

Families and Genera of the Pteridophytes Known from Thailand

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ABSTRACT Definitions are revised for all the families of the pteridophytes known from Thailand. An artificial key to the families is given for all the thirty-four families treated, which are diagnosed in the following enumeration. The genera included are enumerated for all the Thai representatives, and some notes are added when there are different opinions for classification.

Introduction

There are several different systems recently published for the pteridophytes. They have no general agreement for defining the families and genera, though most of the genera are related in the same way. Among those presented in the past thirty-five years, we take into account for special reference the systems by Christensen (1), Ching (2, with some subsequent emendations), Copeland (3, with emendation in 4), Holttum (5 and 6, with emendations in 7 and the others), Reimers (8), Alston (9), Pichi Sermolli (10), and Nayar (11).

In the course of the compilation of the pteridophytes in the Flora of Thailand, it is necessary for us to give here the definition of the families included in that Flora. Many genera are still hardly referable to any of the families, and the authors place them in various families. There are many things to be done in order to elucidate the systematic position of these problematic genera, and a few data have been added by our own work for that Flora. In the following enumeration of the families of the pteridophytes found in Thailand, we prefer to follow generally the system by Holttum (7), though there are some emendations made in the systematic work in recent years. The classification in this paper may be rather conservative, but it may be suggested to follow the more general system for the preparation of a local flora. We do not like to go further

on the taxa in the ranks higher than the families, and will pass over the matter by giving a short list for the higher taxa of the recent pteridophytes.

Psilopsida — Psilotales (Psilotaceae and Tmesipteridaceae).

Lycopsida — Lycopodiales (Lycopodiaceae), Selaginellales (Selaginellaceae), and Isoetales (Isoetaceae).

Sphenopsida — Equisetales (Equisetaceae).

Pteropsida — Ophioglossales (Ophioglossaceae), Marattiales (Marattiaceae), Filicales (about thirty families; Matoniaceae, Lophosoriaceae, Loxomaceae, and Hymenophyllopsidaceae are not represented in Thailand), Marsileales (Marsileaceae), and Salviniiales (Salviniaceae and Azollaceae).

In the following enumeration, the families are defined by short diagnosis and genera included are given for all the Thai representatives. It is intended in this paper only to enumerate the Thai genera according to our definition of families. Short notes are given in some cases where they are necessary, though more detailed discussion will be made in the notes on the genera and the species concerned in the Flora of Thailand, or in separate papers. The notes are restricted to the genera in Thailand, but a few genera not found in Thailand are taken up for discussion when it is inevitable.

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Artificial key to the families known in Thailand

- Roots and leaves not developed.....Psilotaceae
 Roots and leaves developed, or extinct in some species.
 Leaves microphyllous, stele without any leaf gaps.
 Leaves not whorled; stem without differentiation into nodes and internodes.
 Leaves lacking ligules; isosporous..... Lycopodiaceae
 Leaves with ligules; heterosporous.
 Land plants; stems elongate bearing smaller leaves and rhizophores.....
 Selaginellaceae
 Aquatic plants; stems tuberous bearing long leaves..... Isoetaceae
 Stems differentiated into nodes and internodes, bearing whorled leaves at nodes
 Equisetaceae
 Leaves macrophyllous; leaf gaps generally distinct.
 Eusporangiate.
 Leaves partially dimorphic; vernation erect..... Ophioglossaceae
 Leaves not dimorphic; vernation circinate..... Marattiaceae
 Leptosporangiate.
 Isosporous; vernation circinate.

Annulus rudimentary.

- Terrestrial; chaetopteroid; venation all free.....Osmundaceae
 Aquatic; lepidopteroid; venation reticulate, areoles without included
 veinlets..... Parkeriaceae (*Ceratopteris*)

Annulus distinct.

Annulus transverse; sporangia in a sorus maturing simultaneously.

- Annulus apical; sporangium solitary, subtended by an outgrowth so-
 called pseudo-indusium..... Schizaeaceae
 Annulus medial; sporangia a few in a sorus, exindusiate.....
 Gleicheniaceae

Annulus oblique or longitudinal; sporangia in a sorus maturing not simul-
 taneously but basipetally or without any regular order.

Annulus oblique, continuous.

- Lamina thin, usually one cell in thickness, without stomata
 Hymenophyllaceae
 Lamina normally constructed with various tissues, the epidermis with
 stomata.

Fronds pinnate to decompose, or very rarely simple; rhizome scaly.

- Trichomes wanting; dimorphic; base of stipes enlarged
 Plagiogyriaceae

Rhizome and fronds both bearing hairs or scales; fronds not
 dimorphic; stipes without swollen bases.

- Chaetopteroid; sori terminal on veinlets, marginal, protected
 by an indusium consisting of two concave flaps
 Dicksoniaceae

Lepidopteroid; sori dorsal on veinlets, exindusiate or with a
 thin cup-shaped indusium..... Cyatheaceae

Fronds simple or dichotomously forked into two lobes; chaetopteroid.

- Fronds not dimorphic; sori punctiform or elongate along veinlets...
 Dipteridaceae

Fronds dimorphic; fertile laminae linear lanceolate, acrostichoid...
 Cheiroleuriaceae

Annulus longitudinal, interrupted.

- Sori enclosed by revolute lamina..... Athyriaceae

Sori not enclosed by revolute lamina.

Sori round or oblong.

Stipes and/or pinnae articulated.

Sori indusiate.

Rhizome scales peltate; indusia opening at end and sides.

- Rhizome dorsiventral in construction..... Davalliaceae

Rhizome radial in construction..... Oleandraceae

Rhizome scales attached at base; indusia opening on top

-Athyriaceae (*Woodsia*)

Sori naked.

- Fronds simple, pinnatifid, or pinnae..... Polypodiaceae
 Fronds tripinnate..... Davalliaceae (*Gymnogrammitis*)
 Neither stipes nor pinnae articulated.
 Chaetopteroid..... Dennstaedtiaceae
 Lepidopteroid.
 Usually terrestrial; fronds mediocre to larger, pinnate to
 pinnately decomposed; spores bilateral.
 Stipes with several vascular bundles; fronds commonly
 oblong subdeltoid in outline; rhizome scales not hairy
 Peranemaceae
 Stipes containing two hippocampus-type bundles; fronds
 commonly oblong lanceolate in outline.
 Setose hairs present on various parts of fronds; rhizome
 scales hairy..... Thelypteridaceae
 Coarse multiseptate hairs present or absent on axes of
 fronds; setose hairs absent; rhizome scales glabrous
 Athyriaceae
 Usually epiphytic; fronds smaller, simple to pinnate, rarely
 decomposed, often setose hairy; spores tetrahedral
 Grammitidaceae
 Sori not round.
 Sori in marginal cup.
 Stipes not jointed to rhizome; chaetopteroid...Dennstaedtiaceae
 Stipes jointed to rhizome; lepidopteroid..... Davalliaceae
 Sori dorsal or marginal, not in marginal cup.
 Sporangia protected by reflexed margin.
 Sori elongate along margin..... Pteridaceae
 Sori not elongate along margin..... Parkeriaceae
 Sporangia not protected by reflexed margin.
 Sporangia in elongate sori.
 Sori indusiate.
 Sori marginal..... Lindsaeaceae
 Sori dorsal.
 Sori elongate parallel to costae..... Blechnaceae
 Sori oblique to costae.
 Two bundles in stipes united upwards into a single
 strand, X-shaped in cross section; scales clathrate
 Aspleniaceae
 Two bundles in stipes united upwards into a single
 strand, U-shaped in cross section; scales not clathrate
 Athyriaceae
 Sori exindusiate.
 Trunks distinct, usually more than 1 m tall
 Blechnaceae (*Brainea*)

