

CHAPTER VI

CONCLUSION AND DISCUSSION

Diversity of ferns and fern allies at Khunkorn Waterfall Forest Park was investigated from October 1996 to February 1999. Three hundreds and fifty-seven specimens of these vascular plants were collected from 15 forest trails. They included 153 species, 56 genera and 24 families. Among these, 137 species, 53 genera and 21 families of ferns ; and 16 species, 3 genera belonging to 3 families of fern allies were identified.

6.1 Pteridophytes Versus Habitats

It was found that ferns and fern allies in the study area have various habitats, i.e. terrestrial, epiphytes, lithophytes. Among 153 species, the most and the least common Pteridophytes were the terrestrial (91 species.) and the lithophytes (11 species.), respectively. The distinctiveness between the terrestrial and the lithophytes were not very apparent. As used here, the lithophytes were growing from sloping or vertical rock-face where there was no soil accumulation and the ferns survived with their fine, extensive root systems, enable them to penetrate the cracks in the rock. Apparently, the terrestrial, including the lithophytic, growing in a thin soil layer or over the rocks, consisted of the ferns such as *Bolbitis heteroclita* (Presl) Ching ex C. Chr., *Bolbitis virens* (Hook. & Grev.) Schott var. *virens*, *Oleandra undulata* (Willd.) Ching and *Microsorium cuspidatum* (D. Don.) Tagawa.; and also the fern allies such as *Selaginella minutifolia* Spring, sometimes growing in a very thin soil layer. Consequently, in addition to the 11 species., as facultative lithophytes, the further 2 species of ferns might sometimes appear to be growing as the terrestrial and the epiphytes. The two species of fern were found in two habitats: *Lomagramma grossoserrata* Holttum (terrestrial,

lithophytes) and *Drynaria* sp. (epiphytes, lithophytes). A summary of the habitats of ferns and fern allies is shown in Table 6.1.

Table 6.1 Number of Pteridophytes According to Their Habitats.

Group/Habitat	Terrestrial	Epiphyte	Lithophyte
Fern allies	14	2	0
Ferns	77	48	11
Total	91	51	11

6.2 Diversity of Pteridophytes and Vegetation

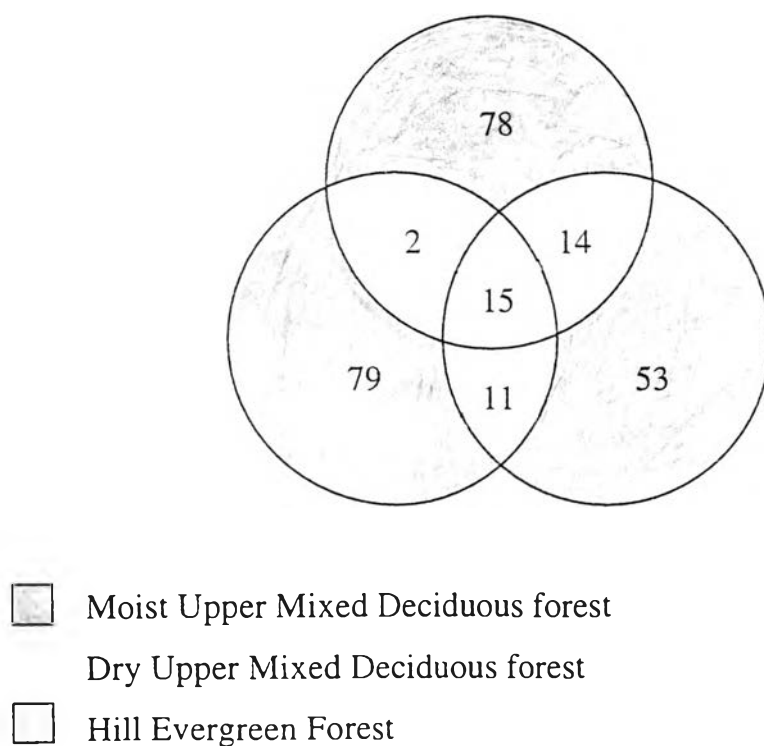
Moist Upper Mixed Deciduous Forest exists at the elevation of 650-800 m This type of forest is characterized by high air humidity as well as shady environment. The soil bearing this forest is usually loamy, either calcareous or granitic. Such physical environments are preferable for most ferns and fern allies. It is evident that there are 79 species of Pteridophytes found in this forest. They are 57 terrestrial species, 11 lithophytic species, and 12 epiphytic species. The common ferns and fern allies families are members of Polypodiaceae (17 species), Thelypteridaceae (13 species), Selaginellaceae (8 species) and Dryopteridaceae (7 species), respectively (Fig. 6.1).

