SPORE MORPHOLOGY OF FORMOSAN PTERIDACEAE[1]

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Abstract: Spores of 90 species in 21 genera belonging to the Pteridaceae of Taiwan (*sensu* Copeland, 1947) are here described. The classification system is also reviewed.

INTRODUCTION

The microspores are "footprints on the sands of time" (Kremp, 1972). Pteridophyte spores are found abundantly in Tertiary sediments of Taiwan. A number of important books on Pteridophyte spores have been published by Harris (1955), Erdtman (1957), Nayar and Devi (1964-68), Heusser (1971) and Kremp and Kawasaki (1972). Yet in Taiwan very little has been published on Pteridophyte spores. DeVol has discussed the spores of some of the *Lycopodium*, *Selaginella* and *Isoetes* (1965, 1966, 1972). Due to the inadequate spore description of Taiwan ferns, the identification of fossil fern spores is difficult. What is more, the study of spore morphology can be of great aid not only to the taxonomy of ferns, but in palaeobotany, palaeoecology, pollen analysis, aeropalynology and allergy, therefore, this work has been undertaken.

According to the classification system of Copeland (1947) and Shieh (1972), there are 23 genera and about 120 species of the Pteridaceae in Taiwan. Spore morphology of 90 species and 21 genera are presented here, the exceptions are: *Gymnopteris* and *Hemionites*.

In this study, a new method for preparing permanent spore slides has been introduced. It can preserve the features of the perine and exine which are usually lost by the usual acetolysis method (Erdtman, 1952).

MATERIALS AND METHODS

The samples were mostly collected from specimens in the herbarium of N.T.U. Botany Department; others were provided by Dr. W.C. Shieh. The method used for the preparation of spore slides is as follows: One or two drops of 10% potassium hydroxide were added to the spores on a slide; the slide was then gently heated (not over 70°C) until nearly dry; these procedures were repeated at least twice; then, one or two drops of 10% acetic acid were added to the spores and heated again until nearly dry; this treatment was repeated twice; the spores were stained with 0.1% gentian violet if necessary; the remaining dye and acid residues were washed away with one or two drops of absolute alcohol followed by an alcohol-glycerine (95:5 v/v) solution; and finally, the spores were mounted in glycerine jelly for permanent study.

Prepared slides were studied and photographed with a photomax type of Olympus microscope providing magnifications up to 1500×. The spore photographs here were magnified as 1000×.

(1) This paper is based partly on a M.S. thesis of the first author to the Research Institute of Botany, NTU.

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SPORE CHARACTERS

The spore characteristics which have been adopted for the criteria of the classification of fern spores in this paper, are described in the following order:

The *tetrad* which is developed from a single spore mother cell is not found in mature spores. After the separation of spores from the tetrad they are called *monads*; *tetrad scars* remain on their *contact areas* which are the *contact surfaces* of the spores in the tetrad stage.

The most distinctive character on the spore is its fissure. In general, spores are recognized as *aperturate* and *inaperturate* according to the presence or absence of a fissure respectively. The former are divided into *trilete* and *monolete* spores.

The trilete spores with three contact surfaces in the tetrad stage (see Fig. 1) are *radiosymmetrical* in polar view. The monolete spores with two contact surfaces in tetrad stage (see Fig. 2) are *bilateral symmetrical* in polar view.

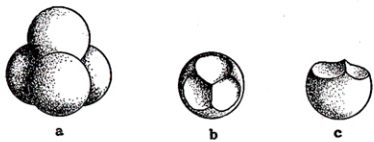

Fig. 1. Diagramatic drawing of radiosymmetrical spores illustrating: a. tetrad; b. proximal view of a single spore showing the trilete suture and contact areas; c. lateral view of single spore (Winslow, 1959)

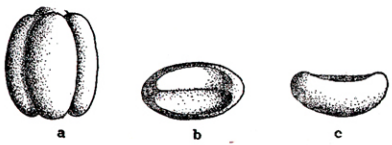

Fig. 2. Diagramatic drawing of bilateral symmetrical spores illustrating: a. tetrad; b. proximal view of a single spore showing the monolete suture and contact areas; c. lateral view of single spore. (Winslow, 1959)

The surface which is in contact with the adjacent members of the spore tetrad is called the *proximal surface* and the opposite one is called the *distal surface*. Their ends are refered to as the *proximal pole* and *distal pole* respectively. Between these two poles, there exists an imaginary band, the *equator*, which separates the spore into two hemispheres and owing to the unequal development of two hemispheres and to the presence of the tetrad scar on the proximal surface, the spores are generally *anisopolar*. On the other hand, globose and alete spores are *apolar* since the two poles are alike.

The shapes of anisopolar spores are different in their *polar* and *equatorial views*. In *polar view* (*amb*), the trilete spores are globose or triangular with various ranks of concave, covex or straight sides; and rounded, acute or truncate angles. The monolete spores are always elliptic. They are summarized as follows (see Fig. 3):

EL type: ellipsoidal with ratio of long axis/short axis falling between 1.25 to 2.
SE type: subellipsoidal with ratio of long axis/short axis above 2.
GL type: globose with ratio of long axis/short axis below 1.25.
RT type: rounded triangular with side convex.
ST type: subtriangular with side straight and angle rounded.
DE type: deltoid triangular with side straight and angle acute.
TQ type: triquete with side slightly concave.
TL type: trilobate with side deeply concave.

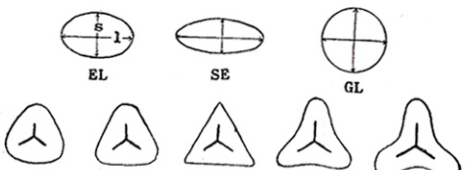

Fig. 3. Shapes of spores from polar view. (Kawasaki, 1971)

There are many shapes of the proximal and distal portions when observed from the *equatorial* (*lateral*) *view* (see Fig. 4). The shapes of the proximal portion may vary from concave, flat, convex, conical to hemispherical. The distal portion of the same may range from convex, subhemispherical, hemispherical to subconical.

The sizes of the spores are measured by excluding the sizes of the perine and equatorial ridge. Size range is based on measurements of the largest and smallest representatives of a species to be found in many preparations from various localities. The size of trilete spores is described as E×P (see Fig. 5). Of these, the *E value* or *equatorial value* is the distance measured from one angle to the opposite side in polar view. This value is different based upon the various shapes of the side of triangular spores. If the side is straight, convex or cancave, the E value is "a-b', "c-d" and "e-f" respectively. The *P value* or *polar value* is the distance from proximal to distal end measured from lateral view. The size of monolete spores is described as S×L×P (see Fig. 6). Of these, S and L are the short and long axes of monolete spores measured from polar view, and P is equal to the P value in trilete spores and is measured from the proximal to the distal pole in lateral view.

The dehiscence fissure, the *laesura*, is also an important character of spores. The laesura includes the commissure and also the margo if it is distinguishable. The margo may be divided as *lip-like margo*, *flange-like margo* and *line-like margo*. If the laesura is devoid of a margo, it is called laesura with a *simple commissure* (see Fig. 7). In general, laesurae are straight, but, for a few spores they are curved.

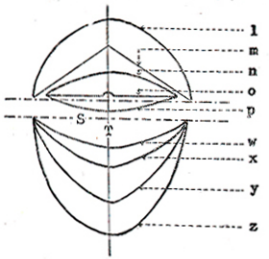

Fig. 4. Shapes of spores from lateral view based on the model of Nayar and Devi 1966, except "l", showing the proximal half (l–p) and distal half (w–z). The etched line representing the equator of the spore. Proximal half: l, hemispherical; m, conical; n, convex; o, flat; p, concave. Distal half: w, convex ($S/T<\frac{1}{4}$); x, subhemispherical ($\frac{1}{4}<S/T<\frac{1}{2}$); y, hemispherical ($S/T=\frac{1}{2}$); z, subconical ($S/T>\frac{1}{2}$).

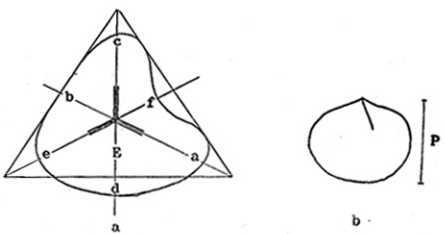

Fig. 5. Measurement of trilete spore by E×P. a. Proximal view of trilete spore showing E value of amb: a-b, straight side; c-d, convex; e-f, concave. (Nayar and Devi, 1966). b. Lateral view of trilete spore showing P value.

The margo of *Lindsaea*, for example, is as curved as the laesural margin. The length of laesura is measured from the center of a tetrad scar to the laesural end for trilete spores, and from one laesural end to the other end for monolete spores.

Around the laesural margin, there arises a swollen protrusion. This protrusion may be formed from part of the elements near the laesural margin and may coalesce to form three rows of rugulae-like structures which run parallel to the Y-mark, which is termed the *laesural ridge* (Fig. 8). The laesural ridges can be differentiated

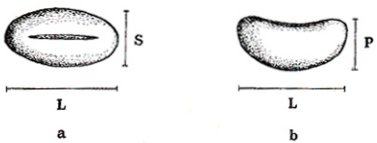

Fig. 6. Measurement of monolete spore by S×L×P. a. Proximal view of monolete spore showing S and L. b. Lateral view of monolete spore showing P.

Fig. 7. Types of margo: a. simple commissure; b. lip-like margo; c. flange-like margo; d. line-like margo.

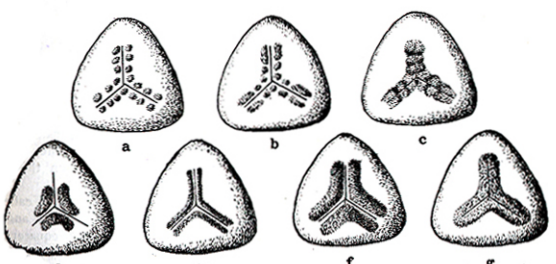

Fig. 8. Variation of laesural ridges. a-b. tuberculate or extervermiculate scattering around laesural margin; c. irregularly sinuous laesural ridges; d. short plane field-laesural ridges; e. narrow band-laesural ridges; f. long plane field-laesural ridges; g. circumfluent laesural ridges.

into irregularly sinuous laesural ridges, short plane field-laesural ridges, narrow band-laesural ridges, long plane field-laesural ridges and circumfluent laesural ridges.

Away from the laesural margin and near to the equator, there also exists a swollen protrusion on the proximal face, which is like the leasural ridge, which is named the *proximal ridge* (Fig. 9). On the other hand, there is a *distal ridge* on the distal face. They can be differentiated into short plane field-proximal (distal)

ridges, irregularly sinuous and interrupted proximal (distal) ridges, narrow band-proximal (distal) ridges, long plane field-proximal (distal) ridges and circumfluent field-proximal (distal) ridges.

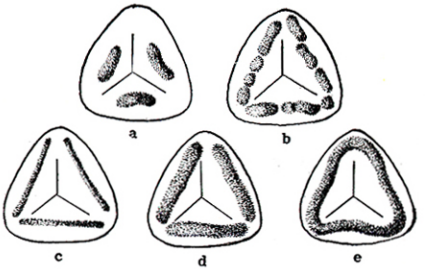

Fig. 9. Variation of proximal ridges. a. short plane field-proximal ridges; b. irregularly sinuous and interrupted proximal ridges; c. narrow band-proximal ridges; d. long plane field-proximal ridges; e. circumfluent field-proximal ridges.

The sculpture of the *exine* and *perine* have been described for two views, i.e., the surface view of sexine patterns (see Fig. 10) and the lateral view of the marginal processes (see Fig. 11). Many spores, for example, *Pteris*, possess sculptures on the proximal surface differing from the ones on the distal surface. Even the sculptures on same surface may be of various types.

Some spores of *Pteris* have a reddish brown, powder-like layer, called the *mesoperine*, which is outside the exine, showing the same sculpture as the exine, and sometimes with a tetrad scar on it. It is relatively easy to loosen this by treating it with KOH and CH_3COOH.

On the equator, there is a narrow structure surrounding the spore called *equatorial ridge*. If the equatorial ridge is of the same width at the radial angle as on the interradial side then it is spoken of as *annulate*, but if the equatorial ridge is wider on the interradial side than at the radial angle then it is termed *annulotrilete* (see Fig. 12). Its dimension (size) can be represented by its height (measured from polar view) and its width (measured from lateral view).

Outside of the exine of certain spores is a transparent and thin layer, the *perine*. This is easily separated from the exine when treated with KOH and CH_3COOH and makes the observation of the spore easier.

GLOSSARY

Aciculate: elements pointed at apex, basal part as wide as middle part. See Fi 11c.

Aggregation: adherence of spores in fours (tetrads) or their multiples.

Alete: spores lacking a tetrad scar; inaperturate; non-aperture.

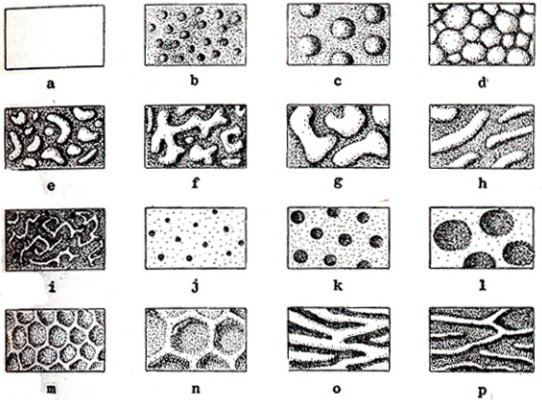

Fig. 10. Surface view of exine and perine sculptures. a. smooth; b. granulate; c. tuberculate; d. areolate; e. extervermiculate; f. convolute; g. ornate; h. rugulate; i. rugate; j. punctate; k. vallate; l. foveolate; m. reticulate; n. lophate; o. striate; p. rivulate.

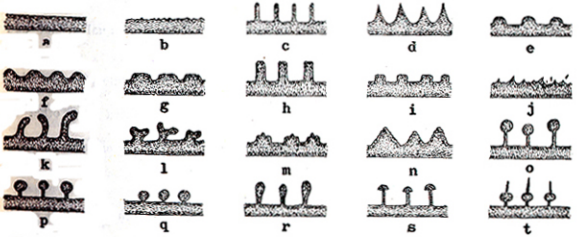

Fig. 11. Lateral view of exine and perine marginal processes. a. psilate; b. scabrate; c. aciculate; d. echinate; e. papillate; f. rounded verrucate; g. flat verrucate; h. columinate; i. baculate; j. irregularly scabrate; k. filiform; l. cuneate; m. mammillate; n. conicuiate; o. capitate; p. pilate; q. gemmate; r. clavate; s. graphelate; t. obcapitate.

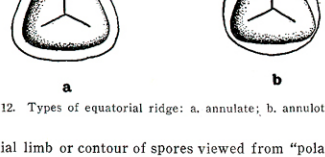

Fig. 12. Types of equatorial ridge: a. annulate; b. annulotrilete.

Amb: the equatorial limb or contour of spores viewed from "polar view"; the shape of spores from polar view. See Fig. 3.

Angle: corner of spore from polar view; see *"radial position"*.

Aperture: the remains of a tetrad scar after separation from a tetrad aggregation.

Areolate: sculptured type with areas (areolae), usually circular or polygonal areas separated by small grooves (fossulae), forming negative reticulation. See Fig. 10d.

Anisopolar: having the proximal and distal hemispheres dissimilar.

Annulate: with equatorial ridge of the same width on both radial and interradial positions, from polar view; contrasted with *annulotrilete.* See Fig. 12a.

Annulotrilete: with equatorial ridge on interradial position wider than that of the radial position, from polar view. See Fig. 12b.

Apolar: with proximal and distal surface not differentiated.

Baculate: elements rod-shaped, both upper and lower part equal in size and as long as or less than twice of the width. See Fig. 11i.

Bilateral symmetrical: displaying only two vertical planes of symmetry; having two sides symmetrical, related to the central axis or plane.

Capitate: elements swollen abruptly at the head, the head rounded with diameter smaller than height of stalk. See Fig. 11o.

Clavate: elements with a gradually swollen head, narrowed at base, club shaped. See Fig. 11r.

Columinate: elements rod-shaped, both upper and lower parts equal in size and twice as long as wide. See Fig. 11h.

