CHAPTER 2
LITERATURE REVIEW

Thailand is one of the most biodiverse areas in the world. It is a unique place represents the fauna and flora which characterizes the Indo-Burma biogeographic province (Ashton, 1989). Since 1961, Thai forest included 53.33 % of the total area of the country deceased to 25.28 % in 1998. Maxwell and Elliott (2001) estimate that now *c.* 15 % of Thailand has forest cover. The northern part of Thailand is now the largest forested area of the country with about 43.5 % of total forest cover (Rojanapaiwong, 2000).

Thai forests can be divided into 2 major groups, *viz.* deciduous and evergreen, due to climate, soil moisture, and elevation (Maxwell and Elliott, 2001). Neal (1967) noted that the largest forest type in Thailand is deciduous forest, which included 147,000 km^2 (46%) mainly occurring in the north and northeast (Rundel and Boonpragob, 1995).

In northern Thailand, the vegetation has the Indo-Burmese and southern Chinese floristic elements (Smitinand, 1966; Ashton, 1989). Maxwell has developed a simplified classification system for Thai forests from his surveys in various areas throughout Thailand. The main vegetation types in northern Thailand (Maxwell, 2001) are:

1. Deciduous forest with bamboo (BB/DF)
2. Deciduous diperocarp-oak forest (DOF)
3. Mixed evergreen + deciduous forest (MXF)
4. Primary evergreen forest (EGF)
5. Primary vergreen forest with pine (EG/PINE)
6. Disturbed areas and secondary growth (DA/SG)
7. Aquatic

Deciduous dipterocarp forest covers the largest area in Southeast Asia extending from northeast India and Burma through Thailand to the Mekong river region of Indo-China (Rundel and Boonpragob, 1995). The highest elevation of Thai dipterocarps is about 1,300 m in dry dipterocarp forest on Doi Suthep (Smitinand, 1969). Deciduous dipterocarp-oak forest (DOF) is open and dry and degraded areas

from the lowlands up to about 800-900 m elevation, and is a secondary, fire climax facies (Maxwell and Elliott, 2001). Sometimes this forest is called savanna (Stott, 1984 and Ogawa *et al.*, 1961). DOF is named because of being dominated by Dipterocarpaceae and Fagaceae. In upper elevations this forest is often mixed with *Pinus kesiya* Roy. *ex* Gord. (Pinaceae, tree-needled pine), so this can be called deciduous dipterocarp-oak + pine forest.

Northern Thailand has two kinds of deciduous forest *viz.* primary and secondary, which are fire-tolerant forests, and less a botanically diverse as upland evergreen areas (Maxwell, 1998). On the upland of Doi Chiang Dao Wildlife Sanctuary, the primary deciduous forest was dominated by *Tectona grandis* L. f. (Verbenaceae, teak). After it was destroyed for commercial logging, it was replaced with bamboo and with other no commercial value deciduous trees. Degraded deciduous forest is replaced and dominated by deciduous dipterocarps (Dipterocarpaceae) and oaks (Fagaceae), which grow in evergreen hardwood pine areas. Dipterocarp-oak + pine forest are found in EG/Pine areas (*c.* 1,000-1,550 m). Many species are found in lowland DOF, but not found in degraded EG/Pine, such as *Shorea obtusa* Wall. *ex* Bl. (Dipterocarpaceae), *Quercus kerrii* Craib var. *kerrii, Q. kingiana* Craib (both Fagaceae). Maxwell (1992) noted that DOF in the lowland (*c.* 450-800 m) of Doi Chiang Dao is a climax secondary growth facies like on the eastern side of Doi Suthep-Pui National Park. Smitinand (1966) made a primitive vegetation survey of Doi Chiang Dao. He found a total of 109 families, 377 genera, and 570 species. The most common family was Orchidaceae with 88 species, followed by Gramineae with 39 species, and Compositae with 34 species. Compositae was a good representation of northern elements as *Adenostemma lavenia* (L.) O.K., *Blumea fistulosa* (Roxb.) Kurz, *Siegesbeckia orientalis* L., and *Inula cappa* (Ham. *ex* D. Don) DC. were very widespread.