- Trunks absent, or small if any.
 Stipes jointed to rhizome.....Polypodiaceae
 Stipes not jointed to rhizome.
 Fronds simple, entire or rarely forked at apex.
 Sori in grooves, with paraphyses; spicular idioblasts present among epidermal tissue.....
 Vittariaceae
 Sori without paraphyses; no spicular idioblasts among epidermal tissue.
 Sori elongate parallel to costae; fronds with stellate hairs...Grammitidaceae (*Scleroglossum*)
 Sori oblique; fronds lacking hairs.....
 Polypodiaceae (*Loxogramme*)
 Fronds pinnate or pinnately compound.
 Setose hairs present on various parts of fronds; stipes containing two hippocampus-type bundles...
 Thelypteridaceae
 No setose hairs on fronds; stipes containing several bundles oblong in cross section.
 Spores bilateral..... Peranemaceae
 Spores tetrahedral..... Parkeriaceae
 Sporangia in coenosori.
 Rhizome not dorsiventral; scandent or mangrove plants
 Pteridaceae
 Epiphytic or terrestrial plants with dorsiventral rhizome.
 Veins free, or anastomosing into sagenioid venation without included veinlets or with free veins directed away from the midrib of pinnae, or with sinus teeth
 Lomariopsidaceae
 Venation drynarioid..... Polypodiaceae
 Heterosporous; aquatic plants.
 Rooting in mud; veneration circinate..... Marsileaceae
 Floating; veneration erect.
 Roots wanting..... Salviniaceae
 Roots present..... Azollaceae

Enumeration of the families

1. Psilotaceae

Stems in two portions, rhizome and aerial stems, both branching dichotomously, bearing no roots nor leaves; branches of aerial stems bearing scaly projections; synangia consisting of three sporangia, on ridge of branches, bearing a forked scaly projection at the base; spores bilateral.

There is only one genus included in this family, *Psilotum* which also occurs in Thailand.

On the systematic position of the Psilotaceae, as well as the Tmesipteridaceae which is not represented in Thailand, Bierhorst (12) proposed to place them among Filicales, close to the Stromatopteridaceae. He compared the features, especially of the gametophyte, juvenile sporophyte, extinct roots, branching of stem, and vascular construction, with those of the Stromatopteridaceae, and concluded that these two were similar to each other. The data given in his papers are really interesting, though we can not yet follow him in his conclusion at present. To determine the systematic position of the Psilotaceae, we may better wait further information on the taxonomic characters of these plants, especially on the reproductive organs.

2. Lycopodiaceae

Sporophytes differentiated into root, stem, and leaves; stems elongate, dichotomous or sympodial; leaves microphyllous, each with a single vein, without ligules, arranged in spirals or whorls; sporangia solitary at base on upper surface of sporophyll, forming cones or not; isosporous.

There are two genera included in this family: *Lycopodium* of some 180 species throughout the world, representing nine species in Thailand; and *Phylloglossum* with a single species, *P. drummondii*, in Australia and New Zealand, different from the other genus in vegetative structure sometimes considered as an permanently embryonic form.

There are opinions to split *Lycopodium* variously into several genera, or even into different families. According to the splitters, the Lycopodiaceae in the sense of this paper is subdivided into (with Thai species in parenthesis):

Urostachyaceae or Huperziaceae — *Huperzia* (*L. carinatum*, *L. hamiltonii*, *L. nummularifolium*, *L. phlegmaria*, *L. piscium*, *L. serratum*, and *L. squarrosum*)

Lycopodiaceae — *Diphasium*, *Lepidotis* (*L. cernuum*), *Lycopodiella*, and *Lycopodium* (*L. clavatum*)

Phylloglossaceae — *Phylloglossum*.

We do not consider it necessary to split the family so minutely, though the grouping of the species seems to be natural in the above list.

3. Selaginellaceae

Stems elongate, bearing leaves and rhizophores, branching dichotomously or pinnately, usually having foliar appearance; rhizophores geotrophic, dichotomously branching, bearing roots in earth; leaves monomorphic and spirally arranged, or as in all the Thai species dimorphic arranged in four rows, two ventral patent or ascending, larger, two dorsal smaller, adpressed to stems, directed to distal direction; sporophylls forming spikes; sporophylls monophyllous and arranged spirally forming cylindrical spikes, monophyllous and arranged in four rows forming spikes, or heterophyllous and arranged in four rows, two larger dorsal and two smaller ventral, or two smaller dorsal and two larger ventral; heterosporous, spores tetrahedral.

There are about 600 species belonging to this family consisting in a single genus, *Selaginella*.

4. Isoetaceae

Stems tuberous, with secondary growth, bearing slender leaves at apex, having the growth point at the bottom of the hollowed apex, with numerous roots underneath, divided into two or three lobes; leaves broad at base, ligulate and soriferous; sporangia solitary in wide hollow under ligules, large, covered by a velum, divided irregularly into several cells; heterosporous, monoecious, spores tetrahedral.

About 65 species are included in the genus *Isoetes*, and an allied genus, *Stylites*, consisting of two species from Peru, found only recently. Only one species of *Isoetes* is known in Thailand by only two collections.

5. Equisetaceae

Roots, stems, and leaves distinct; stems with nodes and internodes, bearing roots, branches, and leaves at nodes in whorls, empty, the surface with grooves and ridges; leaves uninervate, usually small, fused to the next ones to form sheath, the upper portion free forming teeth; cones consisting only of sporangiophores, terminal on stems or branches; sporangiophores hexagonal, peltate, bearing several sporangia; spores isosporous with elators; plants usually monomorphic, or rarely dimorphic.

There is only one living genus including about 25 species growing on wet ground in the temperate regions; only one species is known in Thailand.

6. Ophioglossaceae

Terrestrial or rarely epiphytic ferns of mediocre size, with erect veneration; rhizome subterranean, usually short, naked, fleshy; phyllomophore distinct or less, without stipular base; trophophyll simple or dissected, sporophyll stalked; sporangia marginal in two rows, rather large, with wall composed of multicell-layers, without annulus, opening by longitudinal or transverse slit; spores tetrahedral, numerous.

