

CHAPTER 2 LITERATURE REVIEW

Previous Studies of *Fissidens* in Thailand

The first information of Thai *Fissidens* was provided by Brotherus (1901). He reported about the moss flora of Chang Island, Trat Province with 44 species, among these 5 species were *Fissidens*, viz. *F. mittenii* Par., *F. papillulosus* Broth. sp. nov., *F. siamensis* Broth. sp. nov., *F. silvaticus* Griff., and *F. zippelianus* Dozy & Molk.. In 1932, Dixon published the first checklist of Thai mosses based on Kerr's collections, his own studies, and other specimens. He listed 220 species of mosses, among these 8 species were *Fissidens*. He reduced *F. zippelianus* Dozy & Molk. to a synonym of *F. silvaticus* Griff., while *F. javanicus* Dozy & Molk. was separated from *F. silvaticus*.

In 1964, Horikawa and Ando enumerated the mosses of Thailand from specimens collected from Doi Inthanon and Doi Suthep in northern Thailand. They listed 126 species, 4 of which were *Fissidens* (Table 1). In 1966, Tixier and Smitinand provided a detailed list of mosses in BKF and listed 172 species, among these 10 were *Fissidens*. Two new records were added, viz. *F. hollianus* Dozy & Molk. and *F. zollingeri* Mont..

In 1993, a checklist of Indochinese Mosses was done by Tan & Iwatsuki, which noted 22 *Fissidens* species in Thailand. Several species became synonyms. For example, *F. mittenii* Par., recorded by Brotherus (1901), was reduced to *F. laxus* Sull. & Lesq., and *F. areolatus* Griff. became *F. polypodioides* Hedw. (Table 1).

In 1995, a checklist of *Fissidens* in Thailand based on papers from 1900-1979 was published (Sornsamran & Thaitong, 1995), which included 25 species of *Fissidens* (Table 1). Their work only provides distributions in the country and no synonyms or keys.

He (1996) compiled a list of mosses in Thailand based on Thai collections at the Missouri Botanical Garden (MO) and all known literature. It includes 620 species, including 34 species and 7 varieties of *Fissidens* (Table 1). For *Fissidens*, fifteen taxa were new records and updated binomials. *F. filiformis* Iwats., *F. obtuso-apiculatus* Dix., *F. papillulosus* Broth., *F. siamensis* Broth., and *F. semperfalcatus* Dix. were described from Thai specimens. Of these, three species, viz. *F. filiformis*, *F. obtuso-apiculatus*, and *F. siamensis* are endemic to Thailand. For synonyms, comparison between this checklist and the list of Tan & Iwatsuki (1993) is similar. These studies have added and synonymised many taxa (Table 1). His checklist provided good baseline data for Thai Bryologists to start with, but there still needed to be more detailed study of each taxon.

Since there was no revision for *Fissidens* in Thailand, I decided to do this as my Ph. D. research topic.

Table 1. Checklist of *Fissidens* from 1901 to 1996.

Reference	Amount	Taxon
Brotherus (1901)	5 species	<i>F. mittenii</i> Par. <i>F. papillulosus</i> Broth., <i>sp. nov.</i> <i>F. siamensis</i> Broth., <i>sp. nov.</i> <i>F. silvaticus</i> Griff. (syn.= <i>F. javanicus</i> Dozy & Molk.) <i>F. zippelianus</i> Dozy & Molk.
Dixon (1932)	8 species	<i>F. ceylonensis</i> Dozy & Molk. <i>F. javanicus</i> Dozy & Molk. <i>F. mittenii</i> Par. <i>F. nobilis</i> Griff. <i>F. obtuso-apiculatus</i> Dix., <i>sp. nov.</i> <i>F. papillulosus</i> Broth. <i>F. siamensis</i> Broth. <i>F. silvaticus</i> Griff. (syn.= <i>F. zippelianus</i> Dozy & Molk.)
Horikawa & Ando (1964)	4 species	<i>F. anomalus</i> Mitt. <i>F. cf. gymnogynus</i> Besch. <i>F. nobilis</i> Griff. <i>F. sp.</i>
Tixier & Smitinand (1966)	9 species 1 varieties	<i>F. anomalus</i> Mitt. <i>F. areolatus</i> Griff. <i>F. excedens</i> Broth. <i>F. hollianus</i> Dozy & Molk. <i>F. nobilis</i> Griff. <i>F. cf. papillosus</i> Broth. <i>F. semperfalcatus</i> Dix. <i>F. silvaticus</i> Griff. <i>F. silvaticus</i> Griff. var. <i>fontanus</i> (Fleisch.) Giesy & Richs. forma <i>minor</i> Giesy & Richards <i>F. zollingeri</i> Mont.
Tan & Iwatsuki (1993)	21 species 1 varieties	<i>F. anomalus</i> Mont. <i>F. ceylonensis</i> Dozy & Molk. <i>F. crassinervis</i> Lac. <i>F. excedens</i> Broth. <i>F. gymnogynus</i> Besch. <i>F. hollianus</i> Dozy & Molk. <i>F. javanicus</i> Dozy & Molk. <i>F. laxis</i> Sull. & Lesq. (syn.= <i>F. mittenii</i> Par.) <i>F. microcladus</i> Thwaites. & Mitt. <i>F. mittenii</i> Par. var. <i>javensis</i> Fleisch. <i>F. nobilis</i> Griff. <i>F. obtuso-apiculatus</i> Dix. <i>F. papillulosus</i> Hedw. <i>F. polypodioides</i> Hedw. (syn.= <i>F. areolatus</i> Griff.) <i>F. semperfalcatus</i> Dix. <i>F. siamensis</i> Broth. <i>F. thwaitesii</i> Par. (syn.= <i>F. papillosus</i> Thwaites & Mitt.) <i>F. virens</i> Thwaites & Mitt. <i>F. wichurae</i> Broth. & Fleisch.

Table 1. (continued)

Reference	Amount	Taxon
Tan & Iwatsuki (1993) (continued)	21 species 1 varieties	<i>F. zippelianus</i> Dozy & Molk.(syn.= <i>F. sylvaticus</i> Griff.) <i>F. zippelianus</i> Dozy & Molk. var. <i>fontanus</i> Fleisch. (syn. = <i>F. sylvaticus</i> Griff. var. <i>fontanus</i> (Fleisch.) Giesy & Richards. forma <i>minor</i> Giesy & Richards) <i>F. zollingeri</i> Mont. (syn.= <i>F. xiphioides</i> Fleisch.)
Sornsamran & Thaitong (1995)	22 species 3 varieties	<i>F. anomalus</i> Mont. <i>F. areolatus</i> Griff. <i>F. ceylonensis</i> Dozy & Molk. <i>F. choprai</i> Norkett. <i>F. crassinervis</i> Dozy & Molk. <i>F. excedens</i> Broth. <i>F. cf. gymnogynus</i> Besch. <i>F. hollianus</i> Dozy & Molk. <i>F. hollianus</i> Dozy & Molk.var. <i>semperfalcatus</i> (Dix.) Norkett. <i>F. javanicus</i> Dozy & Molk. <i>F. microcladus</i> Thwaites & Mitt. <i>F. mittenii</i> Par. <i>F. mittenii</i> Par. var. <i>javensis</i> Fleisch. <i>F. nobilis</i> Griff. <i>F. obtuso-apiculatus</i> Dix. <i>F. papillosus</i> Broth. <i>F. semperfalcatus</i> Dix. <i>F. siamensis</i> Broth. <i>F. sylvaticus</i> Griff. <i>F. sylvaticus</i> Griff. var. <i>fontanus</i> (Fleisch.) Giesy & Richards. <i>F. virens</i> Thwaites & Mitt. <i>F. wichurae</i> Broth. & Fleisch. <i>F. xiphioides</i> Fleisch. <i>F. zippelianus</i> Dozy & Molk. <i>F. zollingeri</i> Mont.
He (1996)	34 species 7 varieties	<i>F. anomalus</i> Mitt. <i>F. asplendioides</i> Hedw. <i>F. australiensis</i> Jaeg. (syn.= <i>F. papillosus</i> Broth.) <i>F. bififormis</i> Mitt. <i>F. ceylonensis</i> Dozy & Molk. (syn.= <i>F. siamensis</i> Broth.) <i>F. crassinervis</i> Sande Lac. <i>F. crenulatus</i> Mitt. var. <i>crenulatus</i> <i>F. crenulatus</i> Mitt. var. <i>elmeri</i> (Broth.) Z. Iwats. & Suzuki <i>F. excedens</i> Broth. <i>F. filiformis</i> Z. Iwats. <i>F. firmus</i> Mitt. <i>F. geminiflorus</i> Dozy & Molk.