Commissure: the line of dehiscence on the tetrad scar.

Coniculate: elements with basal part twice as wide as the middle part, forming the figure of a cone with acute apex. See Fig. 11n.

Contact face: or *contact area;* the area on which spores contacted each other in tetrad stage, adjacent to the tetrad scar.

Convolute: sculptured type with elongated and twisted elements on surface view, rarely connected to form reticulation. See Fig. 10f.

Crest: an elevation or ridge of exine or perine.

Cuneate: elements branches widely biforked. See Fig. 11l.

Deltoid triangular: equilateral triangular with more or less straight sides and sharp apices. See Fig. 3.

Distal: the converse of *proximal;* the part of the spore opposite the tetrad scar.

Distal face: the part of a spore surface facing outside from the tetrad scar.

Distal pole: an outer pole of the spore in tetrad.

Distal ridge: the part of elements on distal face coalescing to form three rows of

regular or irregular rugulae-like structure, parallel to equator, sometimes connected with each other. See Fig. 9. The distal ridges can be differentiated into 5 kinds as in *proximal ridges:*

a. short plane field-distal ridges;
b. irregularly sinuous and interrupted distal ridges;
c. narrow band-distal ridges;
d. long plane field-distal ridges;
e. circumfluent field-distal ridges.

Echinate: or *spinate;* elements with basal part twice as wide as the middle part, apex acuminate. See Fig. 11d.

Element: the elevation on exine or perine of spore.

Equator: the great circle midway between the two poles and standing at right angles to the polar axis.

Equatorial ridge: a ridge circling the equator and dividing the grain into two prominent polar hemispheres.

Equatorial value: or *E value;* the distance from one angle to the opposite side measured from polar view. See Fig. 5a.

Equatorial view: or *lateral view;* vision of spore from equator, displaying proximal and distal end simutaneously. See Fig. 1c and 2c.

Exine: the cell wall of spore, consisting of sexine and nexine, but difficult to distinguish them in spores.

Extervermiculate: sculptured type with bent and irregular elements protruding from surface level, forming a worm-shaped figure. See Fig. 10e.

Filiform: elements more or less curved rod-shaped, with both upper and lower parts equal in size. See Fig. 11k.

Flange-like margo: type of margo, along the tetrad scar and parallel to the laesural margin, with obscured ends. See Fig. 7c.

Flat verrucate: elements rod-shaped, shorter than their width and lower part as wide as or slightly wider than upper part, apex flat; contrasted with *rounded verrucate.* See Fig. 11g.

Foveolate: sculptured type with holes or pits with diameters greater than 1 μ, too widely separated to form a reticulum. See Fig. 10l.

Gemmate: elements swollen and suddenly narrowed at head, with diameter wider than the height of stalk. See Fig. 11q.

Granulate: sculptured type with grains more or less isodiametric, which diameter less than 1 μ wide; compared with *tuberculate.* See Fig. 10b.

Granulose: grains of granulate structure.

Graphelate: elements swollen and suddenly narrowed at head, umbrella-shaped. See Fig. 11s.

Inaperaturate: non-aperture; alete.

Interradial position: the side of a spore seen from polar view.

Isopolar: having the proximal and distal hemisphere similar.

Laesura: dehiscence fissure, including the commissure, and also the margo when distinguishable.

Laesural arm: the distance from the centre of tetrad scar to the laesural end.

Laesural ridge: three rows of regular or irregular sinuous ridges close to the laesural margin. See Fig. 8.

The ridges can be differentiated into 5 kinds as follows:

a. irregularly sinuous laesural ridges;

b. short plane field-laesural ridges;
c. narrow band-laesural ridges;
d. long plane field-laesural ridges;
e. circumfluent laesural ridges.

Lateral view: also *equatorial view.*

Line-like margo: type of margo on laesural margin, of very narrow width, usually less than 1 μ. See Fig. 7d.

Lip-like margo: type of margo with lip-like shape and tapering at ends. See Fig. 7b.

Lophate: sculptured type with ridges usually higher than the muri of a reticulum, sometimes vertically striate and perforate. See Fig. 10n.

Lumen: the mesh of the network.

Mammilate: elements with teat-shaped processes. See Fig. 11m.

Margo: a transitional zone between the commissure of the tetrad scar and the remainder of the exine. It is distinguishable by an increase or reduction in thickness within the extexine.

Mesoperine: a powder-like or skin-like layer surrounding the exine surface, showing the same sculpture as exine or not, perfect or cracked into small bits being easily lost after treatment with KOH and CH_3COOH, as seen in some species of *Pteris.*

Monolete: a spore with a single straight tetrad scar.

Murus: low ridge separating the lumina of an ordinary reticulum.

Nexine: inner, non-sculptured part of the exine.

Obcapitate: elements swollen on subbasal part; inversely *capitate.* See Fig. 11t.

Ornate: sculptured type with elongated and curved elements scarcely connected into an incomplete reticulation. See Fig. 10g.

Outline: the *amb;* the contour of spore viewed from the polar view.

Papillate: elements short and with apex rounded, separated from each other. See Fig. 11e.

Perine: the outermost layer of spores, outside of exine.

Pilate: elements with swollen and rounded heads with diameter equal to the height of stalk. See Fig. 11p.

Polar value: or *P value;* the distance from proximal to distal end measured from equatorial view. See Fig. 5b and 6b.

Polar view: view of spore from proximal or distal end.

Process: any elevation, projection or protuberance on exine or perine.

Proximal: the part of a spore closest to the point of attachment in the tetrad.

Proximal face: the portion of a spore surface in a tetrad in contact with othe spores.

Proximal pole: the inner part of the hemisphere of a tetrad.

Proximal ridge: those parts of the elements on the proximal face coalescing to forr three rows of regular or irregular rugulae-like structure, parallel to equato sometimes connected with each other. See Fig. 9.

The proximal ridges can be differentiated into 5 kinds as follows:

a. short plane field-proximal ridges;
b. irregularly sinuous and interrupted proximal ridges;
c. narrow band-proximal ridges;
d. long plane field-proximal ridges;
e. circumfluent field-proximal ridges.

Psilate: exine or perine without any elements on their surface. See Fig. 11a.
Punctate: sculptured type with dot-like depressions on surface of exine or perine. See Fig. 10j.
Radial position: the part of angle of a spore from polar view; contrasted with *interradial position.*
Radiosymmetrical: having similar parts similarly arranged round a central axis.
Reticulate: sculptured type with network formed by anastomosing ridges (muri), enclosing small, frequently more or less irregular spaces (lumina), muri generally lower than the ridges of lophae and lumina smaller than in lophate grains. See Fig. 10m.
Rivulate: sculptured type with elongated and parallel elements which are narrower than furrows; compared with *striate.* See Fig. 10p.
Rounded verrucate: *verrucate* with rounded apex; compared with *flat verrucate.* See Fig. 11f.
Rugate: perine wrinkled. See Fig. 10i.
Rugulate: sculptured type with elongated, coarse elements in irregular or not predominatingly regular arrangement, not connected with each other. See Fig. 10h.
Scabrate: elements small and without dimentsion. See Fig. 11b.
Sculpture: ornamentation or pattern of elements.
Sexine: the sculptured part of the exine.
Side: see *interradial position.*
Simple commissure: the figure of dehiscence of tetrad scar without crassimargination or any other structure. See Fig. 7a.
Smooth: glabrous; without any processes on surface. See Fig. 10a.
Striate: sculptured type with elongated and parallel elements being wider than furrows. See Fig. 10o.
Tetrad: the aggregation of four spores formed from one spore mother cell.
Tetrad scar: the remaining mark of contact face of tetrad.
Trilete: a spore with a triradiate tetrad scar.
Tuberculate: sculptured type with large grains more than 1 μ in area, and too widely separated to form a areolum. See Fig. 10c.
Vallate: sculptured type with pits with diameters not greater than 1 μ but being larger than punctate grains. See Fig. 10k.
Verrucate: elements nearly rod-shaped, shorter than their width, upper part of elements flat or rounded, narrower than or as wide as lower part. See Fig. 11f and g.
Winged: separating of perine to form cavity or cavities.

DESCRIPTION

Copeland (1947) recognized 63 genera in the Pteridaceae. There are 23 genera in Taiwan, and the spore morphology of 21 genera and 90 species of these is here described.

The spores of the Pteridaceae can be divided into two groups: the monolete spores and the trilete spores.

The morphology of the monolete spores is characterized by anisopolar, bilateral symmetry; amb elliptic, planoconvex in lateral view, sometimes cancave on proximal pole; 14-38×29-57×15-42 μ. Laesurae straight, 15-18 μ long, its margin with simple

commissure, lip-like or flange-like margo. Exine smooth or granulate, psilate or with scabrate processes, 1–3 μ thick. Perine smooth, granulate or tuberculate, psilate or with scabrate, rounded verrucate, aciculate, echinate or baculate processes, some closely adhering to the exine, some separate from the spore proper.

The morphology of the trilete spores is characterized by anisopolar, radiosymmetry; amb globose, rounded triangular, subtriangular, triquete or trilobate, proximal pole hemispherical, conical, convex, flat or concave, distal pole subhemispherical, hemispherical or subconical; 20–71×16–55 μ. Laesural arms straight or curved, 7–32 μ long, its margin with simple commissure, lip-like or flange-like margo, sometimes the obscure margo covered by the elements. Exine smooth, granulate, vallate, reticulate, tuberculate, extervermiculate, finely striato-reticulate, coarsely crossed striato-reticulte, areolate, lophate, rugulate or ornate, psilate or with scabrate, baculate, verrucate or cuneate processes, 1–4 μ thick. Some spores with an equatorial ridge separating proximal and distal hemispheres. Some spores with a perine closely adhering to the exine, perine granulate, areolate, irregularly rugate or short striate, with irregularly scabrate, aciculate, baculate or verrucate processes.

KEY TO THE GENERA

1. Spores monolete 2
1. Spores trilete 5
2. Perine winged 3
2. Perine not winged 4
3. Perine smooth or faintly granulate; exine smooth or faintly granulate ..... (XI) *Lindsaea*
(XX) *Sphenomeris*
(XXI) *Tapeinidium*
3. Perine prominently granulate; exine prominently granulate ..... (XV) *Paesia*
4. Perine tuberculate, with verrucate processes ..... (IX) *Histiopteris*
4. Perine tuberculate, with aciculate, echinate or baculate processes ..... (X) *Hypolepis*
5. Spores with equatorial ridges 6
5. Spores without equatorial ridges 8
6. Proximal face with two regular proximal ridges ..... (XVII) *Pityrogramma*
6. Proximal face not as above 7
7. Proximal face with circumfluent field-ridge and distal face with very crowded extervermiculae ..... (II) *Anogramma*
7. Proximal and distal face not as above ..... (IV) *Cibotium*
(XV) *Onychium*
(XIX) *Pteris*
8. Spores with perine 9
8. Spores without perine 13
9. Perine short striate, with aciculate processes ..... (XIV) *Monachosorum*
9. Perine not striate 10
10. Perine areolate, with rounded verrucate processes ..... (XI) *Lindsaea*
(I) *Adiantum*
10. Perine not areolate 11
11. Perine rugate ..... (III) *Cheilanthes*
11. Perine granulate 12
12. Perine granulate, with slightly scabrate processes ..... (I) *Adiantum*
12. Perine granulate, with irregularly scabrate, aciculate or baculate processes ..... (III) *Cheilanthes*
(VIII) *Doryopteris*
(XIII) *Mildella*
(XVIII) *Pteridium*

13. Exine tuberculate, with baculate processes.....(XIX) *Pteris*
13. Exine not tuberculate.....14
14. Exine areolate, with rounded verrucate processes.....(VI) *Cryptogramma*
14. Exine not areolate.....15
15. Exine vallate to reticulate.....(VII) *Dennstaedtia*
15. Exine not vallate or reticulate.....16
16. Exine coarsely crossed or finely striato-reticulate.....(XII) *Microlepia*
16. Exine not as above.....17
17. Exine smooth.....(XII) *Microlepia*
(IV) *Cibotium*
17. Exine granulate.....18
18. Exine prominently granulate.....(V) *Coniogramme*
18. Exine faintly granulate.....(VII) *Dennstaedtia*
(XII) *Microlepia*

I. ADIANTUM L.

Spores trilete; anisopolar, radiosymmetrical, sometimes with one long arm forming bilateral symmetry or asymmetry; amb globose, rounded triangular, subtriangular or triquete, proximal pole flat, distal pole hemispherical or subconical; 28–67×22–55 μ, with great variation in size. Laesural arms straight, its margin with simple commissure or flange-like margo, rarely with lip-like margo, 7–32 μ long. Exine smooth, psilate, 1–3 μ thick. Perine granulate, areolate or rugate, with scabrate, verrucate or echinate processes, 0.5–1.5 μ thick, closely adhering to the exine.

There are twelve species and one form in Taiwan.

KEY TO THE SPECIES

1. Perine rugate, with scabrate and echinate processes.....(5) *A. edentulum*
1. Perine not rugate.....2
2. Perine areolate, with verrucate processes.....(3) ***A. caudatum***
2. Perine granulate, with scabrate processes.....3
3. Amb globose or rounded triangular.....4
3. Amb subtriangular.....5
4. Laesurae 13–20 μ long; exine 1–1.5 μ thick.....(1) *A. capillus-veneris*
4. Laesurae 18–32 μ long; exine 2–2.5 μ thick.....(2) *A. capillus-veneris* f. *lanyuanum*
5. Perine prominently granulate.....6
5. Perine faintly granulate.....7
6. Exine 2–3 μ thick.....(7) *A. flabellulatum*
6. Exine 1–2 μ thick.....(6) *A. edgeworthii*
(8) *A. hispidulum*
(9) *A. philippense*
7. E value 28–35 μ.....(4) *A. diaphanum*
7. E value 32–57 μ.....(10) *A. roborowskii* var. *taiwanianum*

1. Adiantum capillus-veneris L. (Pl. 1, Fig. 1)

Amb globose, proximal and distal poles hemispherical when only mounted in glycerin jelly, but amb rounded triangular or subtriangular, proximal pole flat and distal pole subconical after treated with KOH and CH_3COOH; 43–60×37–55 μ. Laesural arms 13–20 μ long, its margin with flange-like margo, 1.5 μ wide on each side, obscure at ends, rarely with simple commissure. Exine subpsilate, 1–1.5 μ thick. Perine granulate, with scabrate processes, 0.5 μ thick, light brown, granulose often peeling off after treatment with KOH and CH_3COOH.

Taichung: Wushe, *N. Fukuyama 4665*. **Taitung:** Costal Mountain Ranges, *Y. Yamamoto s.n.* March 1930.

2. Adiantum capillus veneris L. *f. lanyuanum* Shieh

Amb globose to rounded triangular, proximal pole convex or flat, distal pole hemispherical or subhemispherical; 43–65×32–50 μ. Laesural arms 18–32 μ long, slit to the margins, sometimes forked at ends, laesural margin with simple commissure or flange-like margo (2 μ wide on each side). Exine 2–2.5 μ thick. Perine granulate, with scabrate processes, up to 1 μ thick, light brown.

Kaohsiung: Hsienwanglien, *T. Suzuki 20921*. **Taitung:** Botel Tobago, *W. C. Shieh et al 389, C. M. Kuo 2214*.

3. Adiantum caudatum L. (Pl. 1, Figs. 2-3)

Amb subtriangular, proximal pole flat, distal pole subconical; 28–42×25–40 μ. Laesural arms straight, rarely curved, 13–19 μ long, always with simple commissure. Exine 1 μ thick. Perine areolate with irregular margin, with rounded verrucate processes, 1.5 μ thick, brown, always opened along the laesurae and formed dense elements bordering the laesurae.

Nantou: Kuantaosi, *C. M. Kuo 2131*. **Hualien:** Tailuko, *M. T. Kao 4075*.

4. Adiantum diaphanum Bl.

Spores radiosymmetrical, rarely asymmetrical, amb subtriangular or triquete, proximal pole flat, distal pole hemispherical or subconical; 28–35×23–35 μ. Laesural arms straight, rarely curved, 12–20 μ long, sometimes forked at ends. Exine 1–1.5 μ thick. Perine faintly granulate, with scabrate processes, 0.5 μ thick, light yellow, skin-like.