Genera in Thailand: *Ophioglossum* (incl. *Ophioderma*), *Botrychium* (*Sceptridium*), and *Helminthostachys*.

The fronds of this family consist of three parts: phyllomophores, or the stipes; trophophyll, or the sterile part; and sporophyll, or the fertile part. The morphological interpretation has not yet been appropriately given to them. Sporophyll is usually placed in the middle or the base of trophophyll, and is unique among the ferns. In spite of the absence in fossils, this family is considered to be primitive. There are no fossil or extant ferns closely referable to these eusporangiate ferns.

There is an opinion that both *Helminthostachys* and *Botrychium* should be separated to form distinct families recognizing more genera; here however we do not advocate the extreme splitting of this family, in which nearly a hundred species have been described from various parts of the world.

7. Marattiaceae

Terrestrial ferns of mediocre to huge size; rhizome short, erect or creeping, fleshy, naked; fronds circinate in veneration, digitately divided to bipinnate; stipes fleshy, with a pair of stipule-like outgrowths at base; pinnae similarly jointed to the rachis or top of stipes; sporangia in elongate or round dorsal sori, free or in synangia; sporangia with walls more than one cell in thickness, without annulus or with rudimentary one, maturing

simultaneously (Simplices), opening by ventral longitudinal slit; spores tetrahedral or bilateral, numerous.

Genera in Thailand: *Angiopteris*, *Christensenia*, and *Marattia*.

Six genera are known among the existing ferns, and some in fossils. All the existing genera are generally included in one family, though there are opinions to split this into a few families. The subdivision of this family should be into four which may better be treated as subfamilies: Angiopteridoideae (*Angiopteris*, *Macroglossa*, and *Archangiopteris*), Marattioideae (*Marattia*), Christensenioideae (*Christensenia*), and Danaeioideae (*Danaea*).

The number of species of *Angiopteris* is difficult to determine, being different according to the authors concerned. De Vries and Hieronymus described a number of species, many based on features unimportant under the focus of recent taxonomic views. Christensen enumerated in his third supplement of Index, 111 species, and this number is recognized as 'misgiving' by Copeland (3). Still more recently, Ching added a great number of new species. In his *Florae* (13), he described 62 new species of *Angiopteris* from China. He evaluated such features as form and size of pinnules, so-called false veinlets, position of sori, and so on for the specific characters. We have observed in the field that most of these features are quite variable, and we can discriminate the 'species' even among the fronds on a single stock by the key given by Ching. Specific classification should be completely revised for this genus.

8. Osmundaceae

Terrestrial perennials with massive, ascending, or erect rhizome without scales; stipe swollen at the base, bearing broad stipule-like flaps, covered when young with mucilage-producing hairs; not jointed to the rhizome; fronds pinnate to bipinnate or more deeply dissected, dimorphic, partly so, or uniform, chaetopteroid; veins all free; sporangia not forming definite sori, each originating in a single epidermal cell with a few surrounding cell to form its stalk, with some thickened cells near the distal end (rudimentary annulus), large, maturing simultaneously (Simplices); spores tetrahedral without perispore, containing chlorophyll, short-lived.

Genus in Thailand: *Osmunda* (*Osmundastrum* and *Plenasium*).

This is the most primitive family of the leptosporangiate ferns characterized by the stalk of the sporangium formed by a few epidermal cells other than that which becomes the sporangium. By this special feature, the order Osmundales may be distinguished for this family only, separating all the other families belonging to Filicales. Veins are all free and the sporangia are placed at the margin of extremely contracted, usually axial lobes forming no distinct sori (in *Osmunda*), or dorsal on laminae (in *Todea* and *Leptopteris*).

9. Plagiogyriaceae

Terrestrial ferns of medium size; rhizome short, erect or ascending, radial in construction, dictyostelic, bearing a rosette of fronds; stipes not jointed to the rhizome, bearing a broad stipule-like flap at the base, having a row of raised wart-like aerophores on each side of ridge, when young covered with mucilaginous glands; hairs and scales wholly wanting throughout the plants; fronds simply pinnate, dimorphic; veins parallel,

all free, distinct on both surfaces of sterile fronds; fertile fronds with longer stipes and narrower pinnae; sporangia seriate on the branches of veins, covering the whole of the under side of fertile pinnae except for midribs and thin edges, protected when young by reflexed edges; sporangia with oblique annulus, opening by a lateral slit, developing in mixed succession (Mixtae); spores tetrahedral, few (48).

There is only one genus containing about 40 Asiatic and a dozen of tropical American species.

Since the detailed classical study by Bower (14), no reliable evidence has been given to suggest the relationship of this family. It is doubtful whether it may be validly placed next to the Osmundaceae based only on the similarity of the winged and enlarged base of stipes. This feature is sometimes highly evaluated to relate *Plagiogyria* to the Osmundaceae, though the similar construction is also found in some species of the Athyriaceae with short erect rhizome. The complete absence of trichomes (in the sporophytes) is strange in the leptosporangiate ferns but occurs in some eusporangiate genera. For the specific classification of the Asiatic species, Ching (15) published a comprehensive revision, though his specific concept is rather narrow as usually the case in his recent work.

10. Gleicheniaceae

Terrestrial evergreen perennials; rhizome long creeping, protostelic or rarely solenostelic, bearing only hairs or both hairs and scales; fronds without any articulation, uniform, pinnate or more compound, the branching system various having the appearance of various forms of dichotomous branching by abortion of terminal bud; veins all free; sori dorsal on veinlets, with at most 10 sporangia, naked, maturing simultaneously (Simplices); sporangia broadly pear-shaped, sessile, opening by vertical slit; annulus transverse, complete; spores tetrahedral or bilateral, without perispore, usually numerous.

Genera in Thailand: *Gleichenia* and *Dicranopteris*.

There are various opinions on the generic classification of this family, though neither Nakai (16) nor Copeland (3) is reliable in the evaluation of key characters. Except for the New Caledonian *Stromatopteris* which has recently been raised to a monotypic family by Bierhorst (12) and excluding *Platyzoma* which also is sometimes treated as a distinct family by itself, Holttum (17) accepted only two genera in this family. His system including the classification in subgeneric rank is here followed in its entirety.

11. Schizaeaceae

Terrestrial perennials with creeping or ascending rhizomes bearing hairs or both hairs and scales (*Mohria*); stipes not jointed to the rhizomes; fronds erect or twining, of various forms; sporangia marginal in origin and dorsal on matured fronds, obovoid or pyriform, large, sessile or short-stalked, each protected by a small flap (false indusium), maturing simultaneously (Simplices); annulus distal, complete; spores tetrahedral or bilateral (*Schizaea*).

There are four living genera: *Schizaea* with about thirty species in the tropics and the southern hemisphere; the largely tropical American *Anemia* with about ninety species, one species in India and a few in Africa and Madagascar; cosmopolitan

Lygodium with some forty species; and *Mohria* with three African species. The important key character in the definition of this family is the structure of the sori: the sporangia are confined to very narrow fertile lobes of the leaflets (sorophores); sporangia large, shortly-stalked, each with a complete distal annulus, opening by a longitudinal slit. Except for these features, however, the genera of this family are fairly different from each other, and some consider that all of these four are so distinct as to justify the rank of family or even of order.