Table 1. (continued)

Reference	Amount	Taxon
He (1996) (continued)	34 species 7 varieties	<i>F. gymnogynus</i> Besch. <i>F. hollianus</i> Dozy & Molk. <i>F. javanicus</i> Dozy & Molk. <i>F. kinabaluense</i> Iwats. <i>F. laxitextus</i> Broth. ex Gangulee <i>F. laxus</i> Sull. & Lesq. var. <i>laxus</i> (syn.= <i>F. mittenii</i> Par. var. <i>mittenii</i> , <i>F. crassinervis</i> Lac. var. <i>laxus</i> Sull. & Lesq.) <i>F. laxus</i> Sull. & Lesq. var. <i>javensis</i> (Fleisch) Tan & Mohamed (syn. = <i>F. mittenii</i> Par. var. <i>javensis</i> Fleisch.) <i>F. microcladus</i> Thwait. <i>F. nobilis</i> Griff. <i>F. oblongifolius</i> Hook. f. & Wils. <i>F. obtuso-apiculatus</i> Dix. <i>F. papillulosus</i> Broth. <i>F. polypodioides</i> Hedw. (syn.= <i>F. areolatus</i> Griff.) <i>F. sedgwickii</i> Broth. & Dix. <i>F. semperfalcatus</i> Dix. (syn.= <i>F. crenulatus</i> Mitt.) <i>F. subangustus</i> Fleisch. <i>F. subspathulatus</i> Dix. <i>F. taxifolius</i> Hedw. <i>F. virens</i> Thwaites & Mitt. <i>F. wichurae</i> Broth. & Fleisch. <i>F. zippelianus</i> Dozy. & Molk. var. <i>zippelianus</i> (syn.= <i>F. sylvaticus</i> Griff.) <i>F. zippelianus</i> var. <i>fontanus</i> Fleisch. (syn.= <i>F. sylvaticus</i> Griff. var. <i>fontanus</i> (Fleisch.) Giesy & Richards forma <i>minor</i> Giesy & Richards) <i>F. zippelianus</i> var. <i>robinsonii</i> (Broth.) Z. Iwats. & Suzuki <i>F. zollingeri</i> Mont. (syn.= <i>F. xiphioides</i> Fleisch.)

Classification of *Fissidens*

Fissidentaceae is the only family in Order Fissidentales, Division Bryophyta, Subdivision Bryidae, Class Bryopsida. Fissidentaceae is an erect moss group (acrocarpous), producing archaegonia and sporophytes mostly at the tip of the main stem. This family is consists of only one genus, *Fissidens* Hedw.

Fissidens is one of the most diversified moss genera which includes about 450 species (Pursell, 2007). The genus is found in temperate and tropical areas throughout the world. *Fissidens* occurs on soil, rocks, trees, and a few species live in fresh water. In Thailand, they can be found in moist habitats with moderate temperature, under wide range of elevations, c. 30-2565 m elevation.

Morphological characteristics

1. Gametophyte

1.1 Growth form and stem characters

Fissidens grow mostly in clusters and have erect, often parallel, stems. Plant sizes vary from a few millimeters to several centimeters, with the colors of light green, green to dark green or reddish-brown. *F. nobilis* is the largest species and *F. angustifolius* is the smallest in Thailand.

Stems are simple or irregularly branched (Figure 1). Most Thai *Fissidens* have a simple stem. Stems are with or without axillary hyaline nodules (Figure 2), a central strand is present or absent (Figure 3), and rhizoids are basal or axillary, smooth or papillose.

1.2 Leaf characters

The leaves are alternate, flat in one plane, distichous, and clasp the stem (Figure 4). Each leaf consists of three parts (Figure 5) 1. vaginant laminae or sheathing laminae (a sheath found in the lower inner half of leaf), 2. apical laminae (the part above vaginant laminae on the same side of costa), and 3. dorsal laminae (entire dorsal surface). A costa (midnerve) is almost always present.

Leaf shapes vary from, ovate, ovate-lanceolate, lanceolate, narrowly-lanceolate to linear and oblong (Figure 6). The apex is acute, acuminate or obtuse. The base either extend beyond the insertion (decurent) or not.

The margin is entire, crenate, serrate, or dentate (Figure 8) and either bordered or not. The leaf border or limbidium is differentiated with elongate, hyaline, smooth, thick-walled cells, and usually with up to 3 rows, 1 cell thick (unistratose) or sometimes 2- to many cells thick (multi-stratose) (Figures 7 and 8).

Laminal cells are variable, *viz.* smooth, mammillose, unipapillose, or multipapillose. The leaf cells are mostly arranged in 1 layer, sometimes 2-multi-stratose. Leaf cell shapes vary from irregularly hexagonal to orbicular, isodiametric, or elongate. The costa is usually well-developed, percurrent (to the tip), excurrent (beyond the tip) (Figures 5b, 9), or ending below the leaf apex (Figures 5a, 9). It is rarely indistinct or lacking.

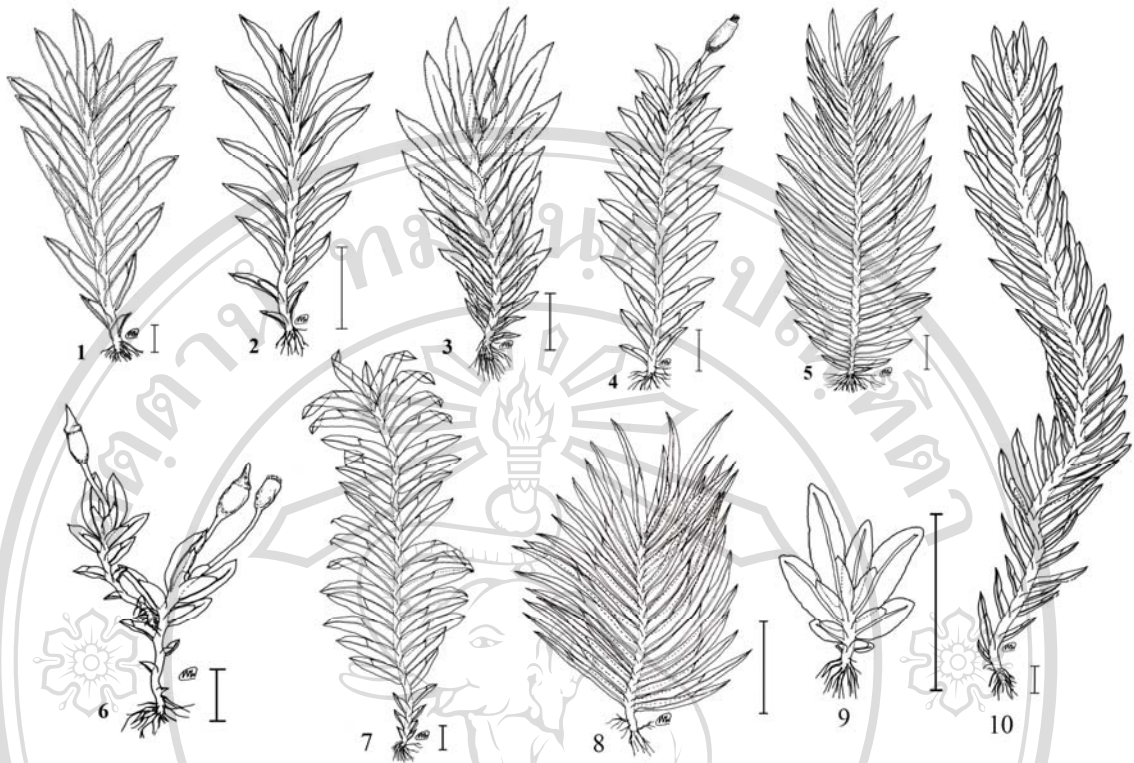


Figure 1. Stem.