Taipei: *T. Suzuki 6207, I. Simozawa s.n.* Aug. 1935, *T. Nakamura 694*.

5. Adiantum edentulum Christ (Pl. 1, Figs. 4-5)

Spores radiosymmetrical, rarely asymmetrical; amb subtriangular, proximal pole convex, distal pole subhemispherical or hemispherical; 35–50×36–37 μ. Laesural arms straight, 16–23 μ long, with lip-like margo, 3–4 μ wide on each side, tapering at ends. Exine 2 μ thick. Perine irregularly rugate, with very irregularly scabrate or echinate processes.

Kaohsiung: Hsiaokuanshan, *W. C. Shieh et al s.n.* Sept. 1972.

6. Adiantum edgeworthii Hook. (Pl. 1, Figs. 6-8)

Spores radiosymmetrical, rarely asymmetrical; amb subtriangular, proximal pole flat, distal pole hemispherical; 31–40×25–32 μ. Laesural arms 7–15 μ long, with simple commissure or lip-like margo (3 μ wide on each side), sometimes forming loop-like circle ends according to the protruding of the radial arms (Pl. 1, Fig. 7). Exine 1–1.5 μ thick. Perine granulate, with scabrate processes, 0.5–1 μ thick, light brown, slit along the laesurae and forming a scabrate edge beside the laesural margin.

Nantou: Kuantaosi, *C. M. Kuo 2158*; Tonpu, *T. Suzuki 13235, I. Simozawa 834*.

7. Adiantum flabellulatum L.

Amb subtriangular, rarely slightly concave on sides, proximal pole flat, distal pole hemispherical; 31–46×30–37 μ. Laesural arms 15–18 μ long, sometimes forked

at ends. Exine 2–3 μ thick. Perine granulate, with scabrate processes, yellow, sometimes granulose, obscure after treatment with KOH and CH_3COOH.

Taipei: Peitou, *M. Murakari s. n.* **Taichung:** Lienhuachih, *Keng, Lin & Kao s. n.* July 1955. **Nantou:** Takenchaio, *C. M. Kuo 1825.*

8. Adiantum hispidulum Sw.

Spores radiosymmetrical or bilateral symmetrical with one long arm; amb subtriangular, rarely globose, proximal pole flat, distal pole subhemispherical to subconical; 32–50×31–40 μ. Laesural arms 14–23 μ long, with obscure lip-like margo. Exine 1–1.5 μ thick. Perine granulate, with scabrate processes, yellow.

Abnormal monolete spores were abundant.

Nantou: Lushan, *M. T. Kao 7942.*

9. Adiantum philippense L. (Pl. 1, Fig. 9)

Spores radiosymmetrical or asymmetrical; amb subtriangular, proximal pole flat, distal pole subhemispherical to subconical; 31–67×22–50 μ, with great variation in size. Laesural arms 14–25 μ long. Exine 1.5–2 μ thick. Perine granulate, with scabrate processes, 0.5 μ thick, brown or light brown, slit along the laesural margin.

Spores are commonly large and asymmetrical, but small and radiosymmetry ones were rarely present. Abnormal monolete spores and abortive exinous masses were observed.

Hsinchu: Chutung, *C. M. Kao 1705.* **Taichung:** Pahsienshan, *Chuang & Kao 2790.* **Nantou:** Cheichei, *C. M. Kuo 1849.* **Kaohsiung:** Shanping, *C. M. Kuo 1932.*

10. Adiantum roborowskii Maxim. var. **taiwanianum** (Tagawa) Shieh

Spores asymmetrical; amb subtriangular, rarely globose, proximal pole flat, distal pole hemispherical; 37–57×32–37 μ. Laesural arms 13–15 μ long, sometimes with flange-like margo. Exine 1.5 μ thick. Perine faintly granulate, with scabrate processes, light brown.

Nantou: Tonpu, *I. Simozawa 831.* **Kaohsiung:** Hsiaokuanshan, *W. C. Shieh et al s. n.* Sept. 1972.

II. ANOGRAMMA Link.

Spores trilete; anisopolar, radiosymmetry; amb rounded triangular, proximal pole convex, distal pole subhemispherical; 40–60×40–45 μ. Laesural arms straight, 14–20 μ long, with lip-like or obscure margo, 3–4 μ wide on each side, tapering at ends. Exine 1.5 μ thick; proximal face with circumfluent field-proximal ridges, 5–6 μ wide, the surface between the proximal ridge and the laesurae bearing tuberculae and extervermiculae, sometimes coalesced to form irregularly sinuous laesural ridge; distal pole crowded extervermiculate, with rounded verrucate processes, muri 3–3.5 μ tall, 2–5 μ wide, sometimes the outermost muri forming a distal ridge; equatorial ridge annulotrilete, smooth, uninterrupted, 5–7 μ tall, 6–7 μ wide, occasionally equatorial ridge connected with the proximal ridge, the outline of the equatorial ridge somewhat smaller than the distal face or the same size.

There is only one species in Taiwan.

1. Anogramma leptophylla (L.) Link. (Pl. 1, Figs. 10–12)
Spore morphology is the same as above described.

Taichung: Pahsienshan, *T. Suzuki 20614.* **Chiayi:** Alishan, *T. Suzuki 13290.*

III. CHEILANTHES Sw.

Spores trilete, except monolete in *C. hirsuta;* anisopolar, radiosymmetry; amb globose, rounded triangular or subtriangular, proximal pole conical or convex, distal pole subhemispherical, hemispherical; 31–71×27–54 μ. Laesural arms straight or curved, 15–19 μ long, with simple commissure, lip-like margo or flange-like margo. Exine smooth, psilate, 1–3 μ thick. Perine rugate or granulate, with scabrate, aciculate or echinate processes, 1–4 μ thick, light brown or brown, closely adhering to the exine.

There are five species in Taiwan.

KEY TO THE SPECIES

1. Spores monolete; perine granulate, with aciculate or scabrate processes .....(3) *C. hirsuta*
1. Spores trilete; perine not as above 2
2. Perine finely granulate and rugately wrinkled, with irregularly echinate or aciculate or aciculate processes.....(2) *C. farinosa*
2. Perine granulate, with scabrate processes.....3
3. Perine granulate, with slightly scabrate processes; amb subtriangular .....(5) *C. tenuifolia*
3. Perine granulate, with irregularly scabrate processes; amb globose or rounded triangular.....4
4. Exine 3 μ thick .....(1) *C. argentea*
4. Exine 1–2 μ thick .....(4) *C. mysurensis*

1. Cheilanthes argentea (Gmel.) Kunze. (Pl. 2, Figs. 1–2)
Amb globose, proximal pole conical, distal pole hemispherical; 41–66×37–50 μ. Laesural arms straight, 21–30 μ long, slit to the margins, with margo tapering toward onds, sometimes the margo obscure. Exine 3 μ thick. Perine granulate, with irregularly scabrate processes, sometimes reticulately folded, 3–4 μ thick, light brown.

Ilan: Bonbonshan, *M. T. Kao 5921.* **Miaoli:** Tafu, *Y. Simeda 4891.* **Nantou:** Sungmae, *F. K. Chang s. n.* Oct. 1970; Tonpu; *T. Suzuki 13245.*

2. Cheilanthes farinosa (Forsk.) Kaulf. (Pl. 2, Figs. 3–5)
Amb globose to rounded triangular, proximal pole conical, distal pole subhemispherical; 40–62×34–54 μ. Laesural arms straight, 15–30 μ long, with simple commissures, sometimes, forked at ends. Exine 1–2 μ thick. Perine finely granulate and rugately wrinkled, with irregularly echinate and aciculate processes, 2 μ thick, the folds 3–8 μ tall, 7–13 μ long, light to deep brown.

Miaoli: Tafu, *Do s. n.* July 1934. **Nantou:** Kuantaosi, *Huang 6076.* **Chiayi:** Alishan, *Huang & Kao 1656;* Funchihu, *C. S. Feung & M. T. Kao 240.* **Kaohsiung:** Tengtzu, *J. L. Tsai 637.*

3. Cheilanthes hirsuta (Poir.) Mett. (Pl. 2, Figs. 6–7)
Spores monolete; globose in polar and equatorial view; 59–71 μ. Laesural arms curved, 30–90 μ long, sometimes with a flange-like margo, 2 μ tall and wide, some-

times with lip-like margo, 4 μ wide. Exine 3 μ thick. Perine granulate, with aciculate or scabrate processes, aciculae 2–3 μ tall, perine sometimes wrinkled or dotted with rounded area.

Taichung: Puli, *W. C. Shieh et al s. n.* July 1967. **Nantou:** Kuantaosi, *C. M. Kuo 2142.*

4. Cheilanthes mysurensis Wall.

Amb globose to rounded triangular, proximal pole convex, distal pole hemispherical; 31–50×27–33 μ. Laesural arms straight, 15–22 μ long, slit to the margins, sometimes with a line-like margo, 3 μ wide on each side, tapering ends. Exine 1–2 μ thick. Perine granulate, with irregularly scabrate processes, 2–3 μ thick, light brown.

Taipei: Tatungshan, *S. Sasaki s. n.* Feb. 1932. **Taichung:** Pahsienshan, ***T. C. Huang 1363.*** **Nantou:** Kuantaosi, *C. M. Kuo 2170, Huang 6112, 6184.* **Pingtung:** Machia, *Huang 7387.*

5. Cheilanthes tenuifolia (Burm.) Sw. (Pl. 3, Fig. 8)

Amb subtriangular, proximal pole conical or convex, distal pole subconical; 42–60×41–46 μ. Laesural arms curved, 20–27 μ long, sometimes with flange-like margo, 2 μ wide, obscure ends. Exine 1–2 μ thick. Perine granulate, with scabrate processes, 1 μ thick, brown.

Nantou: Lienhuachi, *M. T. Kao 4076;* Kuantaosi, *C. M. Kuo 1537, Huang 6115.*

IV. CIBOTIUM Kaulf.

Spores trilete; anisopolar, radiosymmetry; amb subtriangular.

There is only one species in Taiwan based on morphological characters, but there are two different kinds based on spore features.

1. Cibotium barometz (L.) Sm. (Pl. 3, Figs. 1–3)

Spores proximal pole flat, distal pole subhemispherical; 35–43×33–38 μ. Laesural arms straight, 16–25 μ long. Exine 1 μ thick; proximal face with 3 rows of short, plane field-laesural ridges along the laesural margins, the ridges 4–5 μ wide, 15–23 μ long, tapering or rounded at ends; distal face with long, plane field-distal ridge or circumfluent field-distal ridge near to equator, a few but various shapes of rugulae inside of the distal ridge, the elements of the other, with verrucate or slightly cuneate processes, 5–7 μ tall, 4–6 μ wide; equatorial ridge annulate or annulotrilete, margin curved, rarely interrupted on radials, 5–8 μ tall and wide.

The features described above are the same as given by Erdtman (1959) and Nayar and Santha (1968).

Some abnormal monolete spores were observed.

Nantou: Sun Moon Lake, *C. M. Kuo 1827;* Wuchen, *Y. Hashioka s. n.* Nov. 1932.

The other type of **C. barometz** spores (Pl. 3, Figs. 4–5) found in Taiwan is described below.

Spores proximal pole convex, distal pole subconical; 42–58×42–48 μ. Laesural arms straight, 22–26 μ long, with lip-like margo, 3–5 μ wide on each side, tapering ends. Exine smooth, psilate, thickened at angles, 1–2 μ thick at sides, 3–4 μ thick at angles.

Taipei: Chihsingshan, *C. T. Moo & K. S. Hsu 1221.* **Taichung:** Tashueshan, *T. S. Liu et al s. n.* Oct. 1957. **Nantou:** Takenchaio, *C. M. Kuo 1818;* Kuantaosi, *J. L. Tsai 336, Huang 6148.* **Chiayi:** Kuantzuling, *H. Morimoto s. n.* May 1943. **Pingtung:** Kenting, *Matuda s. n.* June 1917.

V. CONIOGRAMME Fee.

Spores trilete; anisopolar, radiosymmetry; amb subtriangular or triquete, proximal pole conical or flat, distal pole hemispherical or subconical; 26–46×22–38 μ. Leasural arms straight, 10–21 μ long. Exine granulate, with scabrate processes, 1.5–2 μ thick.

There are 4 species in Taiwan. Three species are described here. Since it is too difficult to distinguish one from another, the "KEY TO THE SPECIES" is intentionally omitted.

1. Coniogramme fraxinea (Don.) Diels. (Pl. 2, Figs. 9–10)

Amb subtriangular, slightly concave on sides, proximal pole conical or flat, distal pole hemispherical; 32–46×32–38 μ. Laesural arms 12–17 μ long, with simple commissure. Exine 1.5 μ thick.

A few abnormal spores with reniform or ellipsoidal shapes were observed.

Nantou: Hsienshih to Tienti, *T. Simizu s. n.* Dec. 1960. **Kaohsiung:** Shanping, *T. C. Huang 4970;* Kasagizan, *E. Matuda s. n.* Nov. 1916.

2. Coniogramme intermedia Hieron.

Amb subtriangular, proximal pole conical, distal pole subconical; 31–41×34–37 μ. Laesural arms 12–21 long, its margin with line-like margo (2 μ tall, 1 μ wide on each side) or lip-like margo (tapering ends). Exine 1.5 μ thick.

Some giant spores were observed.

Ilan: Szuyan, *Chuang & Kao 2456.* **Chiayi:** Alishan, *W. C. Shieh et al 207.* **Kaohsiung:** Wuweishan, *Matuda s. n.* Jan. 1919.

3. Coniogramme japonica (Thunb.) Diels.

Amb subtriangular or triquete, proximal pole flat with protruding pole, distal pole hemispherical; 26–39×22–27 μ. Laesural arms 10–15 μ long, with simple commissure, rarely with obscure lip-like margo. Exine 2 μ thick.

Taitung: Kuanshan, *M. Yamamoto 97.*

VI. CRYPTOGRAMMA R. Hr.

Spores trilete; anisopolar, radiosymmetry; amb subtriangular, proximal pole flat, distal pole hemispherical; 45–61×46–60 μ. Laesural arms straight, 15–25 μ long, sometimes with obscure margo (3 μ wide on each side), sometimes with irregularly sinuous laesural ridge (1.5 μ broad on either side) on the laesural margins and often dilated at ends. Exine areolate, with rounded verrucate processes, 2–3 μ thick (including ornamentation), the elements 2–3 μ tall, 3–7 μ across, proximal pole much compact than distal pole, but smaller in size and fainter in feature.

There are two species in Taiwan, but only one is described here.

1. Cryptogramma brunoniana (Wall.) Hook. & Grev. (Pl. 3, Figs. 6–8)

Spore morphology is the same as above described.

Hsinchu: Tapachienshan, *C. M. Kuo 1780.* **Chiayi:** Alisan, *H. Simada 869.*

VII. DENNSTAEDTIA Bernh.

Spores trilete; anisopolar, radiosymmetrical; amb subtriangular, triquete, rarely rounded triangular, or with truncate angles, proximal pole convex or flat, distal

pole subhemispherical, hemispherical or subconical; 20–55×17–39 μ. Laesural arms straight, 10–31 μ long. Exine faintly granulate or vallate to reticulate, with scabrate or rounded verrucate processes, 1–3 μ thick.

There are four species in Taiwan.

KEY TO THE SPECIES

1. Exine vallate to reticulate.....(3) ***D. scandens***
1. Exine not reticulate 2
2. Amb subtriangular with truncate angles; sexine brown .....(1) ***D. hirsuta***
(2) ***D. scabra***
2. Amb subtriangular with rounded angles; sexine not brown .....(4) ***D. smithii***

1. Dennstaedtia hirsuta (Sw.) Mett. (Pl. 3, Figs. 9–10)

Amb subtriangular or triquete with truncate angles, proximal pole convex or concave, distal pole hemisphericial or subhemispherical; 30–45×25–36 μ. Lae ural arms 11–18 μ long, with lip-like margo, brown, 2–2.5 μ wide on each side, ends tapering, sometimes with forked tips. Exine faintly granulate, with slightly scabrate processes, 1–2 μ thick at sides and 2–3 μ thick at angles; sexine brown, thickened trilobate shape on proximal and distal faces or thickened all over the distal face or cracked into areolae-like elements in center (Pl. 3, Fig. 9); nexine light yellow.