12. Hymenophyllaceae

Epiphytic and terrestrial ferns; rhizome creeping or erect, protostelic, radial in construction, hairy, sometimes without roots; stipes not articulated, hairy; fronds commonly small, simple to finely dissected, the ultimate segments small, usually uni-veined, laminae one cell in thickness except for veins, or rarely two to four cells thick, without intercellular spaces and stomata; veins dichotomous or pinnate; sori terminal, usually on clavate, rarely capitate, receptacles which are extramarginal extensions of veins; involucre with tubular or conical hollow at base, more or less dilated, often rather deeply divided into two lips; sporangia matured from base towards upper portion (Gradatae), with oblique complete annulus; spores tetrahedral.

The system of the filmy ferns as two comprehensive genera, *Trichomanes* and *Hymenophyllum*, had been criticized by various authors as not being natural until Copeland (3, 18) proposed his splitting system recognizing in total 34 genera for about 700 species, chiefly in the tropical regions and southern hemisphere. Some recent pteridologists have followed the system of Copeland, but others have not accepted the splitting in the generic rank of this family. At present we can only say that we have not yet been satisfied that any of the existing system of the filmy ferns is natural; there are problems in both the systems of the lumpers and those of the splitters. We shall follow here the system of Copeland as all his genera seem to be natural when the species occurring in Thailand are considered; and the two larger genera of the lumpers are not natural, as appropriately pointed out by Copeland (18), especially when the southern species are taken into account. This is, however, a tentative treatise, and it is highly necessary to revise the system of this family as a whole. The junior writer is preparing separate papers on the classification of the filmy ferns.

Genera in Thailand thus recognized are: *Callistopteris*, *Cephalomanes*, *Crepidomanes*, *Crepidopteris*, *Didymoglossum*, *Gonocormus*, *Hymenophyllum*, *Macroglena*, *Mecodium*, *Meringium*, *Microgonium*, *Microtrichomanes*, *Pleuroman*, *Selenodesmium*, and *Vandenboschia*.

13. Cyatheaceae

Tree ferns; rhizome erect, tall, forming a trunk to 10 m or more in height, scaly, bearing a rosette of fronds at apex; stipes scaly at base, not articulated; fronds usually large, arranged spirally, bearing both scales and hairs, pinnately compound; veins usually free; sori round, dorsal on veinlets, on distinct small round receptacles, often mixed with hairs; indusia cup-shaped opening at the top or wanting; annulus oblique, complete; spores tetrahedral.

On the basis of systematic comparison of various taxonomic features, Holttum

has recently revised the circumscription and the generic classification of this family. His system is given in Holttum & Sen (19), recognizing nine genera including *Cyathea*, *Cnemidaria*, *Lophosoria*, *Dicksonia*, *Cystodium*, *Thyrsopteris*, *Culcita*, *Cibotium*, and *Metaxya*. They are more commonly divided into three families: Cyatheaceae, Lophosoriaceae, and Dicksoniaceae. We have at present no additional data, though we prefer here to keep the hairy members separate from the scaly Cyatheaceae. We enumerate, therefore, only one genus, *Cyathea*, from Thailand.

The important difference between the system uniting the Cyatheaceae and the Dicksoniaceae and that separating the two is found in the evaluation of the characters of the soral origin. Holttum & Sen (19) consider that the dorsal sori of the Cyatheaceae are originally marginal and not distinct from those of the Dicksoniaceae. We need further analytical observation on this character before the establishment of the classification of the tree ferns.

14. Dicksoniaceae

Rhizome massive, densely covered with long golden yellow hairs, radial, complicated dictyostelic; stipes stout, not jointed to the rhizome, densely hairy at the base; fronds very large, pinnately decomposed; ultimate segments acute at apex; veins forked, all free; sori terminal on veins, submarginal, protected by cup-shaped or bivalved indusia; sporangia with oblique annulus, developing in gradate sequence; spores tetrahedral.

Among five genera, only one genus *Cibotium* is represented in Thailand by *C. barometz.*

15. Dennstaedtiaceae

Rhizome creeping, or erect in some foreign genera, covered only with hairs, or scaly in some genera, siphonostelic and usually dorsiventral; stipes not jointed to the rhizome, usually in two rows on rhizome; fronds glabrous or hairy, pinnate to pinnately decomposed, veins free or sparsely reticulate; texture thin to firm but never fleshy; sori terminal on veinlets, marginal or submarginal, enclosed in cup-shaped indusia, in small reflexed lobes of margin or the indusia attached below and at the sides of the receptacles, or naked; sporangia maturing basipetal or mixed, with long stalks, often mixed with paraphyses; spores usually tetrahedral.

Pteridium and *Histiopteris* are usually referred to the *Pteris* group because of the similarity of the soral construction, though they are distinct from the latter and similar to *Dennstaedtia* group in such features as the trichomes and the construction of axes. The soral construction is not quite the same in *Pteridium* and *Histiopteris*: the latter lacks the inner indusia. The soral construction of the *Pteris* type is found also in *Doryopteris*, though the latter is a derivative of the *Cheilanthes* group of ferns. The soral construction in question seems to be, therefore, derived by convergent evolution, and we can consider safely that *Histiopteris* and *Pteridium* belong to a different phylletic group from the Pteridaceae.

To the Dennstaedtiaceae, therefore, belong *Saccoloma* (Central and South America) *Orthiopteris* (pantropic), *Dennstaedtia* (warmer places throughout the world), *Microlepia* (palaeotropic), *Monachosorum* (East Asia and Malaysia), *Oenotrichia* (oceanic), *Hypolepis* (pantropic), *Pteridium* (cosmopolitan), and *Histiopteris* (pantropic). Among

them the genera in Thailand are: *Dennstaedtia*, *Histiopteris*, *Hypolepis*, *Microlepia*, and *Pteridium*.

This group is closely related to that of *Dicksonia*, differing from it in the usually creeping, minutely hairy rhizome. It may be true that the *Dennstaedtia* group has evolved from the *Dicksonia* group, though there are opinions that the Dicksoniaceae is related to *Cyathea* and should be included in Cyatheaceae.

16. Lindsaeaceae

Mostly terrestrial, or a few climbers; rhizome creeping, with so-called lindsaeoid protostele, hairy and/or covered with narrow stiff shining scales; stipes not jointed to the rhizome; fronds simple, pinnate to pinnately compound; veins free or anastomosing forming areoles without included veinlets; axes grooved, the grooves usually decurrent to those of the next order; sori terminal on veinlets, simple or jointed to form fusion-sori, marginal or nearly so on lobes; indusia attached on the basal side of sori, opening outwardly; spores tetrahedral or oblong.

Genera in Thailand: *Lindsaea* (incl. *Isoloma*), *Sphenomeris*, and *Tapeinidium*.