1. *Fissidens anomalus*, 2. *F. flabellulus*, 3. *F. flaccidus* var. *flaccidus*, 4. *F. gymnogynus*, 5. *F. javanicus*, 6. *F. guangdongensis*, 7. *F. oblongifolius*, 8. *F. kinabaluense*, 9. *F. tenellus* var. *australiensis*, 10. *F. geminiflorus*. All scales = 1 mm.

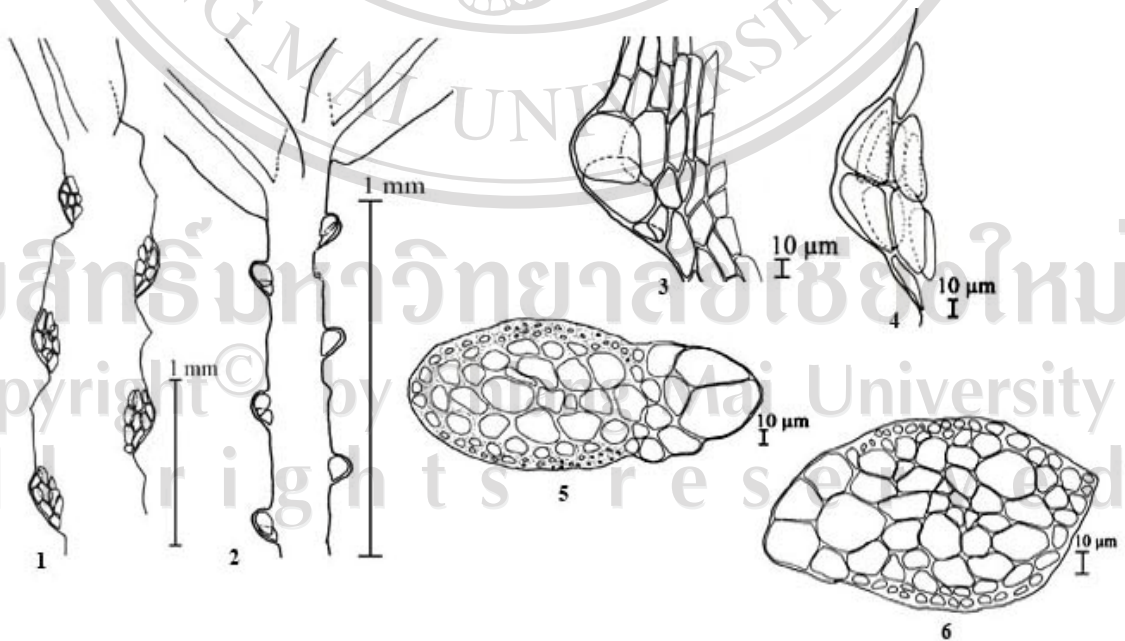


Figure 2. Hyaline nodules.

1-4. hyaline nodules, 5-6. hyaline nodules (cross-section), 1, 3, 5. *F. subangustus*, 2, 4, 6. *F. crispulus* var. *robinsonii*.

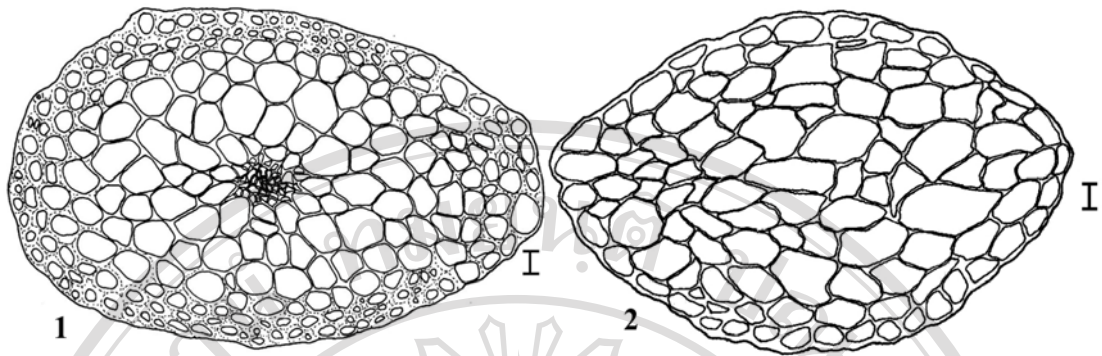


Figure 3. Stem cross-section.
1. central strand present (*F. anomalus*), 2. central strand absent (*F. beckettii*). All scales = 10 μ m.

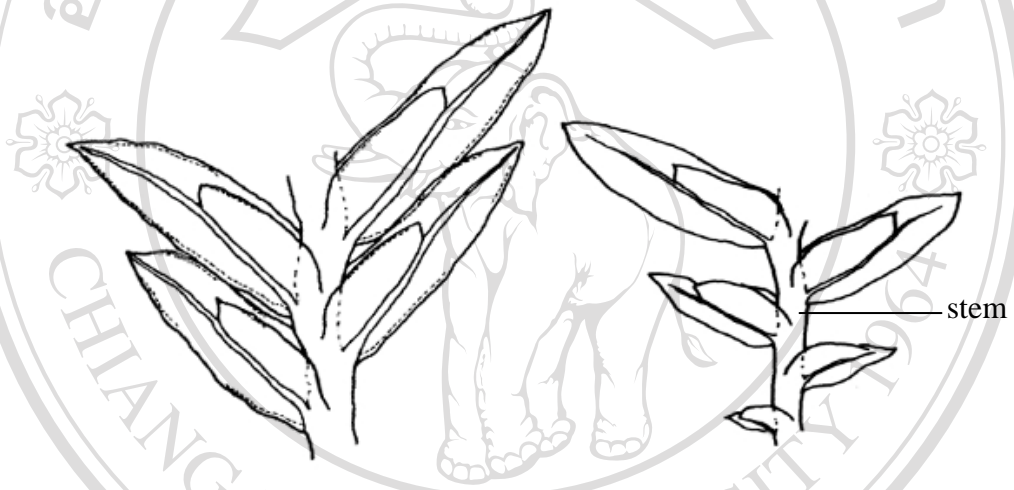


Figure 4. Distichous leaf arrangement.