Taichung: Pahsienshan, *Kao, Kuo & Chuang 2725;* Tachian, *Feung & Kao 4611.* **Nantou:** Kuantaosi, *C. M. Kuo 2085.*

2. Dennstaedtia scabra (Wall.) Moore (Pl. 3, Fig. 11)

Amb subtriangular or triquete with truncate angles, proximal pole convex or nearly flat, distal pole subhemispherical or hemispherical; 27–55×21–37 μ. Leasural arms 13–31 μ long, with simple commissure, lip-like margo (2–3 μ wide on each side, ends tapering) or flange-like margo brown, sometimes dialated at ends, sometimens tips forked. Exine faintly granulate, with scabrate processes, 2–3 μ thick, thickened at angles; sexine brown, thickened trilobate shape on distal face and with tuberculae in centre, sometimes thickened all over the dist al faces; nexine light yellow.

Taipei: Kankou, *M. T. Kao 3715.* **Taichung:** Pahsienshan, *T. C. Huang 1348.* **Nantou:** Kuantaosi, *C. M. Kuo 2045.* **Kaohsiung:** Tientzu, *J. L. Tsai T. 634.*

3. Dennstaedtia scandens (Bl.) Moore (Pl. 4, Figs. 1–2)

Amb subtriangular, rarely triquete, proximal pole flat, distal pole subhemispherical; 20–32×17–21 μ. Laesural arms 10–13 μ long, with simple commissure, obscure or rarely lip-like margo, 3 μ wide on each side. Exine vallate to reticulate, with rounded verrucate processes, 1.5–2.5 μ thick, lumina 0.5–1.5 μ across, brown.

Nantou: Chingshuikou, *T. C. Huang 1893.* **Kaohsiung:** Tientzu, *W. C. Shieh 1738.*

4. Dennstaedtia smithii (Hook.) Moore (Pl. 4, Fig. 3)

Amb subtriangular or rounded triangular, proximal pole flat with protruding pole, distal pole subconical or hemispherical; 30–44×26–36 μ. Laesural arms 13–20 μ long, with lip-like or flange-like margo (2–3 μ wide on each side), dilated at ends. Exine faintly granulate, with scabrate processes, 1–1.5 μ thick.

Taipei: Wulai, *Kao, Chung & Feung 76.* **Ilan:** Suao, *Nakamura 5108;* Bonbonshan, *M. T. Kao 5924.*

VIII. DORYOPTERIS J. Sm.

Spores trilete; anisopolar, radiosymmetrical; amb globose, rarely rounded triangular, proximal pole convex, distal pole hemispherical; 28–35×28–37 μ. Laesural arms straight, 10–14 μ long, slit to the margins, simple commissure, rarely with obscure margo, sometimes forked at ends. Exine smooth, psilate, 1–2 μ thick, thicker in small spores. Perine granulate, with irregularly scabrate processes, sometimes folded in reticulation, 2–3 μ thick, light brown, closely adhering to the exine.

There is only one species in Taiwan.

1. **Doryopteris concolor** (Langsd. & Fisch.) Kuhn. (Pl. 4, Fig. 4)

Spore morphology is the same as above described.

Nantou: Kuantaosi, *C. M. Kuo 2104;* Lushan, *DeVol 8027.*

IX. HISTIOPTERIS (Ag.) J. Sm.

Spores monolete; anisopolar, bilateral symmetrical, amb ellipsoidal, planoconve in lateral view; 25–31×38–48×25–32 μ. Laesural arms straight, 18–30 μ long, with lip-like margo, 4 μ wide on each side. Exine smooth, psilate, 1–1.5 μ thick. Perine undulatedly tuberculate, with rounded verrucate processes, 3–4 μ thick, the elements dense and sometimes coalesced each other, large (4 μ tall, 5–10 μ across) and more prominent on the distal face, but progressively less prominent towards the proximal face and almost absent around the laesurae. Proximal pole flat on centre, but often with two protruding ends, appearing as circles at each end of the laesural tips in polar view (Pl. 4, Fig. 5).

There is one species in Taiwan.

1. **Histiopteris incisa** (Thunb.) J. Sm. (Pl. 4, Figs. 5–8)

Spore morphology is the same as above described.

Ilan: Taipingshan, *Chuang. Chao & Kao 4753.* **Taichung:** Ammashan, *T. S. Liu et al 419.* **Nantou:** Meiyuanshan, *M. T. Kao 6686.*

X. HYPOLEPIS Bernh.

Spores monolete; anisopolar, bilateral symmetrical, amb ellipsoidal, planoconvex in lateral view; 21–37×33–50×20–35 μ. Laesurae straight, 15–31 μ long, with simple commissure. Exine smooth, psilate, 1–3 μ thick. Perine undulatedly tuberculate, with aciculate, echinate or baculate processes, transparent, 1–2 μ thick, the elements 2–4 μ tall.

There are three species in Taiwan. Each of them has similar features. So it is hard to distinguish them.

KEY TO THE SPECIES

1. Exine 2–3 μ thick ..... (3) *H. tenuifolia*
1. Exine 1–2 μ thick ..... (1) *H. alte-gracillima*
   (2) *H. punctata*

1. **Hypolepis alte-gracillima** Hay. (Pl. 4, Fig. 9)

Spores 24–37×34–50×23–35 μ. Laesurae 18–31 μ long. Exine 1–2 μ thick. Perine with aciculate or baculate processes, aciculae 2.5–3.5 μ tall, up to 1 μ wide, baculae 4 μ tall, 2 μ wide.

Taipei: Fushan, *T. Suzuki 19164.* **Taichung:** Pahsienshan, *T. C. Huang 1341.* **Nantou:** Chitou, *C. C. Chuang 2853.* **Pingtung:** Wuweishan, *E. Matuda s. n.* March 1917.

2. Hypolepis punctata (Thunb.) Mett. (Pl. 4, Fig. 10)

Spores 26–32×35–41×23–33 μ. Laesurae 25–31 μ long. Exine 2 μ thick. Perine with aciculate or baculate processes, the elements 2–3 μ tall, sometimes connected by "skines".

Taichung: Anmashan, *Feung & Kao 4437;* Lienhuachih, *S. Hibino & S. Suzuki* s. n. July 1930. **Kaohsiung:** Tientzu, *W. C. Shieh et al 660.*

3. Hypolepis tenuifolia (Forst.) Bernh. (Pl. 4, Fig. 11)

Spores 21–28×33–41×20–26 μ. Laesurae 15–16 μ long. Exine 2–3 μ thick. Perine with aciculate or echinate processes, the elemetns 3–4 μ tall.

Locality: s. loc. *Hosokawa s. n.* May 1938.

XI. LINDSAEA Dryander

Spores trilete or monolete.

In trilete spores, anisopolar, radiosymmetrical or bilateral symmetrical with one long arm; amb subtriangular, triquete or trilobate, proximal pole hemispherical, conical or convex, distal pole subhemispherical, hemispherical or subconical; 20–48×16–40 μ. Laesural arms curved or straight, 8–17 μ long, with flange-like margo (1.5–2 μ wide on each side), lip-like margo (2.5 μ wide on each side) or line-like margo. Exine smooth, faintly granulate, or faintly punctate, psilate or with slightly scabrate processes, 1–2 μ thick. Perine granulate or areolate with irregular margin, with scabrate or rounded verrucate processes, 0.5–1.5 μ thick, light brown or brown, closely adhering to the exine.

In monolete spores, anisopolar, bilateral symmetrical; amb ellipsoidal, planoconvex in lateral view; 20–32×29–57×16–40 μ. Laesurae straight, 24–48 μ long, with lip-like margo or flange-like margo. Exine smooth, psilate, 1–1.5 μ thick. Perine smooth or very finely granulate, psilate or with slightly scabrate processes, 0.8–1.5 μ thick, brown, separated away from the exine after treatment with KOH and CH_3COOH.

There are twelve species in Taiwan. Eleven species are described here.

KEY TO THE SPECIES

1. Spores monolete 2
1. Spores trilete 3
2. Spores 20–21×29–40×16–21 μ ..... (6) *L. japonica*
2. Spores 32×42–57×27–40 μ ..... (9) *L. odorata*
3. Perine faintly granulate ..... (11) *L. yaeyamensis*
3. Perine prominently granulate or areolate 4
4. Perine prominently granulate ..... (4) *L. ensifolia*
(10) *L. orbiculata*
4. Perine granulate to areolate 5
5. Exine faintly granulate ..... (1) *L. chienii*
5. Exine not faintly granulate 6
6. Exine faintly punctate ..... (7) *L. javanensis*
6. Exine smooth ..... (2) *L. commixta*
(3) *L. cultrata*
(8) *L. obtusa*

1. Lindsaea chienii Ching (Pl. 4, Figs. 12–13)

Spores trilete; amb subtriangular, rarely rounded triangular, proximal pole nearly flat, distal pole hemispherical; 22–33×19–28 μ. Laesural arms curved, 11–14 μ long, with flange-like margo, 2 μ wide on each side, obscure at ends, sometimes tips forked. Exine faintly granulate, with faintly scabrate processes, 1–1.5 μ thick. Perine granulate to areolate, with scabrate to gemmate processes, 1 μ thick, light brown, the elements 1×1–2 μ in area, proximal pole with elements less than distal pole, crowded elements scattered along the outer margin of laesural margo.

Some abortive exinous masses were observed.

Taipei: Yama, *T. Suzuki 7442;* Tatungshan, *C. M. Kuo 1430;* Chihsinshan, *C. M. Kuo 3413;* Suhting, *C. M. Kuo 788;* Kueishan, *C. M. Kuo 316:* Tunyenshan, *C. M. Kuo 1021.* **Taoyuan:** Peichatienshan, *C. M. Kuo 2690.* **Miaoli:** Yungmeishan, *C. P. Lin 2386.* **Nantou:** Kuantaosi, *C. M. Kuo 2046.* **Pingtung:** Nanrenshan, *C. M. Kuo 1986.* Kutzulunshan, *C. M. Kuo 1259.*

2. Lindsaea commixta Tagawa (Pl. 4, Fig. 15)

Spores trilete; bilateral symmetrical with one long arm; proximal pole conical or convex, distal pole subhemispherical; 27–48×22–40 μ. Laesural arms curved, 13–17 μ long, with flange-like margo, 1.5 μ wide on each side, obscure at ends. Exine smooth, psilate, 1–1.5 μ thick. Perine granulate to areolate, with scabrate to rounded verrucate processes, 1 μ thick, light brown, the elements 1–3 μ across, different specimens of different sizes.

Taipei: Mutzshan, *C. M. Kuo 2356.* **Nantou:** Chingshuikou, *Huang, Lou & Lao 1052.* **Taitung:** Botel Tobago, *Huang & Kao 7524, C. M. Kuo 2185.*

3. Lindsaea cultrata (Willd.) Sw.

Spores trilete; amb subtriangular or triquete, proximal pole convex, distal pole subconical; 21–35×16–29 μ. Laesural arms curved, 8–14 μ long, with simple commissure or flange-like margo, 1.5–2 μ wide on each side. Exine smooth, psilate, 1–2 μ thick. Perine granulate and areolate with irregular margin, with rounded verrucate processss, finely granulae scattered in the space of areolae, 0.5–1 μ thick, brown, areolae 1–4 μ across, different specimens of different sizes.

Taichung: Pahsienshan, *S. Suzuki s. n.* Oct. 1929. **Chiayi:** Alisan, *T. Suzuki 19689.* **Taitung:** Botel Tobago, *C. M. Kuo 2191, Huang & Kao 7532.*

4. Lindsaea ensifolia Sw. (Pl. 4, Fig. 16)

Spores trilete; amb subtriangular, proximal pole flat, distal pole hemispherical or subconical; 28–33×25–29 μ. Laesural arms curved, 15–17 μ long, with flange-like margo (2 μ wide on each side). Exine smooth, psilate, 1–1.5 μ thick. Perine granulate, somewhat coalesced, with scabrate processes, up to 1 μ thick, light brown.

Taichung: Lienhuachih, *W. C. Shieh 219.*

5. Lindsaea heterophylla Dry.

All spores are irregular and abortive.

Taichung: Lienhuachih, *W. C. Shieh 1290.* **Nantou:** Sun Moon Lake, *Kudo & Sasaki s. n.* Sept. 1929.

6. Lindsaea japonica (Bal.) Diels. (Pl. 4, Fig. 17)

Spores monolete; 20–21×29–40×16–21 μ. Laesural arms straight, 24–26 μ long, with lip-like margo, 3 μ wide on each side, tapering ends. Exine smooth, psilate, 1 μ

thick. Perine smooth, psilate, 0.8–1 μ thick, brown, similar in shape as the spore but it separated from the spore after treatment with KOH and CH_3COOH.

Taipei: Chihsingshan, *T. Nakamura 686.*

7. Lindsaea javanensis Bl. (Pl. 4, Fig. 14)

Spores trilete; amb subtriangular, proximal pole convex, distal pole hemispherical; 25–34×22–25 μ. Laesural arms curved, 12–15 μ long, with flange-like margo, 2 μ wide on each side, obscure ends, rarely with obscure lip-like margo. Exine faintly punctate, with faintly scabrate processes, 1–1.5 μ thick. Perine irregularly areolate, with rounded verrucate processes, 1 μ thick, elements 1.5×1–5 μ in area, densely scattered along the margo, proximal pole less than distal pole or without elements on contact area.

Taipei: Fushan, *T. Nakamura 527.* **Taitung:** Tsushuipo, *H. Simizu s. n.* July 1937.

8. Lindsaea obtusa J. Smith (Pl. 4, Fig. 18, 19)

Spores trilete; amb subtriangular, triquete or trilobate, proximal pole convex, distal pole subhemispherical; 20–33×16–25 μ. Laesural arms straight, 11–17 μ long, with very crowded tuberculae, evenly coalescing to form laesural ridges, sometimes tips forked. Exine smooth, psilate, 1–2 μ thick. Perine coarsely areolate with irregular margin, with rounded verrucate processes, 1–2 μ thick, light brown, the elements 3–5 μ across, of irregular shapes, with finely scattered granulae between the areolae space.

Many abortive spores were observed.

Taipei: Fushan, *S. Sasaki s. n.* July 1930. **Taichung:** Pahsienshan, *S. Suzuki s. n.* Oct. 1929.

9. Lindsaea odorata Roxb.

Spores monolete; amb ellipsoidal with spindle shape; 23–32×42–57×27–40 μ. Laesurae straight, 35–48 μ long, with flange-like margo, 1.2 μ wide. Exine smooth, psilate, 1–1.5 μ thick. Perine with slightly scabrate processes, 1–1.5 μ thick, brown.

Taipei: Chihsinshan, *C. M. Kuo 3418;* Tatungshan, *C. M. Kuo 1371;* Yangmingshan, *C. M. Kuo 433.* **Ilan:** Yenyanghu, *C. M. Kuo 1490.* **Taoyuan:** Peichatienshan, *C. M. Kuo 2559.* **Miaoli:** Yangmeishan, *C. P. Lin 2384.* **Nantou:** Chitou; *C. S. Feung & M. T. Kao 320, M. T. Kao 7193, C. M. Kuo 616.* **Chiayi:** Alishan, *C. M. Kuo 3180.* **Kaohsiung:** Tasulingshan, *C. M. Kuo 1331.* **Pingtung:** Kutzulunshan, *C. M. Kuo 1251.*

10. Lindsaea orbiculata (Lam.) Mett. & Kuhn. (Pl. 5, Fig. 1)

Spores trilete; amb subtriangular, slightly bilateral symmetrical with one long arm, proximal pole convex, distal pole hemispherical to subconical, 27–40×24–34 μ. Laesural arms curved, 12–14 μ long, with flange-like margo, 1–2 μ wide on each side, sometimes ends forked. Exine faintly granulate, with slightly scabrate processes, 1–2 μ thick, sometimes homogenous, sometimes thickened at radial or interradial positions. Perine granulate, with scabrate processes, 1 μ thick, light brown, elements 0.5–1 μ across, with less on proximal pole than distal pole and densely scattered along the laesural margo but none on the margo.