This group of ferns has sometimes been related to *Adiantum*, but this may be incorrect. This is a distinct group, and may be suggested to have an affinity with the Dennstaedtiaceae and also to the Davalliaceae in the other direction. The occurrence of epiphytic species within the terrestrial genus *Lindsaea* does not necessarily suggest an intermediate status of this between terrestrial *Dennstaedtia* and epiphytic *Davallia*.

The rhizome scales of the *Lindsaea* group are distinct from the typical forms of those of the ferns in general, being composed of a few rows of cells which are arranged longitudinally and give the appearance of fused hairs. Really, the texture of the rhizome scales of this group is similar to the hairs on the rhizome, though the texture is distinct between hairs and scales in the other groups of ferns, as seen typically in the Thelypteridaceae. The smaller scales of this group especially, as in *L. napaea* and *L. integra* for instance, may suggest the origin of them by fusion of hairs.

17. Davalliaceae

Epiphytic or rarely terrestrial ferns; rhizome long creeping, dorsiventral, scaly, or with both scales and hairs (*Leucostegia*); scales peltate, not clathrate nor typically bicolored; stipes in two rows on the dorsal surface of the rhizome, jointed at the base to it; fronds simple to pinnately compound, veins all free; rachis raised on upper surface, more or less winged; sori submarginal or dorsal on fronds, terminal or rarely dorsal on veins (*Gymnogrammitis*), indusiate, or rarely naked (*Gymnogrammitis*); indusia open towards margin, attached by base and side forming a cup-shape, or by the base only; spores bilateral, without perispore.

Genera in Thailand: *Araiostegia*, *Davallia*, *Davallodes*, *Gymnogrammitis*, *Humata*, and *Leucostegia*.

Gymnogrammitis is peculiar in having naked sori dorsal on veinlets. This is, however, morphologically similar to the sori of *Araiostegia*, and it is not necessary to consider it as a distinct genus based only on this feature. *Leucostegia* is the only genus of this group bearing hairs, though the indusia are different in the two included species, one taking the form of those of *Humata* and the other of *Davallia*.

Within each genus, the species seem to be homogeneous even in the case where a number of species are included as in *Davallia* and *Humata*. Moreover, the relationship between each two genera seems to be rather close except for *Leucostegia* and *Rumohra*. We can safely subdivide the Davalliaceae into three subgroups, two including *Leucostegia* and *Rumohra*, respectively, and the other containing the remaining seven genera. *Parasorus* is considered to be peculiar in its marginally arranged sori, but is otherwise the genus closest to *Scyphularia*. The sori are arranged marginally, not fused as in the Lindsaeoid form, but as seen in *Nephrolepis acutifolia*. This genus may be included in *Scyphularia* safely.

18. Oleandraceae

Rhizome short, erect or ascending, or long creeping, scaly, with wiry roots; scales peltate, usually concolorous; stipes articulate to the rhizome or not (*Nephrolepis*); fronds simple (*Oleandra*) to bipinnatifid, glabrous or bearing small scales, pinnae jointed to the rachis or not; sori round, terminal on acroscopic branches of veins or dorsal on veins (*Oleandra*), or in one species elongate along margin, indusiate; indusia round reniform, thin; spores bilateral.

All of the three genera included, *Arthropteris*, *Nephrolepis*, and *Oleandra* are natives in Thailand.

There are certain opinions concerning the position of *Oleandra* which differs from the other genera in the simple fronds with dorsal sori. The dorsal position of sori is suggested by Holttum (6) to be the result of simplification in the frond construction. There is no evidence given to support this hypothesis, but we have no discriminative feature to distinguish *Nephrolepis* and *Arthropteris* from *Oleandra* at the family level. This family as a whole seems to be close to the Davalliaceae, differing in the radial construction of rhizome and articulation in axes.

Nephrolepis and *Arthropteris* are referred to davalloid genera by Christensen (1). This is followed by Ching (2), who recognizes a distinct subfamily, Nephrolepioideae, in the Davalliaceae. Copeland (3) united the Oleandraceae with the Davalliaceae, admitting three phylletic groups among the family.

19. Parkeriaceae (Adiantaceae)

Usually terrestrial ferns; rhizome short, erect, to long creeping, solenostelic or dictyostelic, not dorsiventral, hairy and/or scaly; scales basally attached, usually concolorous, subulate, entire at margin; stipes not jointed to rhizome; fronds simple to pinnately decomposed; veins free or reticulate to form areoles without included veinlets; sori terminal on veins, elongate along veins, or forming soral commissure uniting the apices or the midst of veins, naked, covered by the reflexed thin marginal flaps, or borne on reflexed flaps (*Adiantum*); spores tetrahedral.

The circumscription of this family varies with the authors concerned. The above diagnosis is applicable to the vast numbers of genera, and their relationship and circumscription are not yet thoroughly elucidated. These genera are usually understood as gymnoqrammoid genera, following the system of Bower (20) and Christensen (1). Holttum (5, 6) united this group with the *Vittaria* group, and Copeland (3) included the genera in his Pteridaceae.

For the family name, Parkeriaceae Hooker, 1825, is much older than the more commonly used Adiantaceae (Presl) Ching, 1940. Cf. Pichi Sermolli (21)

Some thirty-five genera are usually recognized in this group. Most genera are adapted to dry climates, and many are known in the New World. In Thailand we enumerate twelve genera, which are usually classified into five groups chiefly based on Bower (20).

Ceratopteris subgroup — Monotypic genus with aquatic habit. Nishida (22) reviewed the topics on the systematic position of this genus and supported the opinion of considering it as constituting a distinct family. In spite of the opinion of these authors, it is obvious that this strange fern is a relative of the gymnogrammoid ferns, specially adapted to its aquatic habitat.

Syngamma subgroup — *Coniogramme* and *Taenitis* belong here.

Onychium subgroup — *Onychium* is an only genus in Thailand, probably related to the preceding group.

Cheilanthes subgroup — *Doryopteris*, *Notholaena*, and *Pityrogramma* belong here. *Gymnopteris* and *Hemionitis* may be referable, but some resemblance to *Syngamma* subgroup.

Adiantum subgroup — A distinct genus well defined and probably related to the preceding group. This is another genus which is considered to form a special family for itself. The soriferous lobes are peculiarly constructed, though the systematic position is doubtlessly close to the gymnogrammoid ferns.

20. Vittariaceae

Epiphytic or rarely terrestrial; rhizome creeping, usually short, protostelic or solenostelic, scaly; scales clathrate, attached at base; stipes not jointed to the rhizome, usually closely placed; fronds simple, entire, or rarely cleft at apex, glabrous, usually thick in texture, with long idioblasts in the epidermis; veins anastomosing, or rarely free in very narrow fronds, without included free veinlets; sori elongate along veins, commonly immersed in the grooves along veins, exindusiate, with dense paraphyses; spores globose tetrahedral or bilateral, without epispore.