Dry Upper Mixed Deciduous Forest is along the ridges, at the elevation of 650-800 m It is known that the vegetation type changes into a more open nature, due to the surface erosion and the leaching of organic components of soil. The soil is either sandy loam or lateritic. To sum up, this type of forest is much drier and more exposed than the first one. Moreover, the ground flora in this type of forest is frequently destroyed by fire. In this forest, ferns and fern allies are very variable; 53 species of Pteridophytes were collected; including 39 terrestrial species and 14 epiphytic species.

They are members of the Polypodiaceae (11 species), Thelypteridaceae (7 species), Parkeriaceae (5 species), Dryopteridaceae (4 species) and Selaginellaceae (4 species), etc. (Fig. 6.1).

Hill Evergreen Forest confines to the upper elevation of 800 m upwards. The soil is either red granitic brown-black calcareous or yellow brown sandy. This type of forest includes common families, such as Polypodiaceae (25 species), Dennstaedtiaceae (7 species), Selaginellaceae (6 species) and Davalliaceae (6 species). In all 78 species of Pteridophytes found, the epiphytes (41 species) and terrestrial (37 species) are very common in this type of forest (Fig. 6.1).

Fig. 6.1 A Summary of Ferns and Fern allies Collected in Each Forest.



In this study, 15 species and 9 families of ferns and fern allies were found distributed through all altitudes and all kinds of forests; Polypodiaceae, Schizaeaceae, Thelypteridaceae and Dennstaedtiaceae were

the families mostly observed. Whilst Dicksoniaceae, Dryopteridaceae, Lindsaeaceae, Aspleniaceae and Parkeriaceae each represented by only one species occurred. Twenty-five species of the ferns and the fern allies included *Asplenium nidus* L. (Aspleniaceae), *Microlepia speluncae* (Linn.) Moore, *Pteridium aquilinum* (Linn.) Kuhn var. *wightianum* (Ag.) Tyron (Dennstaedtiaceae), *Cibotium barometz* (Linn.) J. Smith. (Dicksoniaceae), *Tectaria polymorpha* (Wall. ex Hook. & Grev.) Ching (Dryopteridaceae), *Lindsaea ensifolia* (Lindsaeaceae), *Adiantum philippense* Linn. (Parkeriaceae), *Aglaomorpha coronans* (Wall. ex Mett.) Copel., *Drynaria parishii* (Bedd.) Bedd., *Pyrrhosia stigmosa* (Sw.) Ching (Polypodiaceae), *Lygodium flexuosum* (Linn.) Sw., *Lygodium polystachyum* Wall. ex Moore, *Lygodium salicifolium* Presl. (Schizaeaceae), *Thelypteris lakhimpurensis* (Rosenst.) K. Iwats., and *Thelypteris terminans* (Hook.) Tagawa & K. Iwats. (Thelypteridaceae).

6.3 Rare species

The very rare species, only once found, were *Tectaria faurei* Tagawa (Dryopteridaceae), *Nephrolepis delicatula* (Dcne.) Pic. Serm., *Nephrolepis falcata* (Cav.) C. Chr. (Oleandraceae), *Asplenium macrophyllum* Sw. (Aspleniaceae) and *Sphenomeris chinensis* (L.) Maxon (Lindsaeaceae). Among these *Tectaria faurei* Tagawa is a species confined to northern Thailand and its present distribution tends to be a member of Sino-Himalayan elements. Whereas the other species dispersed throughout the country.

