3 schemes. Firstly, further study on altitudinal distribution. The majority of both geometrid moths and Trichoptera were captured at middle altitudinal ranges (700-1,200 m). Further study should emphasise lower altitudes (<700 m) or the extremely high

elevations (> 1,200 m). In case of the Author's monitoring, at 600m *Biston, Chorodna, Hypomecis* and *Metabraxas* and many other interesting geometrid moths can be found. For the study of Trichoptera the specialist Prof. Hans Malicky, suggests further study at low altitude sites in the central part of Thailand and the extremely high mountains such as the upper part of Doi Inthanon.

Secondly, the study should move to places that never been explored very well for example; at Chiang Dow and Ang Kang, the upper parts of Chiang Mai and also Huai-kha-khang and Thung-yai-naresuan Wildlife Reserve. These new sites together with Doi Suthep-Pui and Doi Inthanon, are all in the same westernmost mountains namely the Thanon Thongchai range. This range plays a crucial role as the geographical corridor from the Himalayan. This scheme of study will develop knowledge on biodiversity, and the ecology and biogeography of Thailand.

Finally, more study for conservation is recommended. This paper highlighted some localities that were isolated. In northern Thailand, Doi Suthep-Pui is the example of the area that will be fragmented. The geographical character of Doi Suthep-Pui itself shows its isolated podition from the Thanon Thong Chai range. Moreover, the development of Chiang Mai surrounds the foothills of Doi Suthep-Pui to further isolate the mountain. Khao Yai and Khao Soi Dow are remnants of forest patches near the Thailand capital, Bangkok. Long term monitoring is recommended to put an action in order to assess the impact of fragmentation and disturbance in these vulnerable areas. These recommendations and analysis methods in this paper can be also applied to other organisms.

The alert on biodiversity concern and biological knowledge in Thailand motivates many researchers, international corporations and funding agencies. In

Thailand, the Biodiversity Research and Training Program, BRT, was established in 1996. This program was supported by the Thailand government for 12 Million US$ over 5 years shared among 120 research projects which focused on field survey and taxonomic knowledge (Normile, 1998). Some grantees from the Royal Golden Jubilee Program are also cooperating in the development of bioscience and biodiversity knowledge. It is expected before the year 2010, biodiversity knowledge and closely related sciences in Thailand such as bioassessment, applied ecology, biogeography, molecular biology, will be more presented in international publications.

In conclusion, northern Thailand is a major generator for important natural resources and water. The headwaters on the mountain ranges must be conserved. These mountain ranges behave like a corridor connecting with the great Himalayan and act like a wildlife sanctuary for many species. These are the location where the flora and fauna from temperate and tropical can mix. The ongoing study of both biodiversity and the distribution of flora and fauna will further indicate that this area is one of the most important natural areas remaining on this planet and deserves conservation measures to preserve it for the benefit of all mankind.