In Doi Suthep, DOF forest has 82% deciduous trees, which shed their leaves in the hot-dry season and producing new leaves before the rainy season. The forest canopy is open and usually does not exceed 20 m (Maxwell and Elliott, 2001; Ogawa *et al.*, 1961). Since this forest is deciduous and has an open canopy, the ground flora well developed, especially in Gramineae (grasses). The consequence dry grasses and leaf litter accumulation in the dry season is fire, which is all caused by human activities.

Fire is a significant ecological factor for DOF ecosystems (Stott, 1984). Selection has resulted in a fire-tolerant vegetation in DOF areas. Some examples enabling some plants to survive here are some trees having thickened bark, many herbaceous ground plants are perennials having thickened storage roots, bulbs, corms and rhizomes. The most common tree species in DOF areas in northern Thailand are *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius, D. tuberculatus* Roxb. var. *tuberculatus, Shorea siamensis* Miq. var. *siamensis* (all Dipterocarpaceae), *Quercus kerrii* Craib var. *kerrii, Q. brandisiana* Kurz, and *Castanopsis argyrophylla* King *ex* Hk. f. which is evergreen (all Fagaceae). Maxwell and Elliott (2001) mentioned that the fire resistant palm *Phoenix loureiri* Kunth. var. *loureiri* (Palmae) is easily recognized as an indicator of this forest type. Other common characteristic DOF treelets and trees are *Ochna integerrima* (Lour.) Merr. (Ochnaceae), *Gluta usitata* (Wall.) Hou, and *Buchanania lanzan* Spreng. (both Anacardiaceae).

Maxwell (2001) concluded that there are at least 195 families and 2,247 species of vascular plants in Doi Suthep-Pui National Park. He recorded 533 species (23.72 %) in DOF. There were 274 species of ground flora, 40 % being annual, with many common species, *e.g. Polygala longifolia* Poir. (Polygalaceae), *Biophytum umbraculum* Welw. (Oxalidaceae), *Crotalaria alata* D. Don, *C. albida* Hey. *ex* Roth, *Indigofera hirsuta* L. (all Leguminosae, Papilionoideae), *Gynura integrifolia* Gagnep.(Compositae). Grasses (Gramineae) are very diverse and dominant. Most are deciduous such as *Apluda mutica* L., *Aristida cumingiana* Trin. & Rupr., *Arundinella setosa* Trin. var. *setosa,* and *Capillipedium assimile* (Steud.) A. Camus.

Phuakam (1994) studied on herbaceous ground flora on the easten side of Doi Suthep, at elevation 670-750 m. She found total 24 families, 60 genera, and 71 species in an area of 3,960 m^2 in an ecotone of DOF and MXF. The most common family was Zingiberaceae with 13 species. The flowering peak of herbaceous ground flora was in July and lowest in February.

Maxwell (2000) studied the vegetation in Doi Luang National Park (Chiang Rai, Lampang, and Phayao Provinces) (Figure 1). The DOF, there is similar to that on Doi Suthep-Pui in being dominated with Dipterocarpaceae and Fagaceae, as well as the typically deciduous ground flora. The more abundant ground herbs are *Crotalaria acicularis* B.-H. *ex* Benth. and *C. neriifolia* Wall. *ex* Benth. (Leguminosae,

Papilionoideae), *Inula cappa* (Ham. *ex* D. Don) DC. *forma cappa* and *I. indica* L. (Compositae), and *Premna nana* Coll. & Hemsl. (Verbenaceae). From CMU database analysis, there are 1,155 species of vascular plants of which 439 species are herbaceous ground flora (38 %) of the total flora.

Palee and Maxwell (2000) studied vascular flora of Doi Muang Awn (Figure 1) which is an isolated limestone hill. They found total of 69 families, and 227 species. The database shows there are 95 species of ground herb (41.85 %).