6.4 Endemic species

Of the 153 species of Pteridophytes, 3 species endemic to Thailand were *Selaginella lindhardii* Hieron, *Lomagramma grossoserrata* Holttum, and *Thelypteris siamensis* Tagawa & K. Iwats.. *Selaginella lindhardii* Hieron is a small plant, occurs in Tak, Bangkok and Ratchaburi. Its present

distribution shows relationship with Indo-Burmese plant groups. (Tagawa and Iwatsuki, 1979). *Lomargramma grossoserrata* Holttum known only by the type collection from Phrae Province (Tagawa and Iwatsuki, 1988). But this species thrives healthy along the streams at the altitudes of 650-800 m in Moist Mixed Deciduous Forest. So far, its present distribution is confined to northern Thailand and should be a member of Sino-Himalayan elements. Whilst *Thelypteris siamensis* Tagawa & K. Iwats. was collected from Phu Miang in Phetchabun and Phu Luang in Loei (Tagawa and Iwatsuki, 1988). The present distribution of this species reveals its membership of Sino-Himalayan elements.

6.5 New recorded

Included in this study, there were two species of ferns and fern allies which had previously not been recorded in Thailand. The fern allies was *Selaginella ciliaris* (Retz.) Spring. It had been distributed in Mainland China, Taiwan, Philippines, India and Australia. In Khunkorn Waterfall Forest Park, this species occurs locally abundance in an exposed areas on the mountain slopes at the 670-800 m altitude.

The other new record of ferns is *Dicranopteris linearis* (Burm.f.) Underw. var. *montana* Holttum. This newly recorded variety had been distributed in Tropical Africa, Asia and Australia. In Khunkorn Waterfall Forest Park, this variety occurs on the mountain ridges in the rather dry forests, at the altitude of about 950-1,300 m

Among 153 species collected, the identity of three species is still dubious. They were *Bolbitis appendiculata* (Willd.) K. Iwats., *Drynaria* sp., and *Sphenomeris chinensis* (L.) Maxon.

The *Bolbitis appendiculata* (Willd.) K. Iwats., difference in moniliform fertile pinnae. *Drynaria* sp., which foliage-leaves lacking sori, is closed to *Drynaria fortunei* and *Drynaria bonii*. The other suspected species,

an intensive, *Sphenomeris chinensis* (L.) Maxon is lacking fertile fronds. So these three species need more exploration and investigations to clarify their taxonomic study.

6.6 Relationship with Pteridophytes Flora of Thailand

According to Flora of Thailand Volume III, part 1-4 (Tagawa and Iwatsuki; 1979, 1985, 1988 and 1989), 155 species of ferns and fern allies were reported from Chiang Rai Province. These included 3 species of ferns namely *Bolbitis tonkinensis* (C. Chr. ex Ching) K. Iwats. (Lomariopsidaceae), *Anthophyllum winittii* Tagawa & K. Iwats. (Vittariaceae) and *Cyathea chinensis* Copel. (Cyatheaceae). These three species were found only in Chiang Rai Province. Unfortunately, they were not found in this study area. Though effort has been made to search for these species. However, it should be noted that *Bolbitis tonkinensis* (C. Chr. ex Ching) K. Iwats. is one of the very rare species in Thailand. Since only one collection was made in Chiang Rai at the altitudes of 550-950 m (Tagawa and Iwatsuki, 1988). Meanwhile, *Anthophyllum winittii* Tagawa & K. Iwats was reported as an endemic species and known only from a type specimen which is now kept at Herbarium and Library, Botanic Gardens, in Singapore. A tree fern, *Cyathea chinensis* Copel. is also a rare species in this country. So far its southernmost limit of distribution is in Chiang Rai Province (Tagawa and Iwatsuki, 1979).

Among 153 species collected in this study, 77 species distributed in Chiang Rai were reported in Flora of Thailand. Whereas 76 species were not recorded in Chiang Rai before. Some of them were distributed through the country, such as *Bolbitis appendiculata* (Willd.) K. Iwats., *Blechnum orientale* L., and *Tectaria angulata* (Willd.) C. Chr. However, there are 15 species, which had never been found in northern regions before, were *Asplenium macrophyllum* Sw., *Asplenium perakense* Mettew & Christ, *Belvisia mucronata* (Fee) Copel., *Hymenophyllum acanthoides* (van den

Bosh) Copel., *Dicranopteris curranii* Copel., *Diplazium petri* Tard., *Diplazium simplicivinium* Holttum, *Lepisorus suboligolepidus* Ching, *Pteris tripartita* Sw., *Pyrrosia varia* (Kaulf.) Farw., *Selaginella wallichii* (Hook. & Grev.) Spring, *Thelypteris glandulosa* (Bl.) Tagawa & K. Iwats., *Thelypteris siamensis* Tagawa & K. Iwats., *Trichomanes bimarginatum* van den Bosch, and *Vittaria angustifolia* Bl..