Seven or eight easily defined genera belong to this family, though the affinity is not clearly indicated as yet. Genera in Thailand are: *Antrophyum*, *Vaginularia*, and *Vittaria*.

21. Pteridaceae

Rhizome creeping or erect, typically solenostelic, radial in construction, covered with hairs or scales; stipes not jointed to the rhizome; fronds simple to variously decompound, small to large, the edge of costa-groove decurrent upon the edge of rachis-groove; veins free or anastomosing to form a few series of areoles without free included veinlets; sori marginal or intramarginal, borne on vascular commissure connecting the apex of veins, protected by reflexed margin of lobes, or sporangia scattered on the whole of the under surface of fertile pinnae; spores tetrahedral or bilateral (*Stenochlaena*).

Genera in Thailand: *Acrostichum*, *Pteris*, and *Stenochlaena*.

Stenochlaena is sometimes considered as a member of the Blechnaceae (Cf.

Copeland, 3), though its placing here follows the opinion of Holttum (6, 23).

22. Aspleniaceae

Terrestrial or epiphytic ferns; rhizome short, erect, or long creeping, radial or dorsiventral (§*Hymenasplenium*) in construction, dictyostelic; scales glabrous, not peltate, clathrate, usually entire or with irregular projections at margin; stipes not jointed to rhizome, containing two vascular bundles which meet in upper portion X-shaped in cross section; fronds simple to pinnately compound; veins free or uniting to form areoles without included veinlets; sori elongate along veins, covered by indusia, or exindusiate; indusia in the same shape as sori, attached along veins, facing towards posterior, or two sori meeting with two indusia facing each other (§*Phyllitis*); spores bilateral, with perispore.

More than 700 species belong to this group mainly from the tropics of both the worlds. The generic classification is somewhat different according to the different authors, especially in the circumscription of the largest genus, *Asplenium*. Here we recognize this genus in its broad sense as accepted by Copeland (3), thus enumerating from Thailand only this genus among the genera of this group. *Phyllitis*, *Hymenasplenium*, and *Neottopteris* are better considered as included in *Asplenium* at the present, though the subgeneric classification should be made carefully.

23. Blechnaceae

Terrestrial ferns; rhizome creeping, or more commonly massive with a rosette of fronds, sometimes forming trunks to more than 1 m in height (*Brainea*), scaly, radial in construction, dictyostelic; scales large, attached at basal end, castaneous to darker, not clathrate, glabrous; stipes not jointed to the rhizome, containing several vascular bundles; fronds pinnate to bipinnatifid or more compound, dimorphic or not; veins free and parallel, or united to form areoles without included veinlets; sori elongate near the costae or costules with indusia attached on a side of the sorus remote from costae or costules, opening inwardly, or exindusiate (*Brainea*); spores bilateral.

To this group belong *Blechnum* (some 200 species, cosmopolitan but predominant in southern hemisphere), *Doodia* (11 species in Oceania and Ceylon), *Brainea* (one southeast Asian species), *Woodwardia* (about ten species from both the new and old worlds), *Sadleria* (half a dozen species endemic to Hawaii), *Salpichlaena* (one central American species), and *Lorinseria* (one American species). Among them are found in Thailand three genera: *Blechnum*, *Brainea*, and *Woodwardia*. They are well defined by soral construction as well as by venation, though the relationship with the other groups is still obscure.

24. Lomariopsidaceae

Terrestrial or epiphytic ferns; rhizome creeping, climbing, or epiphytic, dorsiventral in construction, with a broad basal bundle and one or more dorsal strands, scaly but not hairy; scales not peltate nor typically clathrate, glabrous; stipes jointed to the rhizome or not, usually with several vascular bundles; fronds simple and entire to bipinnate, or in two kinds in sterile fronds, bathyphylls and acrophylls, dimorphic; the pinnae in climbing genera jointed to the rachis; veins free, or united, sinus teeth distinct in terrestrial members; sori acrostichoid, sporangia spreading over the whole of the under

surface of fertile laminae; spores bilateral, with perispore, except in *Lomagamma*.

The genera of this family are classified into three distinct subgroups as:

Elaphoglossum (incl. *Microstaphylla* and *Rhipidopteris*) — Epifitic, fronds mostly simple; sometimes distinguished from the others to constitute the Elaphoglossaceae.

Bolbitis (incl. *Egenolfia*) — Usually terrestrial, fronds pinnate.

Lomagamma, *Lomariopsis*, *Teratophyllum* (incl. *Arthrobotrya*), and *Thysanosoria* — Rhizome climbing up trees, sterile fronds of two kinds.

There are various opinions concerning the circumscription of this group. Resulting from the difference in life form, the three subgroups are fairly distinct from each other in the morphology of fronds and rhizome. *Thysanosoria* is not represented in Thailand.

25. Peranemaceae (Dryopteridaceae)

Terrestrial ferns with mediocre or larger size; rhizome erect or ascending, or creeping, radial in construction, dictyostelic; scales attached at the base, usually concolorous, not clathrate, without unicellular hairs, marginal projections, if any, formed of two adjacent cells; stipes not jointed to the rhizome, containing several vascular bundles, scaly at least near the base; laminae simple to pinnately compound; veins free or variously anastomosing; sori dorsal or rarely terminal on veinlets, usually on punctiform receptacles, typically round, rarely elongate along veins or acrostichoid; indusia round reniform, attached at sinus or peltate, rarely wanting; spores bilateral, with perispores.

This is a large family including about 800 species, 70 of which are native to Thailand. There are two distinct subgroups, both of which are sometimes regarded as forming distinct families.

Dryopteridoideae — Genera in Thailand: *Acrophorus*, *Arachniodes*, *Diacalpe*, *Didymochlaena*, *Dryopteris*, and *Polystichum*. *Acrophorus*, *Diacalpe* and *Didymochlaena* are distinct in some features, though they may safely be included here.

Tectarioideae — Genera in Thailand: *Arcypteris*, *Ctenitis*, *Cyclopeltis*, *Heterogonium*, *Pleocnemia*, *Pteridrys*, *Quercifilix*, and *Tectaria*. This is segregated from the other subgroup by the presence of articulated hairs on the upper surface of the rachis, costae, costules, and sometimes also of veins. *Pleocnemia* and *Arcypteris* are separated from *Tectaria* by Holttum (24), but the affinity of them is close to each other and also to *Tectaria*. *Quercifilix* is a direct derivative of *Tectaria* with dimorphic fronds and acrostichoid fertile fronds, and there is an opinion that this is a hybrid. *Heterogonium* may have evolved in parallel with *Tectaria* consisting of both species free in venation and those with reticulate veins. *Cyclopeltis* and *Pteridrys* may safely be placed in this group, though the systematic position of them are fairly distinct. *Hypodematum* is sometimes referred to this group next to *Lastreopsis*, but excluded from here and placed in the Athyriaceae (Iwatsuki, 25).