Taipei: Hsintien, *M. T. Kao 3485;* Tatungshan, *C. M. Kuo 2300.* **Nantou:** Sun Moon Lake, *C. M. Kuo 1832;* Kuantausi, *C. M. Kuo 2022.*

11. Lindsaea yaeyamensis Tagawa (Pl. 5, Figs. 2-3)

Spores trilete; amb subtriangular or rounded triangular, rarely globose, proximal pole hemispherical or conical, distal pole hemispherical; 22-35×17-28 μ. Laesural arms slightly curved, 12-16 μ long, sometimes with a line-like margo, 3 μ tall, 1.5 μ wide, sometimes with obscure lip-like margo. Exine faintly granulate with slightly scabrate processes, 1-1.5 μ thick. Perine faintly granulate, with faintly scabrate processes, 0.5 μ thick, transparent or very light brown, often peeling off after treatment with KOH and CH_3COOH.

Taitung: Botel Tobago, *C. C. Hsu s. n.* Sept. 1968. **Pingtung:** Nanrenshan, *C. M. Kuo 1987*.

XII. MICROLEPIA Presl.

Spores trilete; anisopolar, radiosymmetrical; amb subtriangular or triquete, rarely rounded triangular, proximal pole convex, flat or concave, distal pole subhemispherical, hemispherical or subconical; 24-45×29-35 μ. Laesural arms straight, 7-21 μ long, with simple commissure or obscure lip-like margo (2-3 μ wide on each side). Exine smooth, granulate, finely striato-reticulate or coarsely crossed striato-incomplete-reticulate, psilate or with scabrate or rounded verrucate processes, 1-3.5 μ thick, the granulae very obscure after treatment with KOH and CH_3COOH.

There are 14 species in Taiwan; 11 species are described here.

KEY TO THE SPECIES

1. Exine coarsely crossed striato-incomplete-reticulate, with rounded verrucate processes ..... (11) *M. tenera*
1. Exine sculpture not as above 2
2. Exine finely striato-reticulate 3
2. Exine smooth or granulate 4
3. Striato-reticulae prominent ..... (12) *M. trichocarpa*
3. Striato-reticulae obscure ..... (10) *M. taiwaniana*
4. Exine smooth ..... (8) *M. strigosa*
4. Exine granulate ..... (1) *M. calvescens*
(2) *M. hookeriana*
(4) *M. marginata*
(5) *M. obtusiloba*
(6) *M. speluncae* var. *hancei*

1. Microlepia calvescens (Wall.) Pr. (Pl. 5, Fig. 4)

Amb triquete, rarely subtriangular, proximal pole flat, distal pole hemispherical or subconical; 28-43×25-34 μ. Laesural arms 10-20 μ long. Exine faintly granulate, with slightly scabrate processes, 1.5 μ thick.

Taichung: Pahsienshan, *S. Sasaki s. n.* Nov. 1922; Lienhuachih, *S. Hibino & S. Suzuki s. n.* July 1926. **Nantou:** Sun Moon Lake, *DeVol & Huang 1204*.

2. Microlepia hookeriana (Wall.) Pr.

Amb subtriangular or triquete, proximal pole convex or flat, distal pole subhemispherical or hemispherical; 30-42×25-35 μ. Laesural arms 15-21 μ long. Exine granulate, with slightly scabrate processes, 1.5-2 μ thick.

Nantou: Sun Moon Lake, *C. M. Kuo 1844;* Chingshuikou, *Huang, Kuo & Kao 893*. **Kaohsiung:** Tientzu, *W. C. Shieh et al 661*.

3. Microlepia intramarginalis (Tagawa) Serizawa
All spores are of irregular shape and abortive.

Nantou: Sun Moon Lake, *C. M. Kuo 1843.* **Kaohsiung:** Shanping, *C. M. Kuo 1885.*

4. Microlepia marginata (Panzer) C. Chr.
Amb subtriangular or triquete, proximal pole flat or concave, distal pole hemispherical; 27–45×27–34 μ. Laesural arms 10–19 μ long. Exine faintly granulate, with slightly scabrate processes, 1.5–2 μ thick.

Miaoli: Yangmeishan, *C. P. Lin 2387.* **Nantou:** Meiyuanshan, *M. T. Kao 6667.*

5. Microlepia obtusiloba Hay. (Pl. 5, Fig. 6)
Amb subtriangular or triquete, proximal pole flat, distal pole hemispherical; 30–44×29–31 μ. Laesural arms 12–19 μ long. Exine faintly granulate, with slightly scabrate processes, 1.5 μ thick.

Taipei: Yangmingshan, *C. E. DeVol et al 4480;* Wulai, *T. Suzuki 15554;* Fushan, *T. Suzuki 16545.*

6. Microlepia speluncae (L.) Moore var. **hancei** (Prantl.) C. Chr. & Tard.-Blot
Amb subtriangular or triquete, proximal pole flat or concave, distal pole subhemispherical; 25–40×22–28 μ. Laesural arms 12–19 μ long. Exine faintly granulate, with slightly scabrate processes, 1–2 μ thick.

Taipei: Wutu, *C. E. DeVol 9005;* Kankou, *M. T. Kao 3715.* **Nantou:** Sun Moon Lake, *C. M. Kuo 1828.*

7. Microlepia speluncae (L.) Moore var. **pubescens** (Hook.) Sledge
All spores are of irregular shape and abortive.

Nantou: Sun Moon Lake, *Kudo & Sasaki s. n.* Sept. 1929. **Kaohsiung:** Sanping, *C. M. Kuo 1937.*

8. Microlepia strigosa (Thunb.) Pr. (Pl. 5, Fig. 5)
Amb subtriangular, rarely rounded triangular or triquete, proximal pole flat with protruding pole, distal pole hemispherical or subconical; 24–43×23–32 μ. Laesural arms 8–21 μ long. Exine smooth, psilate, 1–2 μ thick.
Some spores protruding on the three radial positions.

Taipei: Hsiaoyi, *T. Suzuki 19073.* **Kaohsiung:** Tientzu, *W. C. Shieh et al 659.* **Taitung:** Botel Tobago, *C. C. Hsu s. n.* Sept, 1968.

9. Microlepia substrigosa Tagawa
Many abortive spores, regular shapes were rarely observed, about 25 μ in E value.

Taipei: Wulai, *T. Suzuki 15555.*

10. Microlepia taiwaniana Tagawa
Amb subtriangular; proximal pole flat, distal pole subhemispherical or hemispherical; 32–38×28–32 μ. Laesural arms 13–16 μ long. Exine obscurely, finely striato-reticulate with slightly scabrate processes, 1–1.5 μ thick.

Nantou: Chitou, *W. C. Shieh s. n.* Dec. 1967.

11. Microlepia tenera Christ (Pl. 5, Figs. 7–9)

Amb subtriangular or rounded triangular, proximal pole flat, distal pole hemispherical; 25–35×14–20 μ. Laesural arms 7–15 μ long, with simple commissure or lip-like margo, brown. Exine with coarse cross striations forming incomplete reticulation, with rounded verrucate processes, 2–3.5 μ thick, muri 3–3.5 μ wide; sexine 1–2 μ thick, brown; nexine 1–1.5 μ thick, light yellow.

Kaohsiung: Shanping, *C. M. Kuo 1967, U. Faurie 8177.*

12. Microlepia trichocarpa Hay. (Pl. 5, Figs. 10–11)

Amb subtriangular or triquete, proximal pole flat, distal pole hemispherical, rarely subhemispherical; 30–42×24–30 μ. Laesural arms 15–18 μ long. Exine prominently, fine striato-reticulate, with minute scabrate processes, 1.5–2 μ thick.

Nantou: Chingshuikou, *Huang, Kou & Kao 1005.* **Kaohsiung:** Sanping, *C. M. Kuo 1951;* Tientzu, *W. C. Shieh et al 654.*

XIII. MILDELLA Trev.

Spores trilete; anisopolar,radiosymmetrical; amb globose or rounded triangular, proximal pole and distal pole hemispherical; 31–46×35–39 μ. Laesural arms curved, 12–20 μ long, slit to radial position, laesural margin with simple commissure or lip-like margo, 3 μ wide on each side. Exine smooth, psilate, 2–2.5 μ thick. Perine granulate, with irregularly scabrate processes, seldom wrinkled, 2–3 μ thick, light brown, adhering to the exine; mature spores brown or yellow.

There is one species in Taiwan.

1. Mildella hearyi (Christ) Hall. & Lellinger (Pl. 5, Figs. 12–13)

Spore morphology is the same as above described.

Taichung: Pahsienshan, *Kao, Kuo & Chuang 2649, T. C. Huang 1262.* **Nantou:** Tonpu, *I. Simozawa 236.*

XIV. MONACHOSORUM Kunze.

Spores trilete; anisopolar, radiosymmetrical; amb subtriangular, triquete or trilobate, proximal pole flat or concave, distal pole hemispherical or subconical; 20–40×17–37 μ. Laesural arms straight, 10–17 μ long. Exine smooth or obscurely areolate, psilate or with scabrate processes, 1–1.5 μ thick. Perine short striate, with aciculate processes, 0.8–1.5 μ thick, transparent.

There are two species in Taiwan.

KEY TO THE SPECIES

1. Exine obscurely areolate.....(1) ***M. maximowiczii***
1. Exine smooth .....(2) ***M. subdigitatum***

If perine is persistent, then the distinction is difficult.

1. Monachosorum maximowiczii (Bak.) Hay. (Pl. 5, Figs. 14–15)

Amb subtriangular, rarely triquete, proximal pole flat or concave, distal pole subconical; 24–30×17–26 μ. Laesural arms 10–11 μ long, with line-like margo, 2–3 μ tall, 1 μ wide. Exine obscurely areolate, with scabrate processes, 1–1.5 μ thick. Perine 0.5 μ thick, aciculae 1 μ tall, 0.5 μ wide.

Hsinchu: Tapachienshan, *C. M. Kuo 1754.* **Ilan:** Taipingshan, *S. Suzuki 769.*

2. Monachosorum subdigitatum (Bl.) Kuhn.

Amb triquete or trilobate, rarely subtriangular, proximal pole flat, distal pole hemispherical; 20–40×22–37 μ. Laesural arms 15–17 μ long. Exine smooth, psilate, 1 μ thick. Perine 0.8–1.5 μ thick, aciculae 3–5 μ tall, 0.5–1 μ wide, closely adhering to the exine, except when treated with KOH and CH_3COOH.

Nantou: Chingshuikou, *Huang, Kou & Kao 997.* **Chiayi:** Alishan, *Kao & Feung 170.* **Kaohsiung:** between Nanfeungshan and Shanping, *Chuang & Kao s. n.*

XV. ONYCHIUM Kaulf.

Spores trilete; anisopolar, radiosymmetrical; amb subtriangular, proximal pole convex, distal pole hemispherical; 28–50×26–48 μ. Laesural arms straight, 15–23 μ long, slit to the margins. Exine 1–2 μ thick; proximal face tuberculate, with rounded verrucate processes, the elements 3–5 μ tall, 3–4 μ across, sometimes tuberculae scattered along the laesural margins, sometimes coalescing to form short plane field-laesural ridges (5 μ wide), irregularly sinuous and interrupted proximal ridges often present; distal face ornate or orno-reticulate, with verrucate processes, the muri 3–6 μ tall, 5–8 μ wide, forming one or two distal ridges parallel to equatorial ridge by the outermost muri; equatorial ridge annulate, sometimes interrupted, margin smooth or undulated, 3–5 μ tall and wide. Perine (callose ?) (absent in *O. siliculosum*) psilate, 0.5 μ thick, skin-like, light yellow, transparent, closely adhering to the exine.

There are 3 species in Taiwan.

KEY TO THE SPECIES

1. Distal face ornate mixed with tuberculae.....(3) *O. siliculosum*
1. Distal face ornate without tuberculae.....(1) *O. contiquum*
   (2) *O. japonicum*

1. Onychium contiquum (Wall.) Hope (Pl. 5, Figs. 16–18)

Spores 31–46×32–38 μ. Laesural arms 16–19 μ long, with obscure margo. Proximal face tuberculate, with rounded verrucate processes, the elements 3 μ tall, 3–4 μ across, the elements scattered along laesural margins or coalescing to form short plane field-laesural ridges, and the elements often connecting to form irregularly sinuous and interrupted proximal ridges; distal face ornate or orno-reticulate, with verrucate processes, muri 4–5 μ tall, 5–8 μ wide, forming irregular distal ridges by the outermost muri; equatorial ridge interrupted on radial position, margin smooth or undulated, tilted to the proximal pole, 3–4 μ tall, 5 μ wide.

Nantou: Hohuanshan, *C. M. Kuo 396.* **Kaohsiung:** Hseshan, *C. M. Kuo 2445.* **Hualien:** Fongshan Branch station, *Liu, Chen & Kao 124.*

2. Onychium japonicum (Thunb.) Kunze

Spores 28–45×26–40 μ. Laesural arms 15–20 μ long, sometimes with obscure margo. Proximal face tuberculate, with verrucate processes, the elements 4–5 μ tall, 3 μ across, short plane field-laesural ridges and irregularly sinuous and interrupted proximal ridges often present; distal face ornate, with verrucate processes, the muri 3–4 μ tall, 5–6 μ wide, the outermost muri forming a regular distal ridge

parallel to the equatorial ridge; equatorial ridge interrupted, with undulated margin, 3–4 μ tall and wide.

Taichung: Pahsienshan, *Chuang, Kou & Chuang 2805.* **Nantou:** Kuantaosi, *J. L. Tsai 45.*

3. Onychium siliculosum (Desv.) C. Chr. (Pl. 6, Figs. 1–4)

Spores 39–50×30–48 μ. Laesural arms 20–23 μ long. Proximal pole tuberculate, with verrucate processes, the elements 5 μ tall, 4 μ across, short or long plane field-laesural ridges and irregularly sinuous and interrupted proximal ridges present, one row of tuberculae scattered between proximal and equatorial ridges; distal face with slightly connected ornae mixed with tuberculae, the muri 6 μ tall, 8 μ wide, two outermost muri forming two circumfluent distal ridges parallel to the equatorial ridge; equatorial ridge uninterrupted, margin smooth, 4–5 μ tall, 3 μ wide.

Nantou: Cheichei, *M. T. Kao 3614;* Kuantaosi, *C.M. Kuo 2156, Huang 6164.* **Kaohsiung:** Liukwei, *C.M. Kuo 700.*

XVI. PAESIA St. Hilaire

Spores monolete; anisopolar, bilateral symmetrical; amb ellipsoidal, plano convex in lateral view; 30–36×47–55×35–42 μ. Laesurae straight, 37–40 μ long, with lip-like margo, 4–5 μ wide on each side. Exine prominently granulate, with scabrate processes, 2 μ thick. Perine prominently granulate, with scabrate processes, 2 μ thick, another skin-like transparent membrane (1 μ thick) closely adhering to the perine, this transparent membrane sometimes folded into irregular shapes.

There is one species in Taiwan.

1. Paesia taiwanensis Shieh (Pl. 6, Figs. 5–6)

Spore morphology is the same as above described.

Taitung: Luanshan, *W. C. Shieh 1101.*

XVII. PITYROGRAMMA Link.

Spores trilete; anisopolar, radiosymmetrical; amb subtriangular, proximal pole convex, distal pole hemispherical; 39–54×35–42 μ. Laesunal arms straight, 15–19 μ long, with simple commissure or liplike margo (5 μ wide on each side, tapering ends). Exine 1.5–2.5 μ thick; proximal face extervermiculate, the inner extervermiculae bordering the laesural arms on either side forming narrow hand-laesural ridge, the outer extervermiculae arranged in two regular uninterrupted circumfluent field-proximal ridges, about 2–3 μ broad, parallel to and 2–3 μ away from the equatorial ridge as well as from each other, both laesural and inner proximal ridges connected to form reticulation; distal face irregularly reticulate, with slightly verrucate processes, the lumina irregular in shape, 2–8 μ across, sometimes with tuberculae protruberance (2 μ across), the muri irregular, often interrupted and appearing as extervermiculae-like, 1.5–2.5 μ wide, the outermost two rows of muri forming two circumfluent distal ridges, 2–3 μ away from and parallel to the equatorial ridge, the size ratio between muri and lumina variable; equatorial ridge annulotrilete, margin smooth, uninterrupted, 3–8 μ wide.

There is one species in Taiwan.

1. Pityrogramma calomelanos (L.) Link. (Pl. 6, Figs. 7–9)

Spore morphology is the same as above described.