Among the 15 species, 5 species namely *Pteris tripartita* Sw., *Pyrrosia varia* (Kaulf.) Farw., *Thelypteris glandulosa* (Bl.) Tagawa & K. Iwats., *Thelypteris siamensis* Tagawa & K. Iwats., and *Vittaria angustifolia* Blume. were distributed in the eastern, north-eastern, south-eastern, south-western, peninsular Thailand and throughout Malesia, while the other 10 species were distributed throughout Taiwan, S. China and Indochina. Their absence from northern Thailand may be due partly to the lack of taxonomic study in northern Thailand in the past. Moreover, some species may be wiped out from the mountainous areas of the north due to slash-and-burn agriculture, which destroyed the forests as well as the habitats of these plant groups.

Khunkorn Waterfall Forest Park is one of the mountainous areas that shifting cultivation is still active (Photo 3 and 5). The Hill Evergreen Forest and Dry Mixed Deciduous Forest were strongly influenced by hill tribes which conducted shifting agriculture in the past. For the present situation, it is fairly safe to say that no part of the areas have recently been without human influence. In some areas, hill tribes completely removed the vegetation and replaced it with their cultural vegetation. Whilst some hills were selectively cut of trees, burned, and pastured. The destruction of the vegetation was much more permanent in some places than in the others where it was permitted to return to its original state, especially in the hill-tribe villages. Due to the deforestation in the study area, it can be assumed that some species of Pteridophytes as well as some other wild vegetation was cleared completely, probably long before this study had been done.

6.7 Relationship with Pteridophytes found in Chiang Mai

In the past taxonomic study of the plants in the north was usually restricted to Chiang Mai. So the species diversity of the ferns and the fern allies in Khunkorn Waterfall Forest Park was compared with Doi Chiang Dao, Doi Inthanon, and Doi Suthep- Pui (Table 6.2).

6.7.1 Doi Chiang Dao

Doi Chiang Dao situates between the latitude of 19° 24' N, the longitude of 98° 54' E, and about 65 km far north from Chiang Mai. It is an eastern outpost of the Upper Tenasserim Range, situating on an almost flat, alluvial plain of the about 350 m elevation in the broad valley of the Ping River, covering an area of about 60 square km. In profile, it has steep slopes on all sides, topped by conical peaks. In ground plan, it has a horse-shoe-shaped valley of the very steep slopes with the three peaks arranged in juxtaposition. The highest peak is about 2,200 m above sea level in altitude. The climate is in conformity with Chiang Mai. The rainy season lasts from May to September, while the heaviest rain fall is in September. The cold, dry season lasts from October to February, and the hot dry season is from March to April (Smitinand, 1966).

According to 98 species, 46 genera and 18 families of the ferns and the fern allies found (สำนักนายกรัชมณตรี, องค์การสวนพฤกษศาสตร์ 2541), 87 out of 98 species is also recorded from this study. They are 80 species of ferns and 7 species of fern allies

6.7.2 Doi Inthanon

Doi Inthanon is a granitic massif rising to 2,565 m above sea level. It is part of the Thanon Thongchai Range, a southern extension of the Shan Hills of Myanmar. The mountain and surrounding area is about 272 square km. Sandy loam is the predominant soils on the mountain. Doi Inthanon experiences a strongly monsoonal climate. The annual rainfall of

about 2,000 mm was recorded, most of which is between May-October. The coldest months are December and January when ground frost may cover the exposed ridges near the summit where a low of $-8\text{ }^{\circ}\text{C}$ has been recorded (Graham, 1991).

171 species, 67 genera and 24 families of the ferns and the fern allies were found (Koyama 1986), and 72 species of ferns and fern allies are the same with the species found in Khunkorn Waterfall Forest Park. They were 62 species of ferns and 10 species of fern allies.

6.7.3 Doi Suthep-Pui

Doi Suthep (elevation 1,601 m above sea level) and Doi Pui (1,685 m above sea level) are part of a geologically ancient ridge forming the western boundary of the Ping River Valley, covering an area of 261 square km. The bedrock of the park is almost entirely granitic. The park comprises of deciduous and evergreen forest. Annual rainfall of about 2,000 mm is recorded each year, mostly from May to October. The dry season comes between November and March. The average annual temperature, recorded near Phu Phing Palace, is $20\text{ }^{\circ}\text{C}$, with maximum and minimum average temperatures of $24\text{ }^{\circ}\text{C}$ and $17\text{ }^{\circ}\text{C}$, respectively (Graham, 1991).