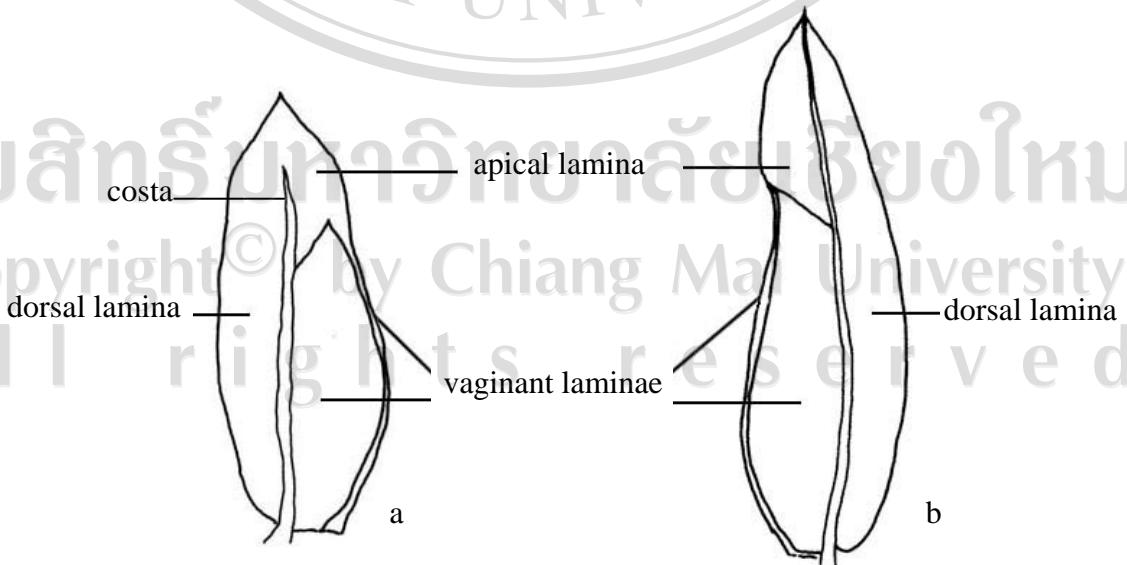


Figure 5. Leaf parts.

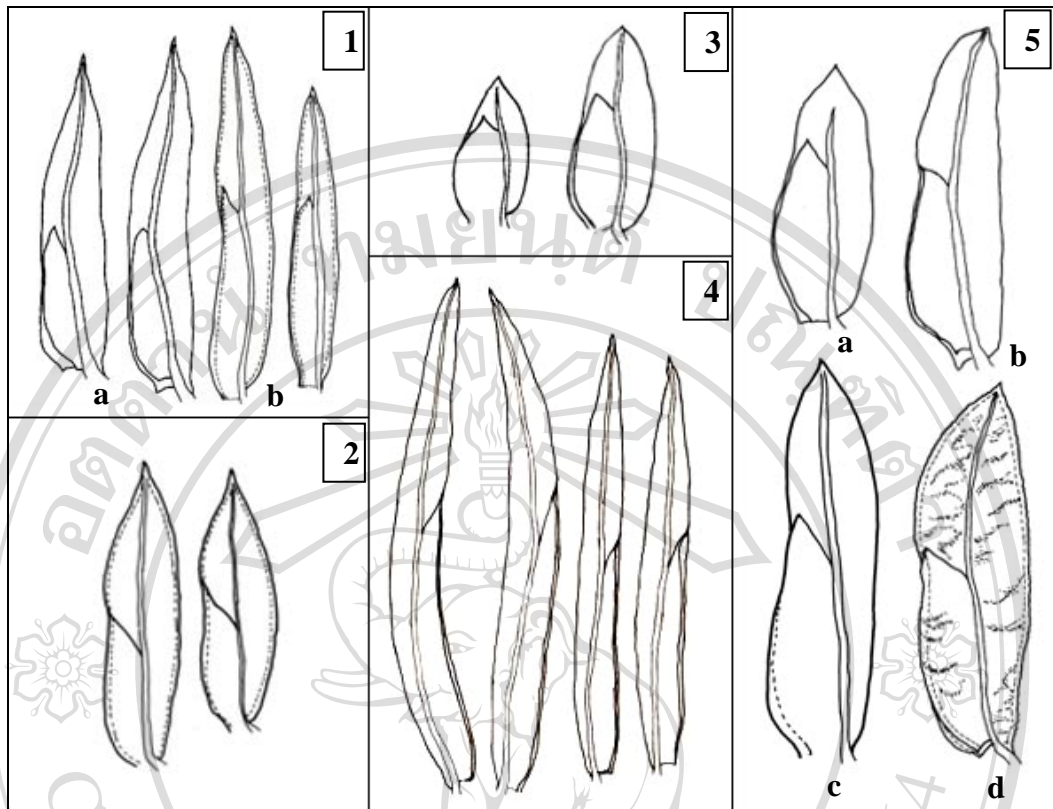


Figure 6. Leaf shapes.

1. lanceolate (a: *F. crassinervis*, b: *F. biformis*), 2. ovate-lanceolate (*F. bryoides* var. *schmidii*), 3. ovate (*F. filiformis*), 4. linear (*F. kinabaluense*), 5. oblong (a: *F. quangdongensis*, b: *F. polypodioides*, c: *F. firmus*, d: *F. anomalus*).

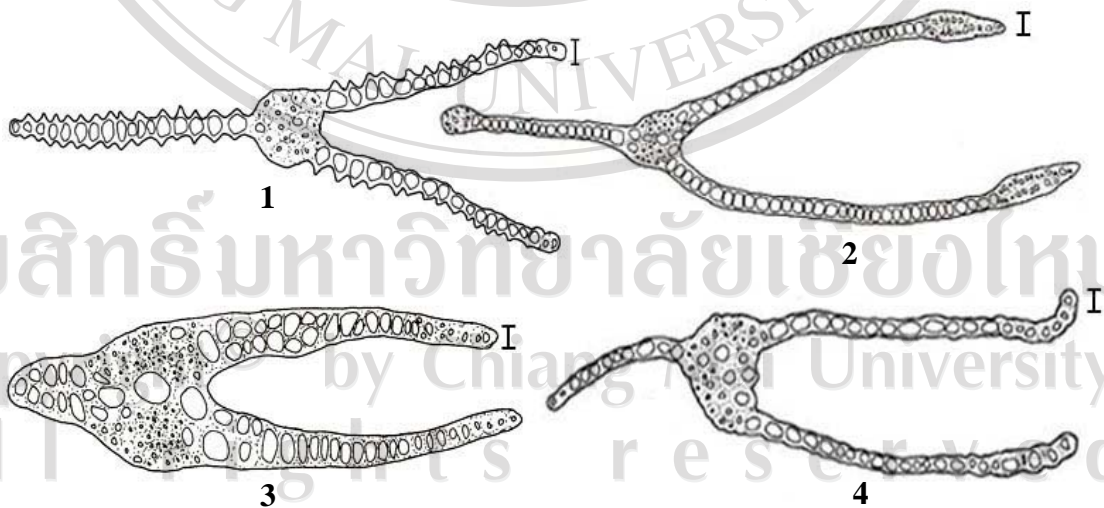


Figure 7. Leaf cross-section.

1. leaf limb unistratose and lamina cells unipapillose (*F. crenulatus* var. *crenulatus*), 2. leaf limb multi-stratose (*F. geppii*), 3. lamina cells multi-stratose (*F. sedgwickii*), 4. limb and lamina cells unistratose and lamina cells smooth (*F. beckettii*). All scales = 10 μ m.