It is rather a pity that the family name Peranemaceae (Presl) Ching, 1940, based on a peculiar genus, antedates the Dryopteridaceae Ching, 1965, which more appropriately expresses the contents of the family. Cf. Pichi Sermolli (21).

26. Thelypteridaceae

Rhizome creeping or suberect, radial, dictyostelic; scales basally attached, con-

colourous, usually hairy at the margin as well as on the surface; stipes not jointed to the rhizome, containing two vascular bundles which are united in the upper portion to form a single strand, U-shaped in cross section; fronds usually longer than wide, pinnate-bipinnatifid, rarely simple, pinnatifid, or more compound; veins free or anastomosing to form goniopteroid or sagenioid venation; plants usually bearing setose hairs on various portions, but without coarse multiseptate hairs; sori typically round, mostly dorsal on veinlets, or elongate in a few species; indusia round reniform, attached at sinus, rarely crescent-shaped or wanting, often hairy or glandular; spores bilateral, with perispore.

Genera in Thailand: *Meniscium* and *Thelypteris*.

The classification of the species belonging to this series is problematic, and recently several systems have been proposed independently. Here we follow the system of the junior author (Iwatsuki, 26) in classifying the family into three genera, though his subgeneric classification needs some emendment. The detailed notes will be given in the Flora.

27. Athyriaceae

Terrestrial; rhizome erect or creeping, radial in construction, dictyostelic; scales basally attached, concolorous, glabrous, the marginal projections formed of two adjacent cells; stipes not jointed to the rhizome (except for *Hypodematium*), or articulated (*Woodsia*), containing two vascular bundles which are united upwards into a single strand, U-shaped in cross section, the base often enlarged with distinct wings; fronds usually longer than wide, mostly pinnate-bipinnatifid, rarely simple, pinnatifid, or more compound; veins free or anastomosing to form seemingly goniopteroid or sagenioid venation; axes hairless, or sometimes with coarse multiseptate hairs; sori usually elongate along veinlets, rarely round; indusia crescent-shaped, rarely round reniform, or cystopteroid (*Cystopteris*) or woodsoid (*Woodsia*) with basal indusia; spores bilateral, with perispore.

Genera in Thailand: *Anisocampium*, *Athyrium* (incl. *Lunathyrium*), *Cornopteris*, *Dryoathyrium*, *Diplazium* (incl. *Callipteris* and *Dictyodroma*), *Hypodematium*, and *Microchlaena*.

Diplazium is sometimes reduced to *Athyrium*, though these two are distinct, when the combination of the characteristic features is considered, although any one feature cannot stand on its own as a distinct key character to discriminate these two. *Microchlaena* and *Anisocampium* are close, and may better be placed in *Athyrium* if there is a good definition for that (Cf. Iwatsuki, 27). *Dryoathyrium* should be compared with *Lunathyrium* more carefully, and *Cornopteris* seems to be close to *Athyrium*. On *Hypodematium* the junior author published a paper in Japanese (Iwatsuki, 25).

28. Dipteridaceae

Terrestrial; rhizome creeping, solenostelic, clothed with brown bristles; stipes not jointed to the rhizome, glabrous except at the hairy base; fronds solitary, dichotomously forked, the two lobes flabellate, more or less incised; main veins dichotomous, veins finely reticulate, the areoles with included veinlets; sori punctiform or irregularly spreading along veinlets, exindusiate, with paraphyses; sporangia maturing in short sequence

(in origin transitional between *Simplices* and *Mixtae*), with usually longitudinal and complete annulus; spores bilateral.

Dipteris is the only genus included here, and known in Thailand as the type and most common species, *D. conjugata*.

Both Copeland and Holttum consider that *Dipteris* is a primitive fern in the polypodiaceous series and include *Dipteris* in the Polypodiaceae. One of the most distinct key characters to discriminate the genus from the latter family is the chaetopteroid rhizome of *Dipteris*. Copeland (3) describes that the dark bristles of *Dipteris* are, on old parts, several cells wide in the lower parts, but this is quite different from the scales generally found in the Polypodiaceae. Bower and others relate *Dipteris* and *Matonia* by their apparent similarity, and this affinity may be found in a very old and primitive stage. We are at present not sure of the direct affinity between *Dipteris* and the Polypodiaceae, and prefer here to treat both of them as distinct families.

29. Cheiropleuriaceae

Terrestrial ferns of moderate size; rhizome creeping, solenostelic, not scaly but hairy; hairs soft, ferruginous; stipes not jointed to the rhizome, glabrous except at the hairy base; fronds simple, dimorphic; sterile fronds broader, bi-lobed at the apex with a broad sinus, entire; fertile fronds narrowly lanceolate, entire; main veins dichotomous, veins forming fine areoles with included veinlets; sori acrostichoid, with capitate paraphyses; sporangia with oblique annulus; spores tetrahedral.

The family includes only one genus *Cheiropleuria* which is represented in Thailand by the type and sole species, *C. bicuspis*.

This is usually included in the Polypodiaceae, but seems to be different from the latter in the same way as *Dipteris* differs from the former family. Moreover, *Cheiropleuria* differs from *Dipteris* similarly. If we recognize the Dipteridaceae as a distinct family, it is necessary to distinguish the Cheiropleuriaceae as another. The Cheiropleuriaceae cannot stand as an intermediate between the Dipteridaceae and the Polypodiaceae, and we doubt the suggestion given by Copeland (3) and Reimers (8) that *Dipteris* and *Cheiropleuria* have a close affinity. These two are usually treated as being similar, though this is based on the over-estimation of the sharing of these two of the chaetopteroid rhizome, dichotomous branching, and other primitive features. The dichotomous branching of *Cheiropleuria* is often equated with that of *Dipteris* and of *Platyserium*, though the similarity of this feature in these three genera does not indicate the affinity among them but the primitiveness of the evolutionary stage of their frond construction.

30. Polypodiaceae

Epiphytic or rarely terrestrial ferns of mediocre or smaller size; rhizome creeping, more or less densely scaly, containing a ring of small vascular strands; scales mostly peltate, clathrate or not; stipes in two alternate rows on the rhizome, in most cases jointed to it; fronds simple, pinnatifid, or pinnate, not pinnately decomposed; veins usually copiously anastomosing to form areoles with included veinlets, rarely free; sori exindusiate, round, elongate, or acrostichoid, sometimes sunk in cavities, with or without

paraphyses; spores bilateral, or rarely globose tetrahedral (*Loxogramme*), without perispore.

Recent pteridologists agree with the delimitation of this family according to the definition given above, though there are some different opinions as to the exclusion of the Dipteridaceae and the Cheiroleuriaceae. Thus confined, this family contains some 50 genera and 600 species mainly from the tropical regions. As most species of this family are epiphytes, they usually show adaptation to this life form, usually forming small sparsely dissected fronds.