169 species, 59 genera and 23 families of Pteridophytes were found (Tagawa and Iwatsuki 1979, 1985, 1988 and 1989), while 84 species of the ferns and the fern allies were the same as the species found in Khunkorn Waterfall Forest Park. They were 76 species of ferns and 8 species of fern allies.

Of the three protected areas in Chiang Mai, Doi Chiang Dao and Khunkorn Waterfall Forest Park tend to share the same Pteridophytes flora as evidence from the common species found in both areas. About 89 percent of Pteridophytes found at Doi Chiang Dao also occur at Khunkorn Waterfall Forest Park. Geographically, these two sites are located in different mountain ranges, but about 95 km apart. In term of geological feature, they differ

(Table 6.2), though calcareous soil can be found in some parts of the park. Khunkorn Waterfall Forest Park houses a higher species diversity than Chiang Dao despite its smaller area. This discrepancy in species richness may be due to different types of habitat. It can be postulated that Chiang Dao, as a limestone mountain, has a severer environment for Pteridophytes' life than Khunkorn Waterfall Forest Park.

It is interesting to note that there are 31 common species of ferns and fern allies found in all four comparative areas. The terrestrial species include *Adiantum caudatum* L., *Athyrium dissitifolium* (Baker) C. Chr., *Brainea insignis* (Hook.) J. Sm., *Lygodium flexuosum* (L.) Sw., *Lygodium salicifolium* Presl, *Microlepia speluncae* (L.) Moore, *Pteris venusta* Kunze, *Tectaria impressa* (Wall. ex Hook.) C. Chr., etc. Whilst the epiphytic species include *Crypsinus oxylobus* (Wall. ex. Kunze) Sledge, *Drynaria rigidula* (Sw.) Beddome, *Elaphoglossum stelligerum* (Wall. ex Baker) Moore ex Alston & Bonner, *Lepisorus nudus* (Hook.) Ching, *Leucostegia immersa* (Wall. ex Hook.) Presl, *Loxogramme involuta* (D. Don) Presl, *Lycopodium cernuum* L., *Lycopodium hamiltonii* Spring, *Microsorium membranaceum* (D. Don) Ching, etc. These common species disperse throughout the country.

Table 6.2 Summary of Pteridophytes Found in Four Protected Areas.

Protected area	Geological feature	Altitudes (m)	Total area (sq. km)	Diversity of Pteridophytes		
				Family	Genus	Species
Doi Chiang Dao	Limestone	300-2,225	60	18	46	98
Doi Inthanon	Granite	300-2,565	272	24	67	171
Doi Suthep-Pui	Granite	350-1,685	261	23	59	169
Khunkorn Waterfall Forest Park	Granite, Limestone	625-1,635	18	24	56	153

6.8 Miscellaneous Uses

In this study, 2 species of the ferns used for medicine were 'wan kip raet', *Angiopteris evecta* (G. Forst.) Hoffm., rhizomes used in local medicine in Malaysia and Hawaii and 'wan kai noi', *Cibotium barometz* (L.) J. Sm., especially the silky hairs on buds, used as a styptic for wounds (Burkill, 1935).

The young fronds locally consumed as vegetable was 'kut kin', *Diplazium esculentum* (Retz) Sw. The adventitious root from the trunk of 'maha sadam', *Cyathea gigantea* (Wall.ex Hook.) Holttum, was used for orchid media.

Last but not least, the stipe of *Lygodium flexuosum* (L.) Sw., *L. polystachyum* Wall. ex Moore and *L. salicifolium* Presl was used as a natural material for handicraft, such as handbags, hats, etc.

6.9 Recommendation

Two-year collection of Pteridophytes in Khunkorn Waterfall Forest Park could not cover the whole area of the park. Some steep cliffs are still unexplored. More exploration should be made in the near future to obtain some more species.

Hopefully, this study may be both the basis for further taxonomic work, and example to other students and botanists, so that they may also find it interesting and rewarding to undertaking a similar project elsewhere.