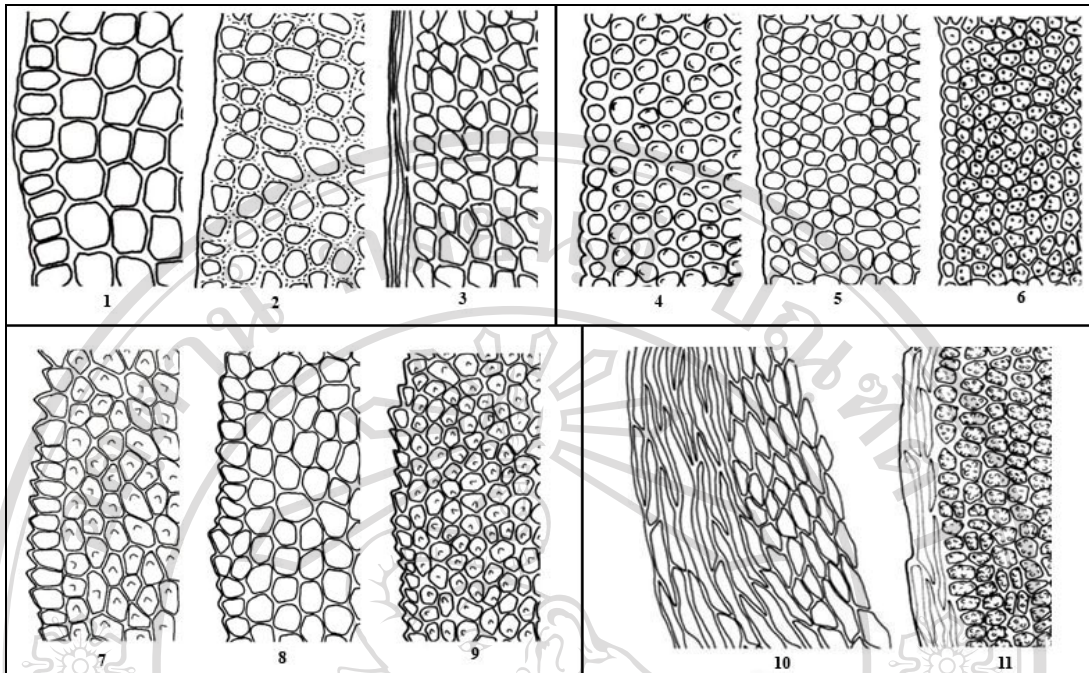


Figure 8. Leaf margin and lamina cells.

1. entire margin, leaf cells smooth, thin-walled (*F. guangdongensis*), 2. entire margin, leaf cells smooth, thick-walled (*F. crassinervis*) 3. entire margin, limbidia, smooth, thin-walled (*F. taxifolius*), 4. crenate margin, leaf cell mammillose, thin-walled (*F. involutus*) 5. crenate margin, leaf cell smooth, thin-walled (*F. firmus*) 6. crenate margin, leaf cell multipapillose, thin walled (*F. subangustus*), 7. serrate margin, leaf cells unipapillose, thin-walled (*F. serratus*), 8. serrate margin, leaf cells smooth, thin-walled (*F. flabellulus*) 9. serrate margin, leaf cells unipapillose, thin-walled (*F. crenulatus*), 10. limbidia, leaf cells smooth, thin-walled (*F. beckettii*), and 11. limbidia, leaf cell multipapillose, thin-walled (*F. ceylonensis*).

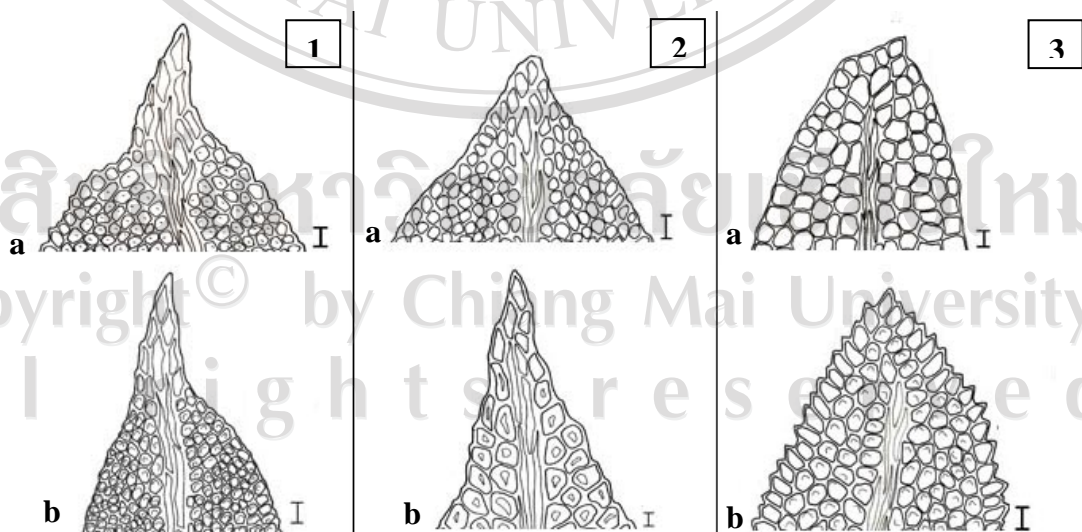


Figure 9. Leaf apex.

1. excurrent costa (a: *F. taxifolius*, b: *F. crispulus* var. *robinsonii*), 2. percurrent costa (a: *F. geminiflorus*, b: *F. pellucidus*), 3. costa ending below the leaf apex (a: *F. guangdongensis*, b: *F. tenellus* var. *australiensis*). All scales = 10 μ m.

1.3 Reproduction of *Fissidens*

Fissidens is either be dioicous (plant with archegonia and antheridia on separate plants), or autoicous (plants with archegonia and antheridia on separate branches of the same plant), or synoicous (plant with archegonia and antheridia mixed in the same gametoeceium). Most *Fissidens* are dioicous, some are autoicous such as *F. angustifolius* (Figure 10 a-f) and a few are synoicous. Perichaetial leaves are terminal or axillary; perichaetial and perigonal leaves are variable in size, smaller or larger than vegetative leaves, and ovate-lanceolate to subulate-lanceolate (Figure 11).

Gemmae are a type of vegetative diaspore with cylindric bodies consisting of a few cells. *F. flaccidus* var. *flaccidus* is only Thai *Fissidens* species producing gemmae (Figure 10 g-h).

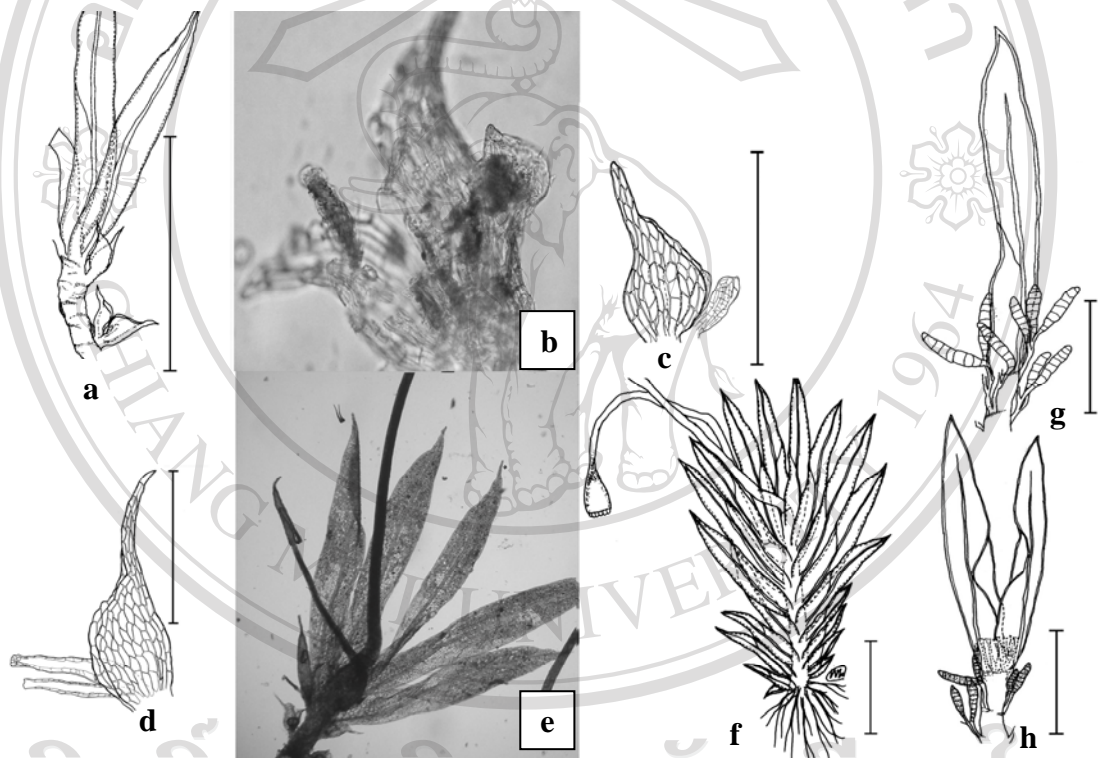


Figure 10. Autoicous and vegetative reproduction.