Most of the species of the Polypodiaceae have so-called drynarioid venation with conspicuous anastomosis of smaller veins with included free veinlets in the areoles, and the less anastomosing or free venation found in *Polypodium* is usually interpreted as a derivative feature. Typically the sorus of the Polypodiaceae is round and superficial, though there are also linear sori, sori sunk in cavities, and acrostichoid fertile fronds. The transformation in soral construction is found in various groups of genera, and this may have resulted from the parallel evolution in this feature.

Platynerium is a primitive member of this family, indicated by the dichotomous branching of fronds, though here we follow those who consider it as having the same origin as *Pyrrosia*, this being suggested by the presence of the stellate hairs on the fronds. *Didymoglossum* is another genus close to *Pyrrosia*. It is not certain as yet whether the stellate hairs of these genera are the primitive form of peltate scales generally found in the Polypodiaceae.

Pleopeltis and the related genera are well characterized by having the peltate scales on the young sori or on the frond surface as well. *Belvisia*, *Lemmaphyllum*, and *Neocheiropteris* belong to the group of *Pleopeltis*. Copeland (3) distinguishes *Paragramma* and *Weatherbya* as distinct genera, but we prefer to retain them in *Pleopeltis* and *Lemmaphyllum*, respectively.

Microsorium and *Crypsinus* may have a common origin but this may be in far back in the evolutionary history. They differ distinctly in their rhizome scales, clathrate in the former and not so in the latter. *Microsorium* and *Phymatodes* are united here, though they need to be studied further. The genera having distinct relationship with *Microsorium* are *Colysis*, *Leptochilus*, and *Myrmecophila*. The genera belonging to the *Drynaria* group, such as *Drynaria*, *Aglaomorpha*, and *Photinopteris*, may be peculiar derivatives of *Microsorium*.

Christiopteris is usually interpreted as another primitive genus, and the affinity of it seems to be with *Crypsinus* and *Selliguea*, from which *Arthromeris* and *Polypodium* are derived highly likely to have been by reduction of the venation.

Loxogramme is a genus with unknown relationships, and Copeland (3) seems to be incorrect in placing it in the Grammitidaceae. Recent researches on the gametophyte of this genus made by S. Momose (28) and on the spores by F. Konta (29) support the opinion that *Loxogramme* should have a distinct position among the Polypodiaceae. We do not know as yet the position of this genus in that family, though we suggest placing it near *Microsorium*.

The twenty-two genera noted above are native in Thailand. The limitation of the genera of the Polypodiaceae is rather strict, and it will be much better if we can

arrive at more suitable method of subdividing this family into fewer numbers of genera.

31. Grammitidaceae

Usually small epiphytic plants; rhizome short, creeping, ascending, or suberect, bearing a tuft of fronds near the apex, with stipes alternating in two close ranks, solenostelic or dictyostelic, scaly; scales narrow, concolorous with uniform cell walls or slightly clathrate, sometime setose hairy at margin; stipes usually not jointed to the rhizome, hairy with simple setose or stellate hairs; fronds simple to pinnate, rarely bipinnate, usually small and simple in dissection; veins free, or rarely with occasional anastomosis; sori round or elongate along veins, superficial or sunk in cavities, naked or rarely protected when young with setose unicellular hairs; spores tetrahedral.

Formerly, the members of this family were all treated as belonging to *Polypodium* s. lat. solely on the basis of having the round naked sori, though they are distinct from the species of the nominal genus in having non-jointed stipes, tetrahedral spores, trichomes with setose hairs, simple anatomical structure, and so on. Some ten genera belonging to this family are known throughout the tropics, usually as small epiphytes in dense mossy forest.

Both the generic and specific classifications are still obscure for this family, chiefly because of the insufficiency of the material, because most species are found in the tropical rain forest and are difficult to cultivate in green houses. Copeland published some monographs in his later life on the genera of this family, but there remain various unsolved problems. The generic classification is based on the structure of fronds and sori. As to Thai genera, *Scleroglossum*, *Acrosorus*, *Calymmodon*, and *Prosaptia* are defined by the distinctness in the soral structure, and the remaining three genera with naked round superficial sori, *Ctenopteris*, *Grammitis*, and *Xiphopteris* are distinguished from each other by their frond construction — pinnate, simple, or pinnatifid. Although the specialization of the soral grooves in *Scleroglossum* may be distinct, the condition found in *Acrosorus* and *Calymmodon* seems to be derived by specialization in parallel to each other. The soral cavities in *Prosaptia* and various in forms and are hardly acceptable as a feature to define a genus. We can see the presence of soral cavities even in the sori of *Calymmodon* and *Acrosorus*. *Ctenopteris* with pinnate to bipinnate fronds comprises some 200 species and is rather heterogenous. We cannot recognize the difference between *Xiphopteris* and *Ctenopteris* as a phylogenetic one, for the frond forms of *Xiphopteris* may have been derived in parallel from various forms found in *Ctenopteris*. All of the species of this family are much specialized by the reduction of fronds, perhaps being an adaptation to the epiphytic life in mossy forest in the tropics. The extreme reduction of the frond surface in this family makes an appearance common to many species differentiated from various stocks.

32. Marsileaceae

Water plants; rhizome creeping, solenostelic, hairy; fronds circinate, simple, or with two or four leaflets at apex; veins forked, anastomosing at apex; sporocarps, or highly specialized soriferous pinnae, on or at base of stipes, globose, firm, hairy; sori four to several, marginal in origin, enveloped by soft tissue (so-called indusium);

sporangia of two kinds, mega- and micro-sporangia; spores of two kinds, both tetrahedral.

There are three genera included in this family: *Marsilea* with four leaflets, with about seventy species in temperate and tropical regions including Thailand; *Regnelidium* with two leaflets, with a single species restricted in southern Brazil; and *Pilularia* without a leaflet, with six species in Europe, America, and Australia.

The family as a whole is usually related to the Schizaeaceae as noted by Bower, but is a peculiar derivative in its aquatic habitat.

33. Salviniaceae

Water plants; rhizome short creeping, hairy, rootless, bearing the leaves in whorls of three rows, two being simple, green, floating, the upper surface exposed to air, the third submerged, branching and growing downwards taking an attitude of roots; veins of floating leaves anastomosing; sori on submerged leaves, enclosed completely by indusia; mega- and micro-sporangia borne in different sori; heterosporous, spores tetrahedral.

About ten species belong to this family consisting a single genus, *Salvinia*, distributed in all the warmer parts of the world.

34. Azollaceae

Water plants; rhizome short creeping, branching alternately to bear fronds in two alternate rows, bearing numerous submerged roots, hairy; fronds bilobed, with one floating and the other submerged, with *Anabaena* among tissues; sori near base of submerged lobes, enclosed by indusia; a megasporangium or numerous microsporangia in each sori; heterosporous, spores tetrahedral.

Nearly ten species are reported from all the warmer parts of the world. All are included in a single genus *Azolla*.

This is sometimes combined with *Salvinia* to form the Salviniaceae s. lat. However, the relationships of both these two genera are variously attributed, and the similarity between them seems to be the result of their common habitats in water. It may be advisable at present to separate them in different families, not placing them next to each other.

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