A few of abnormal spores were observed. The alete spores globose, 59–67 μ in diameter, extervermiculate on two faces, two faces separated by an undulated equatorial ridge; the monolete spores ellipsoidal, 63×45 μ.

Nantou: Chingshuikou, *C.E. DeVol 7268;* Cheichei, *M.T. Kao 3913;* Kuantaosi, *J.L. Tsai 58, H.J. Chang 1431, Huang 6008, 6158.*

XVIII. PTERIDIUM Scopoli

Spores trilete; anisopolar, radiosymmetrical; amb rounded triangular to subtriangular; 25–33×23–31 μ. Laesural arms straight, 7–15 μ long, with line-like margo, 1 μ wide. Exine smooth, psilate, 1 μ thick. Perine granulate, with irregularly scabrate processes, 1.5–2 μ thick, closely adhering to the exine.

There are two subspecies in Taiwan, but no difference in spore morphology can be observed.

1. Pteridium aquilinum (L.) Kuhn ssp. **latiusculum** (Desv.) Shieh (Pl. 6, Fig. 10)

Spore morphology is the same as above described.

Taichung: Tungshe, *Do s.n.* Apr. 1928. **Taitung:** Tawu, *C.C. Chuang 2057.*

2. Pteridium aquilinum (L.) Kuhn ssp. **wightianum** (Wall.) Shieh

Spore morphology is the same as above described.

Taipei: Samaoshan, *Do s.n.* Sept. 1933. **Hsinchu:** Tafu, *N. Fukuyama s.n.* July 1932. **Kaohsiung:** Dabushan, *Masamune s.n.* Dec. 1930.

XIX. PTERIS L.

Spores trilete; anisopolar, radiosymmetrical, rarely bilateral symmetrical in some spores with one long arm; amb subtriangular, rarely with slightly convex or concave side, proximal pole convex or flat, rarely slightly concave, distal pole subhemispherical, hemispherical or subconical; 22–66×17–55 μ. Laesural arms straight, 10–25 μ long, with lip-like margo, 2–5 μ wide on each side. Exine 1–2 μ thick, with various sculptures: tuberculate, extervermiculate, reticulate, rugulate or convolute, with baculate, flat or rounded verrucate or cuneate processes; proximal face always with elements different from distal face (except in *P. cadieri, P. grevilleana* and *P. ensiformis*); equatorial ridge (except in *P. cadieri* and *P. grevilleana*) annulate or annulotrilete, sometimes interrupted, side smooth or curved, 2–11 μ tall and wide. In some species, mesoperine (reddish brown) with various pattern, but lost after treatment with KOH and CH_3COOH, then the sculpture of inner exine appeared more conspicuously.

There are 27 species in Taiwan. 23 species are described here.

KEY TO THE SPECIES

1. Spores without equatorial ridge .....(3) *P. cadieri*
   (12) *P. grevilleana*
1. Spores with equatorial ridge.....2
2. Proximal and distal faces tuberculate, baculate processes with rounded apex.....(8) *P. ensiformis*

2. Proximal and distal faces with different sculpture, and the elements not as above....3
3. Distal face lophate....(22) *P. vittata*
3. Distal face not lophate....4
4. Distal face convolute....5
4. Distal face not convolute....12
5. Proximal face with circumfluent field-proximal ridge....6
5. Proximal face without circumfluent field-proximal ridge....7
6. Convolute muri 2-4 μ wide; two rows of tuberculae on either side of equatorial ridge....(5) *P. dactylina*
6. Convolute muri 4-5 μ wide; either side of equatorial ridge without elements....(17) *P. scabristipes*
7. Proximal face with laesural ridge....8
7. Proximal face without laesural ridge....11
8. The outermost muri of convolute coalescing to form a circumfluent distal ridge....9
8. The outermost muri of convolute not coalescing....10
9. The surface between the equatorial and distal ridges with one row of tuberculae....(20) *P. tokioi*
9. The surface between equatorial and distal ridge without tuberculae....(16) *P. multifida*
10. Equatorial ridge 2-4 μ tall and wide....(7) *P. dispar*
10. Equatorial ridge 3-7 μ tall, 5-8 μ wide....(18) *P. semipinnata*
11. Mesoperine present....(4) *P. cretica*
11. Mesoperine absent....(10) *P. faurici*
12. Distal face tuberculate....13
12. Distal face not tuberculate....15
13. Tuberculae only in central surface of distal face....(14) *P. longipes*
13. Tuberculae dense....14
14. Tuberculae 2-3 μ across....(2) *P. biaurita*
14. Tuberculae 4-10 μ across....(7) *P. excelsa*
15. Distal face rugulate....16
15. Distal face extervermiculate....17
16. Rugulae Y-shape....(1) *P. bella*
16. Rugulae not Y-shape....(2) *P. biaurita*
17. Extervermiculae dense....(2) *P. biaurita*
(13) *P. linearis*
(18) *P. semipinnata*
(19) *P. setuloso-costulata*
(21) *P. venusta*
(23) *P. wallichiana*
17. Extervermiculae sparse....18
18. Extervermiculae coalescing to form a flat plane....(6) *P. deltodon*
18. Extervermiculae not coalescing to form a flat plane....19
19. Extervermiculae obscure....(11) *P. formosana*
19. Extervermiculae prominent....20
20. Laesural margins without laesural ridges....(11) *P. longipes*
20. Laesural margins with laesural ridges....21
21. The surface between distal and equatorial ridges with tuberculae....(15) *P. longipinna*
21. The surface between distal and equatorial ridge without elements....(16) *P. multifida*

1. Pteris bella Tagawa (Pl. 7, Figs. 1–3)

Amb subtriangular, proximal pole convex, distal pole subhemispherical; 42–50 ×36–42 μ. Laesural arms 20–23 μ long, straight or curved, with obscure lip-like margo, 3 μ wide on each side. Exine 0.5–1 μ thick; proximal face with tuberculae (2 μ tall, 2–4 μ across) along the laesurae; distal face sometimes with brown circumfluent field-distal ridge (5–10 μ wide) triangular in shape with sharp angles and extervermiculae in the centre (Pl. 7, Fig. 2), sometimes with compact rugulae (light brown, 3–5 μ tall, 7–10 μ wide, 14–25 μ long), seldom mixed with extervermiculae, the rugulae coalescing to form a Y-shape (Pl. 7, Fig. 3), sometimes with depressed ditches of areolae-like appearance, with verrucate processes; equatorial ridge annulotrilete, with smooth or wavy margin, uninterrupted, up to 7 μ tall, 5–10 μ wide. A reddish brown mesoperine present.

Kaohsiung: Tentzu, *C.M. Kuo 773.*

2. Pteris biaurita L. (Pl. 7, Figs. 4–7)

Amb subtriangular, proximal pole flat or convex, distal pole subhemispherical; 30–53×25–48 μ. Laesural arms 12–25 μ long. Exine 0.8 μ thick; proximal face tuberculate, with verrucate processes, the elements 2 μ tall, 1–4 μ across, tuberculae scattered along the laesural margins, evenly forming irregularly sinuous circumfluent laesural ridges, 2–6 μ wide; distal face compact and slightly elongated tuberculate (1.5 μ tali, 2–3 μ across) or extervermiculate (3–4 μ tall, 2–5 μ wide, 2–12 μ long, Pl. 7, Fig. 7), the extervermiculae coalescing as rugulae triangular in shape and mixed with scattered tuberculae on its circumference (Pl. 7, Fig. 6), the outermost extervermiculae forming a distal ridge, one row of extervermiculae between the distal and equatorial ridges, with verrucate or cuneate processes; equatorial ridge annulotrilete, margin smooth or slightly curved, uninterrupted, 3–11 μ tall and wide. A reddish brown mesoperine present.

Nantou: Kuosin, *W.C. Shieh s.n.* Jan. 1968, *C.M. Kuo 932.* **Kaohsiung:** Shanping, *C.M. Kuo 1962.*

3. Pteris cadieri Christ (Pl. 7, Figs. 8–9)

Spores radiosymmetrical, rarely bilateral symmetrical; proximal pole convex, distal pole hemispherical; 33–50×27–35 μ. Laesural arms 12–18 μ long, simple commissure, rarely with lip-like margo. Exine rounded tuberculate, with baculate or rounded verrucate processes, 2.5–3 μ thick (including the elements), baculae 1–2 μ tall, 1–2.5 μ across, sometimes the compact tuberculae scattered along the laesural margins, evenly coalescing to form an elongated irregularly undulated laesural ridge, 2–3 μ wide, 1–2 μ away from the laesural margin.

Taipei: Neihu, *C.M. Kuo 794.* **Pingtung:** Nanrenshan, *C.M. Kuo 1981;* Kuskus, *Shieh & Tsai 420.*

4. Pteris cretica L. (Pl. 7, Figs. 10–13)

Amb rounded triangular, proximal pole flat or convex, distal pole subhemispherical or hemispherical; 31–46×28–37 μ. Laesural arms 12–18 μ long, with lip-like margo, but often covered by the elements. Exine 1 μ thick; proximal face irregularly tuberculate, with rounded verrucate processes, the elements 1 μ tall, 1–2.5 μ across; distal face convolute or extervermiculate, with verrucate processes, the muri 2 μ tall, 1.5–2 μ wide; the equatorial ridge annulotrilete, margin smooth, rarely curved, sometimes interrupted on the radial position, 2–5 μ tall, 3–7 μ wide. Mesoperine

with narrow band-proximal ridge (2-4 μ wide, Pl. 7, Fig. 10) on proximal face; distal face sparsely extervermiculate and with a distal ridge, 15-18 μ away from equatorial ridge, one row of tuberculae between distal and equatorial ridges, 1.5 μ tall, 1.3 μ across. Perine (callose?) irregular shape, transparent, loosely around some spores.

Some giant spores (E value 43-55 μ) were observed.

Hsinchu: Tapachienshan, *C. M. Kuo 1808.* **Taichung:** Lishan, *C. S. Feung & M. T. Kao s. n.* Nov. 1962; Chika, *Huang 7291.* **Nantou:** Chingshuikou, *Huang, Kou & Kao 1078;* Kuantaosi, *Huang 6146.* **Pingtung:** Tawushan, *Huang 7473.*

5. Pteris dactylina Hook (Pl. 8, Fig. 1)

Amb subtriangular with slightly convex sides, proximal pole flat, distal pole subhemispherical; 36-55×40-43 μ. Laesural arms 13-20 μ long, with lip-like margo, 2.5 μ wide on each side. Exine 1-1.5 μ thick; proximal face with circumfluent field-laesural ridge (4 μ wide); distal face compactly convolute, with rounded verrucate processes, the muri 3 μ tall, 2-4 μ wide, the outermost muri coalescing to form distal ridge, tuberculae between distal and equatorial ridges; equatorial ridge annulate, margin smooth, uninterrupted, 2-4 μ tall, 4-5 μ wide; mesoperine, reddish brown skin-like, cracked into small bits. Perine (callose?) transparent, wrinkled, closely adhering to the exine but separated away from the spore after treatment with KOH and CH_3COOH.

Taichung: Tayuling, *K. S. Hsu 7752.*

6. Pteris deltodon Bak. (Pl. 8, Figs. 2-5)

Amb subtriangular, proximal pole convex, distal pole subhemispherical; 31-50 ×33-44 μ. Laesural arms obscure, 15-20 μ long, rarely with lip-like margo. Exine 1 μ thick; proximal face with long plane field- to circumfluent field-laesural ridge, 6-10 μ wide, its outer margin always with one narrow brown ridge (1.5 μ wide), this narrow ridge undulated and interrupted in the central portion; distal pole sparsely extervermiculate with verrucate or slightly cuneate processes, the elements 4-7 μ tall, 3-4 μ wide, 9-16 μ long, sometimes forming a triangular flat plane with a few of line-like ridges on it; equatorial ridge annulotrilete, with undulated margin, uninterrupted, 3-10 μ tall, 4-5 μ wide. Perine (callose?) transparent, closely adhering to the exine.

Nantou: Lenkaoyei, *W. C. Shieh & Chen 914.* **Hualien:** Chingshuishan, *T. Shimizu & M. T. Kao 1982.*

7. Pteris dispar Kunze (Pl. 8, Figs. 6-7)

Amb subtriangular, proximal pole flat, distal pole subhemispherical; 22-35×17 μ. Laesural arms 10-14 μ long, lip-like margo, 2 μ wide on each side. Exine 0.5 μ thick; proximal face tuberculate, with dense verrucate processes, the tuberculae 1-2 μ across, slightly coalescing with each other, three bands of irregularly sinuous laesural ridges (2-3 μ wide) closed to the laesural margins; distal face convolute to reticulate, with rounded verrucate processes, the muri 2 μ tall and wide; equatorial ridge annulotrilete, margin smooth, rarely interrupted at the center of the interradial position, 2-4 μ tall and wide. Mesoperine lost after treatment with KOH and CH_3COOH.

Nantou: Lushan, *C. E. DeVol 8029;* Kuantaosi, *C. M. Kuo 2026, J. L. Tsai 60.*

8. Pteris ensiformis Burm. (Pl. 8, Figs. 8–11)

Amb subtriangular; proximal pole convex, distal pole hemispherical or subconical, distal face larger than proximal face; 33–45×31–42 μ. Laesural arms 15–20 μ long. Exine 4–6 μ thick (including the elements), elliptically tuberculate, with baculate processes, the baculae with rounded apex, the elements larger and denser on distal face, 3–4 μ tall, 1–2×1–5 μ in area, the elements on either side of the equatorial ridge arranged into regular rows; equatorial ridge annulate, margin undulated, rarely interrupted, 4–6 μ tall, 3–5 μ wide. Mesoperine present.

Miaoli: Yangmeishan, *C.P. Lin 2388*. **Taichung:** Suigenchi, *T. Suzuki s.n.* Apr. 1929. **Changhua:** Pahkuashan, *C.P. Lin 746*. **Nantou:** Kuantaosi, *J.L. Tsai 83*.

9. Pteris excelsa Gaud. (Pl. 9, Figs. 1–2)

Spores radiosymmetrical or bilateral symmetrical with one long arm; amb subtriangular, proximal pole flat, distal pole subhemispherial; 38–53×37 μ. Laesural arms 17–23 μ long, with lip-like margo, 3 μ wide, always covered by elements. Exine 1 μ thick; proximal face obscurely tuberculate, 12 μ across, sometimes with 3 rows of sinuously long plane field-laesural ridges (2–3 μ wide) closely along to laesural margins; distal face densely tuberculate with irregular margin, with rounded verrucate processes, 4–5 μ tall, 4–10 μ across, sometimes coalescing into irregular shape, the outermost elements coalescing to form irregular distal ridges; equatorial ridge annulotrilete, margin curved, uninterrupted, 3–9 μ tall, 5–9 μ wide. Mesoperine (reddish brown) lost after treatment with KOH and CH_3COOH. Perine (callose?) skin-like, transparent, closely adhering to the exine, lost after treatment.

Many abnormal monolete spores and abortive exinous masses were observed.

Taichung: *W.C. Shieh 553*.

10. Pteris fauriei Hieron (Pl. 9, Figs. 3–4)

Amb subtriangular, sometimes sides concave, proximal pole flat, distal pole subhemispherical; 38–45×28–30 μ. Laesural arms 15–22 μ long, with lip-like margo, 4 μ wide. Exine 1 μ thick; proximal face obscurely tuberculate, 1–2 μ across; distal face convolute, with verrucate processes, muri 2–3 μ tall and wide, the outermost muri forming irregular distal ridge, sometimes coalescing to form a flat plane triangular in shape; equatorial ridge annulate or annulotrilete, margin smooth, uninterrupted, 3–5 μ tall. Perine (callose?) usually lost, transparent, closely adhering to the exine, sometimes folded.

Many abnormal tetralete spores (Pl. 9, Fig. 4) were observed.

Taipei: Kuanyinshan, *M.T. Kao & C.S. Feung 128*. **Taichung:** Tonse, *I. Simozawa 549*.