a. autoicous: plant with archegonia and antheridia on separate branches of the same plant (*F. angustifolius*), b, c. perigonia and antheridia (*F. angustifolius*), d. perichaetial and archegonia (*F. angustifolius*), e, f. plant with sporophyte (*F. angustifolius*), g, h. vegetative reproduction in cylindric gemmae of *F. flaccidus* var. *flaccidus*. All scales = 1 mm.

2. Sporophyte characters

Sporophytes are terminal or lateral (Figure 12). The setae are mostly smooth, rough in *F. hollianus* and *F. firmus*; mostly elongate, sometimes very short to immersed e.g. *F. anomalus* and *F. firmus*. Capsules are mostly symmetrical, rarely asymmetrical e.g. *F. beckettii*, erect, inclined, or curved. There is no annulus. The

operculum is mostly short to long-rostrate, sometimes conic. The calyptra is mostly cucullate, rarely mitrate, usually smooth, and in some species scabrous, e.g. *F. angustifolius* and *F. serratus*. The peristome is in one layer of 16 bifid teeth, red to reddish, brown, and smooth to papillose. The spores are spherical, mostly smooth, some finely papillose, 7-25 μm diameter.

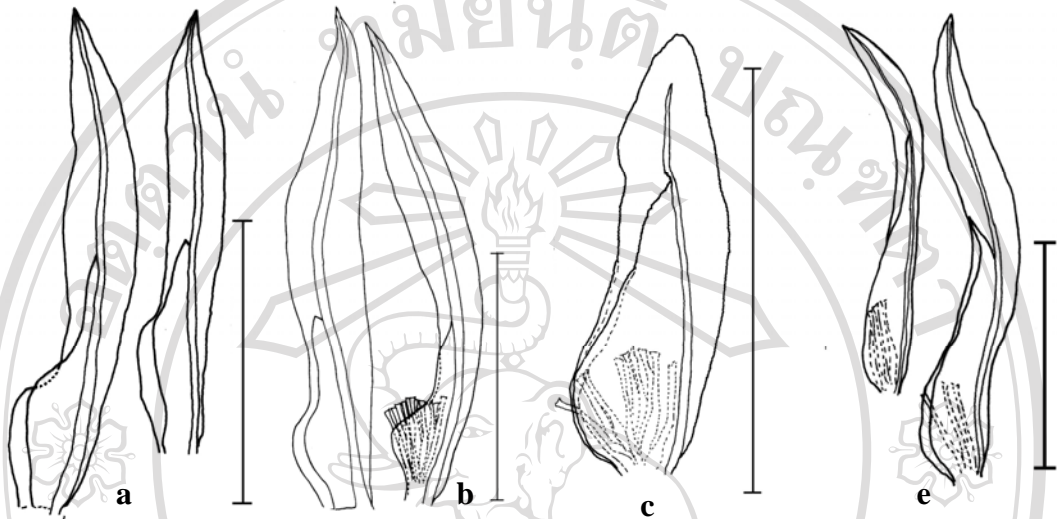


Figure 11. Perichaetial leaves.

a: *F. pellucidus*, b: *F. crassinervis*, c: *F. guangdongensis*, e: *F. taxifolius*. All scales = 1 mm.

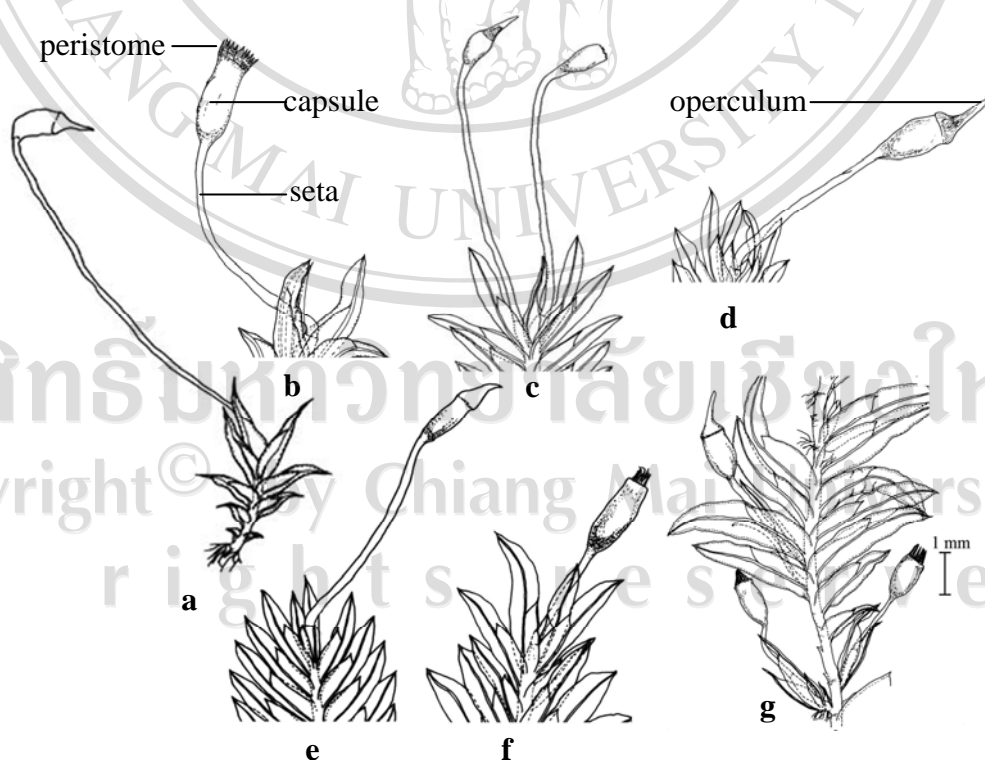


Figure 12. Sporophytes.

a-f: sporophytes terminal (a: *F. beckettii* b: *F. bryoides* var. *esquirolii*, c: *F. geppii*, d: *F. ceylonensis*, e: *F. firmus*, f: *F. gymnogynus*), g: sporophytes lateral (*F. anomalus*).

Phenology

The phenology of Thai *Fissidens* is poorly understood. I have included notes on this for all taxa, *i.e.* months when gametophytes and sporophytes have been found. For lowland (below 850 m elevation) deciduous forest taxa which grow on bare soil are presumed to be annual. Forests above 850 m the taxa are probably evergreen (*i.e.* perennial), especially in permanent streams and wet places. Since sporophytes for 15 taxa have not been during this research, I can only assume that they are seen produced during the rainy season.

Vegetation of Thailand

Thailand is situated Southeast Asia, between the latitudes 6°-20° N and longitudes 98°-105° E, sharing borders on west and northwest by Myanmar (Burma), on the northeast by Laos, southeast by Kampuchea (Cambodia), and in the south by Malaysia (Figure 13). The country is *c.* 1,620 km long, 780 km wide, with an area of 513,115 square kilometers. The elevation ranges from sea level to 2565 meters. Most of the mountains over 1000 m are in the north with the exception of Khao (Mt.) Kieo (1200 m) in the central area, Khao Soi Dao in the southeast (1556 m), and Khao Luang (1800 m) in the peninsula (Maxwell, 2001). Thailand is divided politically into 76 provinces. There are seven floristic regions (Figure 13), *i.e.* Northern (N), Northeastern (NE), Eastern (E), Central (C), Southeastern (SE), Southwestern (SW), and the Peninsular (PEN). The following are descriptions of the vegetation of each division (He, 1996; Maxwell, 2004).