Maxwell *et al.* (1997) surveyed the vegetation in Jae Sawn National Park, Lampang, Lamphun Provinces from August 1995 to 1997. They found 1,353 species of vascular plants, with 410 species of herbaceous ground herb (30.3 %). The DOF is found from about 300-800 m. The herbaceous plants are similar to those found in BB/DF forest. The tree component is slightly similar to DOF in Doi Suthep-Pui Nationa Park (Maxwell and Elliott, 2001), and Doi Khuntan National Park (Maxwell *et al.,* 1995). *Quercus kerrii* Craib var. *kerrii* and *Q. kingiana* Craib are very common, but uncommon at Doi Khuntan. The ground flora is mostly deciduous and many places are dominated by Gramineae (grasses) such as *Apluda mutica* L., *Themeda triandra* Forssk., and *Arundinella setosa* Trin. var. *setosa.* More open, fire-damaged areas have many annual herbs such as *Crotalaria alata* D. Don. (Leguminosae, Papilionoideae).

Maxwell (1996) studied the flora in the Mae Soi Conservation area (Figure 1) (now is a part of Awp Luang National Park), Chom Tong District from December 1989 to July 1993. There is deciduous dipterocarp-oak forest present in the lowland vegetation. He found a total of 149 families and 806 species. The CMU Herbarium database shows that there are 175 species of herbaceous plants (20.61 % of the total flora).

Maxwell *et al.* (1995) studied the flora in Doi Khuntan National Park (Figure 1), Lamphun-Lampang Provinces from May 1993 to June 1995. They found at least 165 families and 1,285 species of vascular plants. Deciduous dipterocarp-oak forest is mainly located at 325-850 m with *Pinus merkusii* Jungh. & De Vriese scattered in the upper range from 800-900 m. The CMU database shows that there are 319 species of herbaceous plants (24.28 % of the total flora). Some typical ground herbs are: *Blumeopsis flava* (DC.) Gagnep. (Compositae), *Euphorbia capillaris* Gagnep.

(Euphorbiaceae), *Barleria cristata* L. and *Andrographis laxiflora* (Bl.) Lind. (both Acanthaceae). Gramineae (Grasses) are very common with *Arundinella setosa* Trin. var. *setosa*, *Capillipedium parviflorum* (R. Br.) Stapf, *Heteropogon contortus* (L.) P. Beauv. *ex* Roem. & Schult., and *Hyparrhenia rufa* (Nees) Stapf var. *siamensis* Clay. Common Cyperaceae (sedges) include *Carex indica* L. var. *microcarpa* T. Koy., *C. speciosa* Kunth, *Rhynchospora rubra* (Lour.) Mak., *Scleria kerrii* Turr., and *S. levis* Retz.

Santisuk (1997) mentioned that pine-deciduous dipterocarp forest is extensively developed on the plateau-like rolling hills of Bo Luang-Mae Sanam–Om Koi areas, but the commercial logging in 1986 has destroyed the original vegetation.

Phengklai *et al.* (1988) studied the vegetation in a bog area along the road 1099 (Bo Luang–Om Koi Road), which is near Ban Mae Sanam (village). The study site is at 850 m elevation in pine-dipterocarp forest. They found 99 species of seed plants, mostly herbs, *e.g. Aristolochia kerrii* Craib (Aristolochiaceae), *Impatiens chinensis* L. (Balsaminaceae), *Cyperus brevifolius* (Rottb.), *C. compactus* Retz., *Fimbristylis cinnamometorum* (Vahl) Kunth, *F. dichotoma* (L.) Vahl (all Cyperaceae), *Dysophylla cruciata* Benth., and *Elscholtzia winitiana* Craib (both Labiatae).

Two new taxa were collected from this area, *viz. Ranunculus siamensis* Tam. (Ranunculaceae) was collected from Bo Luang in 1978 (Tamura, 1997). The type of *Inula wissmanniana* Hand.-Mzt. *forma disciformia* H. Koy. (Compositae) was collected from Mae Sanam (Koyama, 1984). Many species have been collected from the Mae Sanam area, *e.g. Piloselloides hirsuta* (Forssk.) C. Jeff. (Koyama, 1981), *Cyathocline purpurea* (Ham. *ex* D. Don) O. Ktz. (Koyama, 1983), *Blumeopsis flava* (DC.) Gagnep., *Pluchea polygonata* (DC.) Gagnep. (Koyama, 1984), and *Artemisia japonica* Thunb. (Koyama, 1989).

Bo Luang (5 km from the study site) was chosen to be a collecting site for the fourth Thai-Danish Botanical Exhibition in 1964 (Larsen, 1966). Many species of vascular plants were collected, but no species list was made.