11. Pteris formosana Bak. (Pl. 9, Fig. 5)

Amb subtriangular, slightly convex on sides, proximal pole flat, distal pole subhemispherical, hemispherical or subconical; 40–66×40–48 μ. Laesural arms 17–25 μ long, with lip-like margo, 3 μ wide, tapering ends. Exine 1 μ thick; proximal face sometimes without elements, sometimes with 3 rows of obscure irregularly sinuous laesural ridges (4 μ wide) close to laesural margins; distal face elements obscure or sparsely extervermiculae, with rounded verrucate processes; equatorial ridge annulate or annulotrilete, margin smooth, uninterrupted, 2–3 μ tall. Mesoperine reddish brown, lost after treatment with KOH and CH_3COOH.

Hualien: Chingshuishan, *T. Nakamura 3803*. **Taitung:** Tzuben, *J.L. Tsai 897*; Taitomoutibus, *Y. Yamamoto s.n.* Apr. 1930.

12. Pteris grevilleana Wall. (Pl. 8, Figs. 12–13)

Amb subtriangular, proximal pole nearly flat or convex, distal pole subconical; 34–44×28–35 μ. Laesural arms 15–18 μ long, slit to the margins, lip-like margo 2.5 μ wide. Exine tuberculate, with baculate processes, 2.5–4 μ thick (including the elements), the baculae 2 μ tall, 0.8–2 μ across, denoe and large baculae on distal face tending to form areolae, the elements more compact around the laesural margins,

Pingtung: Nanrehshan, *C.M. Kuo 1990;* Kuskus, *Shieh & Tsai 418.* **Taitung:** Soka, *I. Simozawa s.n.* July 1938.

13. Pteris linearis Poir (Pl. 9, Fig. 6)

Amb rounded triangular, proximal pole flat or concave, distal pole subhemispherical; 41–50×25–43 μ. Laesural arms 13–17 μ long, with lip-like margo, 2.5 μ wide. Exine 1 μ thick; proximal face extervermiculae bordering the laesural margins, evenly coalescing to form irregularly sinuous laesural ridges; distal face extervermiculate densely, with rounded verrucate or slightly cuneate processes, the elements 4 μ tall, 2–5 μ wide, 7–11 μ long, the outermost muri coalescing to form irregular, interrupted distal ridge; equatorial ridge annulotrilete, margin smooth, rarely, curved, sometimes interrupted, up to 6 μ tall.

Abnormal tetralete spores were observed.

Nanton: Tahenpingshan, *C.M. Kuo 798.* **Chiayi:** Kuantzulin, *W.C. Shieh s.n.* Jan. 1968.

14. Pteris longipes Don. (Pl. 9, Figs. 7–8)

Amb subtriangular, proximal pole flat or convex, distal pole hemispherical; 36–40×30–40 μ. Laesural arms 16–19 μ long, with obscure lip-like margo. Exine 1.5 μ thick; proximal face tuberculate, 3 μ tall, 2–4 μ across, with irregularly sinuous and interrupted proximal ridge; distal face tuberculate (3–4 μ tall, 3–5 μ across) or sparesely extervermiculate (*Shieh 212*), with rounded verrucate processes, irregularly undulated circumfluent distal ridge enclosing the tuberculae and 15–18 μ away from each other, one row of tuberculae (2–4 μ tall, 3–6 μ tall, 3–6 μ across) between distal and equatorial ridges; equatorial ridge annulotrilete, side undulated curved, uninterrupted, up to 5 μ tall, 4–5 μ wide.

Taichung: Lienhuachih, *W.C. Shieh 212, T. Seki 44.*

15. Pteris longipinna Hay. (Pl. 9, Figs. 9–10)

Amb subtriangular, rarely slightly convex on sides, proximal pole flat or convex, distal pole subhemispherical or hemispherical; 27–39×25–37 μ. Laesural arms 8–15 μ long, with obscure lip-like margo, 2.5–3 μ wide, margo always covered by the elements. Exine 1–2 μ thick; proximal face tuberculate (4 μ tall, 3–5 μ across) around the laesural margins, the elements always coalescing to form long plane field or circumfluent field-leasural ridges (3–5 μ wide), a few of tuberculae scattered outside of laesural ridge; distal face sparsely extervermiculate (3–4 μ tall, 2–5 μ wide, 7–12 μ long) or irregularly tuberculate, with rounded verrucate processes, an irregularly undulated circumfluent distal ridge (sometimes interrupted) enclosing these elements and 15–20 μ away from equatorial ridge, one row of obscure tuberculae (2 μ tall, 2–6 μ across) sometimes coalescing to form extervermiculae or a band-like ridge (3 μ wide) between distal and equatorial ridges; equatorial ridge annulate, margin smooth, rarely curved, uninterrupted, 2–5 μ tall, 4–5 μ wide. Some spores with transparent perine.

Taichung: Anmashan, *T.S. Liu et al 29.* **Nantou:** Kuantaosi, *C.M. Kuo 2129.* **Chiayi:** Tsueco, *C.M. Kuo 1862.*

16. Pteris multifida Poir

Amb subtriangular, proximal pole flat, distal pole subhemispherical or hemispherical; 31–42×25–31 μ. Laesural arms 11–15 μ long, with lip-like margo, 2.5 μ wide on each side. Exine 1.5–2 μ thick; proximal face tuberculate (2×3–4 μ in area) and always coalescing to form extervermiculae and evenly to form circumfluent laesural ridge (3–4 μ wide); distal face sparsely extervermiculate (2–4 μ tall, 3 μ wide, 8–12 μ long), with rounded verrucate processes, sometimes coalescing to form convolute structure, and forming an irregular circumfluent distal ridge, the laesural, distal and equatorial ridges parallel and 5 μ away from one another; equatorial ridge annulate or annulotrilete, margin curved, sometimes interrupted at the radial positions, up to 6 μ tall, 3–4 μ wide.

Taipei: Noannoan, *Y. Sotoyama s.n.* Feb. 1969. **Nantou:** Lushan, *W.C. Shieh 355.*

17. Pteris scabristipes Tagawa (Pl. 10, Figs. 1–3)

Amb subtriangular, proximal pole nearly flat, distal pole subhemispherical; 45–60×45–55 μ. Laesural arms 20–22 μ long, with obscure lip-like margo, 3 μ wide. Exine 1 μ thick; proximal face extervermiculate, always coalescing to form irregularly sinuous laesural ridges (2–4 μ wide), the circumfluent field-proximal ridges (5 μ wide) 3 μ away from the laesural ridges, sometimes confluent with laesural ridges and equatorial ridges at radial position, some tuberculae connected with proximal and laesural ridges; distal face convolute, with verrucate or cuneate processes, the muri 5 μ tall, 4–5 μ wide, the outermost muri coalescing to form an irregular distal ridge; equatorial ridge annulotrilete, margin smooth, sometimes interrupted on radial position, 5–8 μ tall, 6–8 μ wide.

Some abnormal tetralete spores were observed.

Nantou: Kuantaosi, *C.M. Kuo 2084;* Rukuraka, *T. Suzuki 13281.*

18. Pteris semipinnata L. (Pl. 9, Figs, 11–12)

Amb subtriangular, proximal pole flat, distal pole subhemispherical; 30–40×22–32 μ. Laesural arms 11–21 μ long, with lip-like margo, 2 μ wide. Exine 1 μ thick; proximal face irregularly tuberculate, 1–2 μ across, the dense tuberculae bordering the laesural margines, evenly coalescing to form sinuous laesural ridges, 2 μ wide; distal face extervermiculate to convolute, with rounded verrucate processes, the muri 1.5–2.5 μ wide; equatorial ridge annulate or annulotrilete, margin smooth, sometimes interrupted on the centre of interradial position, 3–7 μ tall, 5–8 μ wide.

Taichung: Pahsienshan, *Liu, Kuo, Kao et al 460;* Lienhuachih, *M.T. Kao 4069.* **Nantou:** Kuantaosi, *C.M. Kuo 2018.*

19. Pteris setuloso-costulata Hay. Pl. 10, Figs. 4–5)

Amb subtriangular, proximal pole flat, distal pole hemispherical; 32–45 μ in E value. Laesural arms 14–17 μ long, with lip-like margo covered by elements, 3 μ wide. Exine 1 μ thick; proximal face extervermiculate, enclosing the laesural margins, always coalescing to form circmfluent laesural ridges (4 μ wide) with undulated margins; distal face extervermiculate, with rounded verrucate processes, the outermost elements sometimes coalescing to form circumfluent distal ridges; equatorial ridge annulate or annulotrilete, margin smooth, uninterrupted, up to 7 μ tall, 4–9 μ wide. Mesoperine (reddish brown) enclosing the spores, sometimes

cracked into small bits, and lost after treatment with KOH and CH_3COOH.

Kaohsiung: Ghost Lake, *W. C. Shieh 1350.* **Taitung:** Tapushan, *M. T. Kao 5942.*

20. Pteris tokioi Masamune (Pl. 10, Fig. 6)

Amb subtriangular to triquete, proximal pole convex, distal pole hemispherical; 30–45×27–31 μ. Laesural arms 14–20 μ long, with lip-like margo, 3 μ wide. Exine 1 μ thick; proximal face compactly extervermiculate, the extervermiculae bordering the laesural margins, coalescing to form irregularly sinuous long plane field-laesural ridges (3–4 μ wide) somewhat interrupted; distal face convolute, with rounded verrucate processes, the muri 2–3 μ tall and wide, the outermost muri coalescing to form an irregular or regular circumfluent distal ridge, one row of tuberculae between distal and equatorial ridges; equatorial ridge annulotrilete, margin smooth, sometimes interrupted, up to 7 μ tall. Mesoperine (reddish brown) enclosing the spore.

Many abortive spores were observed.

Taipei: Fushan, *T. Suzuki 9094.* **Kaohsiung:** Shanping, *C. M. Kuo 1938;* Tentzu, *W. C. Shieh et al 657.*

21. Pteris venusta kunze (Pl. 10, Figs. 7–8)

Amb subtriangular, proximal pole flat or concave, distal pole subhemispherical; 42–60×35–39 μ. Laesural arms 15–17 μ long. Exine 1 μ thick; proximal face tuberculate, 2.5 μ tall, 1.5–3 μ across, the elements enclosing the laesural margins, always coalescing to form irregularly sinuous laesural ridge (3–5 μ wide), somewhat interrupted; distal face densely extervermiculate (3–4 μ tall, 2 μ wide, 3–9 μ long) or mixed with tuberculae (2–4 μ across); equatorial ridge annulate, rarely annulotrilete, margin smooth, sometimes interrupted at radial position, up to 8 μ wide. Mesoperine enclosing the spore.

Kaohsiung: Liukuei, *W. C. Shieh 593;* Chishan, *S. Sasaki s. n.* Mar. 1936.

22. Pteris vittata L. (Pl. 11, Figs. 1–2)

Amb subtriangular, with slightly convex sides, proximal pole convex, distal pole hemispherical; 41–57×45–47 μ. Laesural arms 10–15 μ long, lip-like margo (sometimes difficult to observe) 5 μ wide. Exine light yellow, 2 μ thick; proximal face with tuberculae along the laesural margins, sometimes coalescing to form sinuously elongated laesural ridges, the undulated circumfluent field-proximal ridges (4 μ wide) 4 μ away from the laesural ridges and sometimes connecting by a few of short ridges, one row of tuberculae at the outside of proximal ridges; distal face lophate, with rounded verrucate processes, the muri 4–6 μ tall, 3–4 μ wide, the lumina polygonal, 5–15 μ across, with tuberculae protruding from the centre of some of the lumina; equatorial ridge annulate, with undulated margin, often interrupted, up to 7 μ tall, the lateral branch originating from equatorial ridge extending toward distal side to connect with reticulate muri.

Abnormal spores of globose shape were observed (60 μ in diameter).

Nantou: Cheichei, *M. T. Kao K3917;* Kuantaosi, *C. M. Kuo 2151.* **Chiayi:** Tsueco, *C. M. Kuo 1863.*

23. Pteris wallichiana Ag.

Amb subtriangular, proximal pole convex, distal pole subhemispherical; 24–35×

21–25 μ. Laesural arms 11–15 μ long. Exine 0.5–1 μ thick; proximal face tuberculate, the elements always coalescing to form irregularly sinuous laesural ridges, 2–3 μ wide; distal face compactly extervermiculate, with rounded verrucate processes, the elements always coalescing to form a flat plane of triangular shape; equatorial ridge annulate, smooth, uninterrupted, 3–7 μ tall, 5–6 μ wide.

Taipei: Fushan, *T. Suzuki 14994, 19086, 7026.* **Nantou:** Kuantaosi, *Huang 6091.*

XX. SPHENOMERIS Maxon

Spores monolete; anisopolar, bilateral symmetrical; amb ellipsoidal, plano-convex in lateral view; 27–38×40–54×26–40 μ. Laesural arms straight, 30–40 μ long, with flange-like margo, 1.2–2 μ wide, sometimes with lip-like margo, 5 μ wide. Exine smooth, psilate, 1.5 μ thick. Perine smooth or faintly granulate, psilate or with slightly scabrate processes, 1 μ thick, brown, lost after treatment with KOH and CH_3COOH.

There are two species in Taiwan.

KEY TO THE SPECIES

1. Perine faintly granulate.....(1) *S. biflora*
1. Perine smooth.....(2) *S. chusana*

1. Sphenomeris biflora (Kof.) Tagawa (Pl. 11, Fig. 5)

Spores 27–33×45–48×28–35 μ; laesural arms 33–40 μ long, with flange-like margo, 1.2 μ wide. Exine smooth, psilate. Perine faintly granulate, with slightly scabrate processes.

Taitung: Botel Tobago, *W.C. Shieh et al 326.*

2. Sphenomeris chusana (L.) Copel. (Pl. 11, Figs. 3–4)

Spores 27–38×40–54×26–40 μ. Laesural arms 30–40 μ long, with flange-like margo (2 μ wide) or lip-like margo (5 μ wide, tapering ends). Exine smooth, psilate. Perine smooth, psilate, a light yellow transparent membrane (1 μ thick) adhering to the perine before treatment with KOH and CH_3COOH, but lost after treatment.

Nantou: Chingshuikou, *Huang, Kuo & Kao 962;* Kuantaosi, *J.L. Tsai T90, C.M. Kuo 2028.*

XXI. TAPEINIDIUM (Pr.) C. Chr.

Spores monolete; anisopolar, bilateral symmetrical; amb ellipsoidal, plano-convex in lateral view, sometimes slightly concave on proximal pole; 23–35×34–52×22–36 μ. Laesural arms straight, 34–48 μ long, with flange-like margo, 1 μ wide. Exine smooth to faintly granulate, psilate or with slightly scabrate processes, 1.5–2 μ thick. Perine smooth, psilate, 0.5 μ thick, light brown, lost after treatment by KOH and CH_3COOH. A light yellow, transparent membrane (1 μ thick) adhering to the perine before treatment, but lost after treatment with KOH and CH_3COOH.

There are two species in Taiwan, but no difference in spore morphology was observed.

1. Tapeinidium biserratum (Blume) v. A. v. R. (Pl. 11, Figs. 7–8)

Spores 23–30×34–50×23–36 μ. Laesural arms 36–44 μ long. Exine smooth to faintly granulate, psilate or with slightly scabrate processes. Perine smooth, psilate.

Taitung: Botel Tobago, *T. I. Chuang & C. C. Hsu 2449, C. M. Kuo 2192.*

2. Tapeinidium pinnatum (Cav.) C. Chr. (Pl. 11, Fig. 6)

Spores 26–35×35×22–29 μ. Laesural arms 34–48 μ long. Exine smooth, psilate. Perine smooth, psilate.

Pingtung: Nanrenshan *C. M. Kuo 1984.* **Taitung:** Botel Tobago, *S. Sasaki s. n.* June 1955.

DISCUSSION AND CONCLUSION

Copeland (1947) treated 63 genera in his family of Pteridaceae. Twenty-three of these genera have been discovered in Taiwan. Ching (1940) classified this family into nine families and Shieh (1972) divided them into five families. The rearranged groups based on spore morphology are presented here. In all, five major groups (but not exactly the same as Shieh's) including 21 genera are here recognized.