In Thailand, there are two main types of forest, *viz.* evergreen and deciduous. During the past century the forest cover of Thailand has been reduced to 15% (Maxwell, 2001), most of which is in the north. The amount of forest cover has decreased throughout in this country because of increasing upland human population which has destroyed forests for agriculture; urban expansion, and economic development. A variety of forests are presented in Thailand, which can be divided into 24 forest types (Table 2) (Maxwell, 2001 and 2004).

Northern division (N): This division is under the Indo-Burmese floristic influence. The region is rich in mountains over 1500 m elevation having the highest peak (Doi (mt.) Inthanon, 2565 m) in Thailand. Types of forests range from deciduous dipterocarp-oak forest and deciduous hardwood with bamboo forest below 850 m, mixed evergreen+deciduous seasonal forest 850-1000 m, and primary, evergreen, seasonal, hardwood forest above 1000 m (Maxwell 2001 and 2004). Floristic affinities are close to southwestern China as well. Both historically and in recent times, northern Thailand has received the most attention of botanists who have collected bryophytes. The division includes 17 provinces.

Northeastern division (NE): This region corresponds to the Indochinese flora, but some Indo-Burmese elements can also be found here. Primary, evergreen, seasonal hardwood with pine forest is present above 1000 m. A significant number of bryophytes have been collected from this region. This division includes 11 provinces.

Eastern division (E): This region is under the influence of the central and southern Indochinese flora. Deciduous dipterocarp-oak forests are the main feature of the region. Deciduous dipterocarp-oak forest can be seen adjacent to deciduous, seasonal, hardwood+bamboo forest. No significant bryophyte collections have been made from this region. This division includes 8 provinces.

Central division (C): This division corresponds with the Bangkok plain or central valley. The region is mostly under cultivation. Original forests have almost totally disappeared. Little bryological field work has been carried out in this area. The division has 10 provinces.

Southeastern division (SE): This region is under the influence of both Indochinese and Malayan floras. Deciduous dipterocarp-oak forests are widespread in the plains and primary, evergreen, seasonal, hardwood forest in the mountains. Mangrove and beach vegetation are found along the coast and along the estuaries of the main rivers. Bryophyte collecting has been relatively well-done in this region. This division has 8 provinces.

Southwestern division (SW): This region is predominated by limestone topography and corresponds with the Burmese flora. Deciduous, seasonal, hardwood+bamboo forest is present in the region near the border between Myanmar and Thailand. This forest often gradually changes into deciduous dipterocarp-oak forests due to fire and logging. Only a few of bryophytes have been collected here. This division includes 8 provinces.

Peninsular division (PEN): This region is mostly under the influence of the Malayan flora. The Malayan elements are fairly common in the region although in the northern part of the region Burmese elements are present. The forests are mainly primary, evergreen, seasonal, hardwood forest. Mangrove vegetation in the region is rapidly disappearing. A large number of bryophyte collections have been made from this region. This division includes 14 provinces.

Table 2. Simplified classification for forest/vegetation types in Thailand (Maxwell, 2001 & 2004).

Forest Type		Primary Growth	Secondary/Degraded Growth (da/sg)	Tertiary Growth (da/sg)	Elevation (m)
Seasonal (Monsoonal)	Almost ever-wet (rain forest)	evergreen (egf)	evergreen scrub	bamboo thickets, grassland, cultivated areas, plantations	sea level – c. 1800
	Distinctly Seasonal	evergreen hardwood (egf)	evergreen + bamboo (eg/bb) deciduous dipterocarp-oak	bamboo thickets, grassland, cultivated areas	sea level – c. 1000 – c. 2565*
		deciduous hardwood with bamboo (bb/df)	bamboo thickets, grassland, deciduous dipterocarp-oak (dof)	cultivated areas	sea level – c. 850
		mixed evergreen+deciduous hardwood (mxf)	bamboo+ mixed evergreen+ deciduous scrub, deciduous dipterocarp-oak (dof)	bamboo thickets, grassland, cultivated areas	sea level – c. 1000
		evergreen+pine (eg/pine), deciduous dipterocarp-oak with pine (do/pine)	deciduous dipterocarp-oak (dof)	grassland, cultivated areas	c. 60– c. 1800
Aquatic	Saline	mangrove	no vegetation, mangrove scrub	no vegetation	sea level – 25
	Fresh	lakes, pond, swamps, marshes, river, etc.	scrub, grassland, cultivated areas	scrub, grassland, cultivated areas	sea level – 2550
Beach	beach vegetation	scrub, grassland	grassland, cultivated areas	sea level	

*in peninsula and central Thailand egf can be found starting at or near sea level, but in northern Thailand, where the dry season is longer and more severe, it starts at about 1000 m.

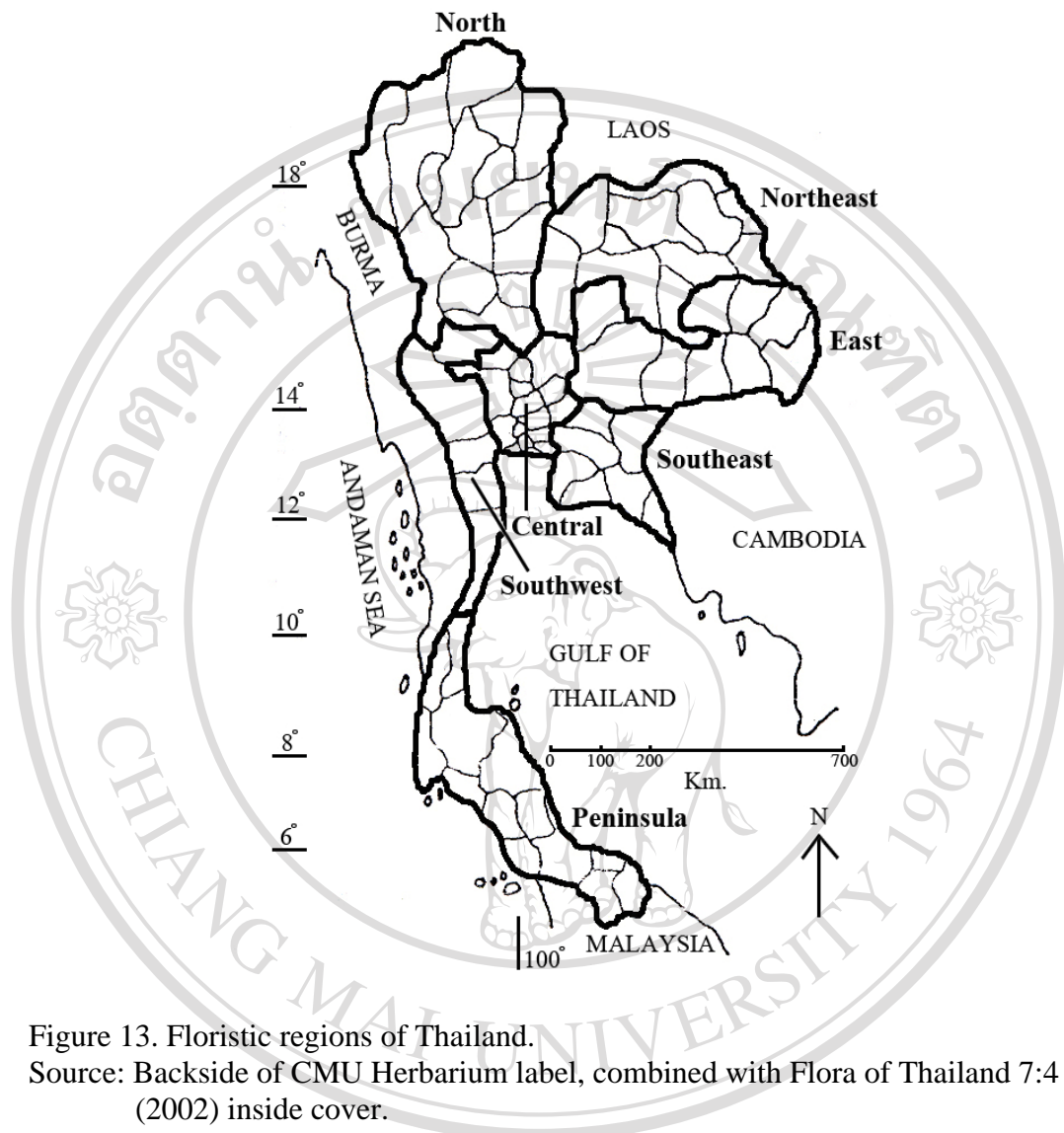


Figure 13. Floristic regions of Thailand.

Source: Backside of CMU Herbarium label, combined with Flora of Thailand 7:4 (2002) inside cover.

Climate

The climate in Thailand is characterized by a tropical monsoon system which reverses its cycle seasonally. The NE monsoon (dry) is from October-November to February-March and the SW monsoon (wet) lasts from April-May to October. Northern Thailand has three seasons, *viz.* rainy (May-October), cool-dry (November-February), hot-dry (March-April). The amount of rainfall decreases (3000-4000 mm/year) from the peninsula to the north (1000-2000 mm/year) (Figure 14) (Maxwell, 2004).

The annual cycle for temperatures and rainfall in Thailand are show in Figure 15. The hottest periods are March-May and rainfall peaks during August-October.

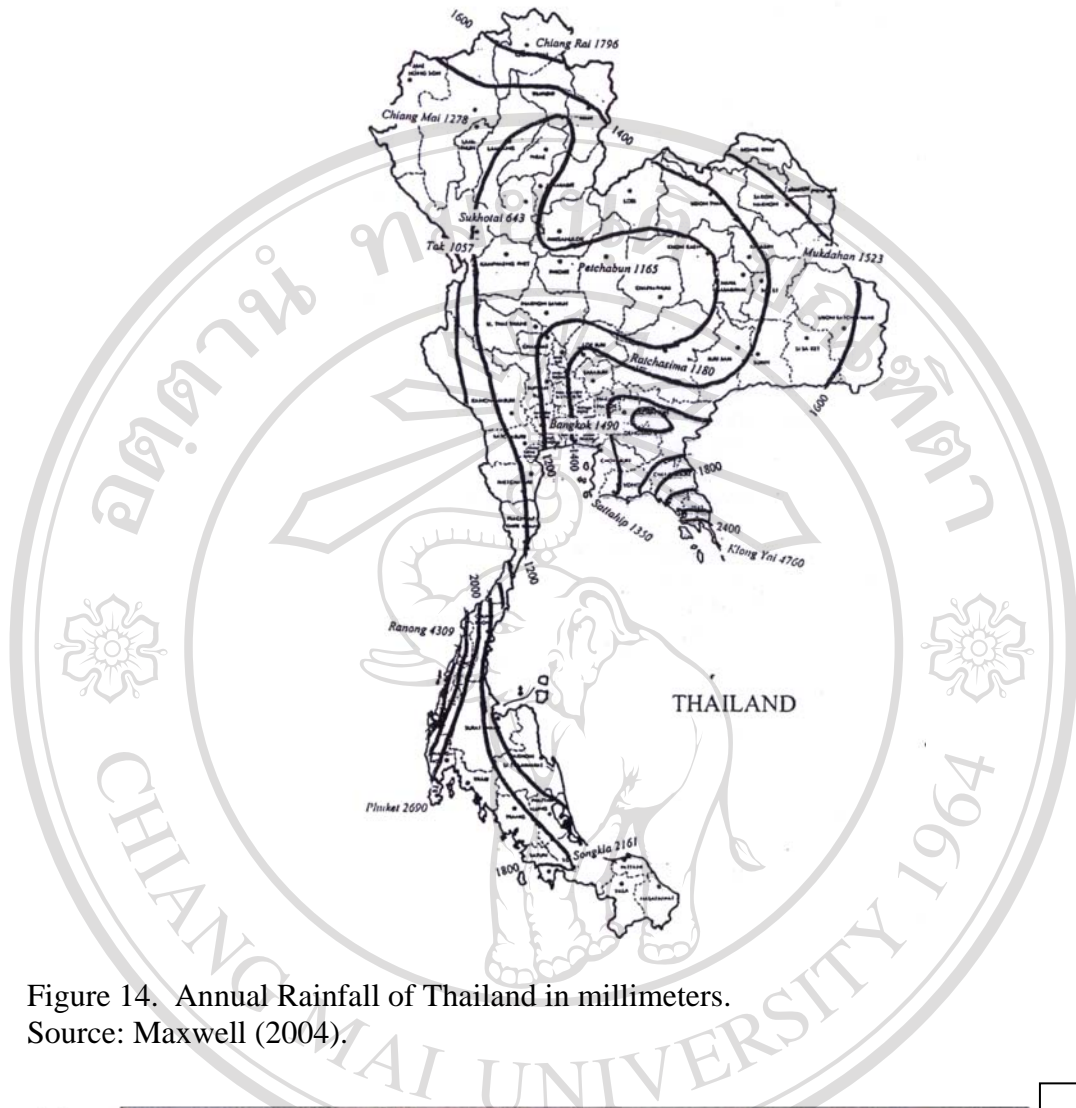


Figure 14. Annual Rainfall of Thailand in millimeters.
Source: Maxwell (2004).

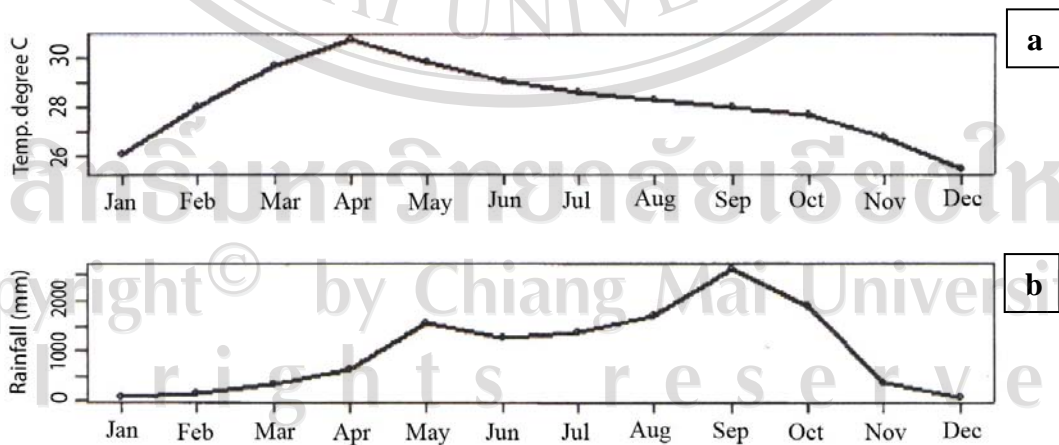


Figure 15. Annual monsoon cycle in Thailand: a: temperature, b: rainfall
Source: redrawn from “Interannual and Interdecadal Variability of Thailand Summer Monsoon Season”, Singhrattna *et al.*, (2005) 1701.