The spores of the first group are of the monolete bilateral type with the perine smooth or scabrate. Genera belonging to this group are *Lindsaea*, *Sphenomeris* and *Tapeinidium*. The spores of the second group are of the monolete bilateral type with the perine granulate or tuberculate. The genera are *Paesia*, *Hypolepis* and *Histiopteris*. The spores of the third group are of the trilete tetrahedral type being without equatorial ridge or perine. The spores of *Cibotium*, *Coniogramme*, *Microlepia*, *Dennstaedtia*, *Cryptogramma* and a few species of *Pteria* belong to this group. The spores of the fourth group are of the trilete tetrahedral type with various kinds of perine but devoid of an equatorial ridge. Genera belonging to this group are *Cheilanthes*, *Doryopteris*, *Mildella*, *Pteridium*, *Monachosorum*, *Adiantum* and most species of *Lindsaea*. Spores of the fifth group are characterized by having an equatorial ridge girdling the spore. The spores of *Pteris*, *Onychium*, *Anogramma*, *Pityrogramma* and *Cibotium* belong to this group.

The divisions of the Pteridaceae grouped according to their spore morphology are in some ways different from the groups recognized by Ching and Shieh based upon external morphology. Some species are quite different from other species of same genus and may be very similar to another genus in its spore morphology. Typical examples are as follows: *Cheilanthes hirsuta* with monolete fissure (Pl. 2, Fig. 6) is quite different from the other species of *Cheilanthes* which are trilete (Pl. 2, Figs. 1–5, 8). *Dennstaedtia smithii* (Pl. 4, Fig. 3) is similar to the species of *Microlepia* (Pl. 5, Fig. 4) in having granulate sculpture, and based on spore morphology it would be better to place *D. smithii* in *Microlepia*. *Lindsaea japonica* (Pl. 4, Fig. 17) and *L. odorata* are very similar to both *Sphenomeris* (Pl. 11, Figs. 3–5) and *Tapeinidium* (Pl. 11, Figs. 6–8) in spore morphology. Perhaps these are closely related to each other.

Only one species of *Cibotium* (*C. barometz*) is recorded from Taiwan (Shieh, 1972), but two distinctive types of spores are found in the different specimens examined. One is a trilete spore with an equatorial ridge (Pl. 3, Figs. 1–3). It is the same type as Erdtman (1957) and Nayar and Devi (1968) described. The other is a trilete spore without an equatorial ridge (Pl. 3, Figs, 4–5). It is similar to the Indian species *Cibotium glaucum* and *C. schiedei* (Nayar and Devi 1968). Perhaps the *Cibotium* in Taiwan should be divided into two taxa. The gross morphology of these fern needs further study, but evidence indicates that we may have two separate species.

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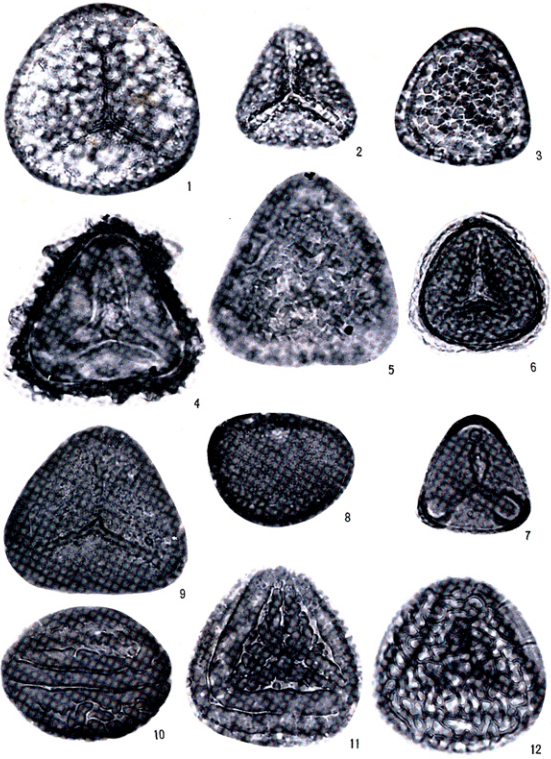

Plate 1. *Adiantum* and *Anogramma*. 1, *Adiantum capillus-veneris*; 2-3, *A. caudatum*; 4-5, *A. edentulum*; 6-8, *A. edgeworthii*; 9, *A. philippense*; 10-12, *Anogramma leptophylla*.

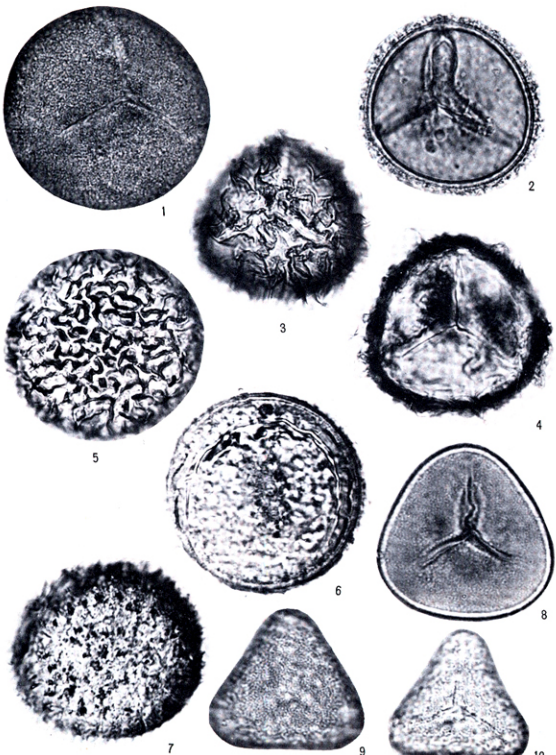

Plate 2. *Cheilanthes* and *Coniogramme*. 1–2, *Cheilanthes argentea*; 3–5, *C. farinosa*; 6–7, *C. hirsuta*; 8, *C. tenuifolia*; 9–10, *Coniogramme fraxinea*.

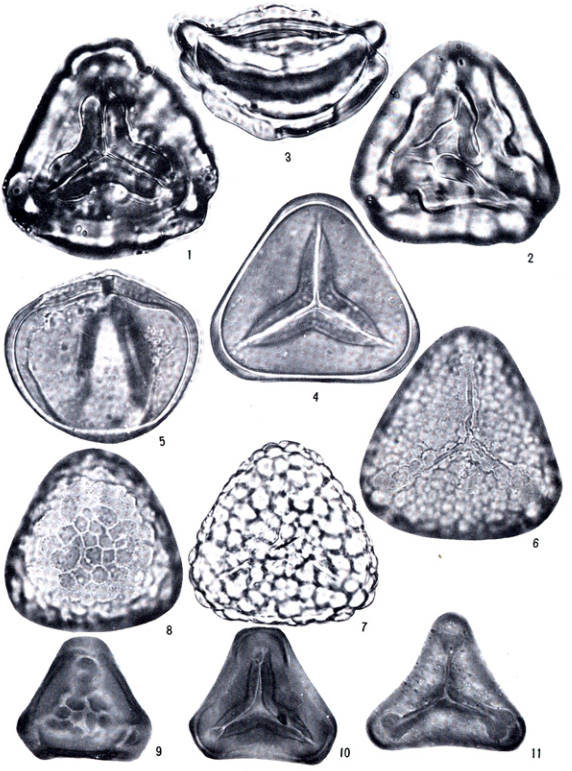

Plate 3. *Cibotium*, *Cryptogramma* and *Dennstaedtia*. 1-3, *Cibotium barometz* with equatorial ridge; 4-5, *C. barometz* without equatorial ridge; 6-8, *Cryptogramma brunoniana*; 9-10, *Dennstaedtia hirsuta*; 11, *D. scabra*.

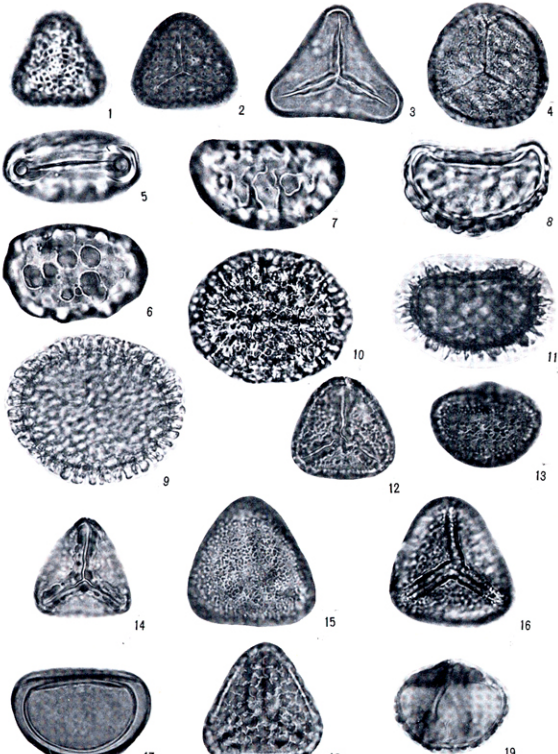

Plate 4. *Dennstaedtia, Doryopteris, Histiopteris, Hypolepis* and *Lindsaea*. 1–2, *Dennstaedtia scandens*; 3, *D. smithii*; 4, *Doryopteris concolor*; 5–8, *Histiopteris incisa*; 9, *Hypolepis alte-gracillima*; 10, *H. punctata*; 11, *H. tenuifolia*; 12–13, *Lindsaea chienii*; 14, *L. javanensis*; 15, *L. commixta*; 16, *L. ensifolia*; 17, *L. japonica*; 18–19, *L. obtusa*.

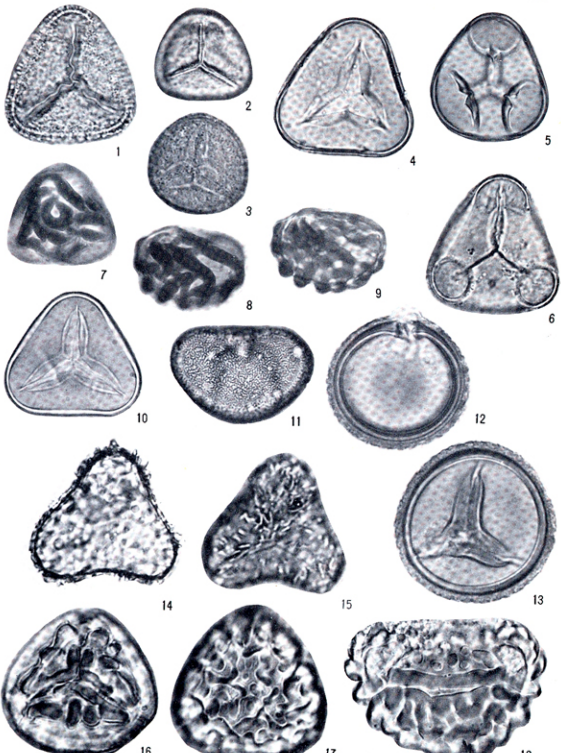

Plate 5. *Lindsaea, Microlepia, Mildella, Monachosorum* and *Onychium*. 1. *Lindsaea orbiculata;* 2-3, *L. yaeyamensis;* 4, *Microlepia calvescens;* 5, *M. strigosa;* 6, *M. obtusiloba;* 7-9, *M. tenera;* 10-11, *M. trichocarpa;* 12-13, *Mildella henryi;* 14-15, *Monachosorum maximowiczii* 16-18, *Onychium contiguum.*

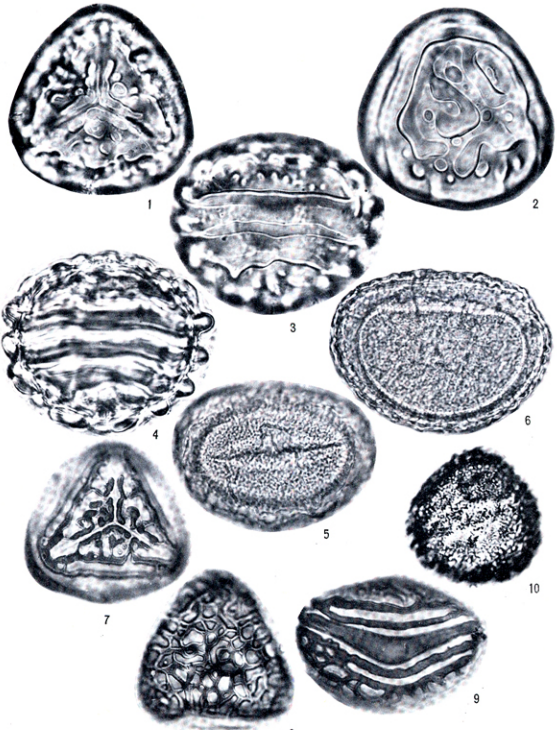

Plate 6. *Onychium*, *Paesia*, *Pityrogramma* and *Pteridium*. 1–4. *Onychium siliculosum*; 5–6, *Paesia taiwanensis*; 7–9, *Pityrogramma calomelanos*; 10, *Pteridium aquilinum* ssp. *latiusculum*.

Plate 7. *Pteris.* 1-3, ***P. bella;*** 4-7, ***P. biaurita;*** 8-9, ***P. cadieri;*** 10-13, ***P. cretica.*** (10 & 11, spores with mesoperine)

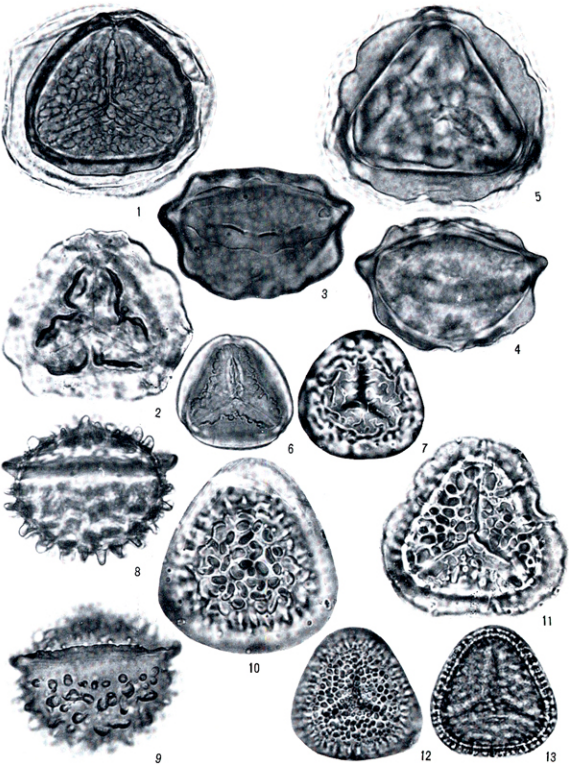

Plate 8. *Pteris*. 1, *P. dactylina*, 2-5, *P. deltodon*; 6-7, *P. dispar*; 8-11, *P. ensiformis*; 12-13, *P. grevilleana*.

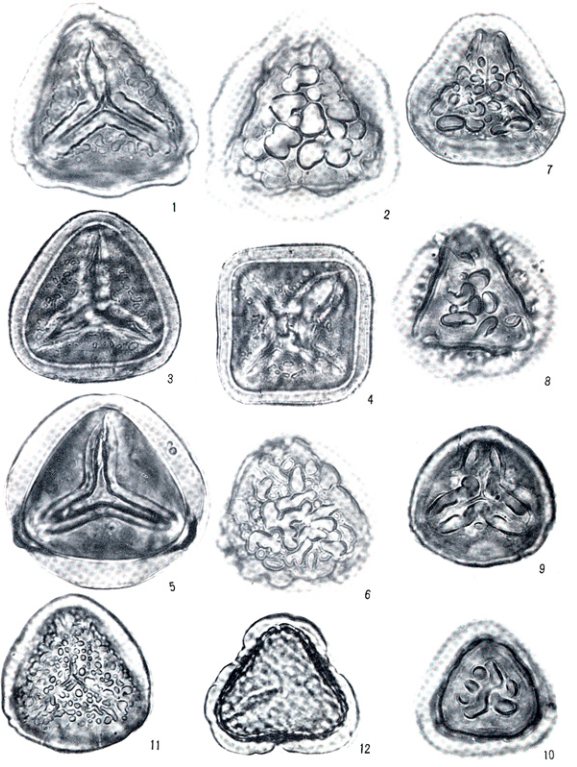

Plate 9. *Pteris.* 1-2, *P. excelsa;* 3-4, *P. fauriei;* 5, *P. formosana;* 6, *P. linearis;* 7-8, *P. longipes;* 9-10, *P. longipinna;* 11-12, *P. semipinnata.*

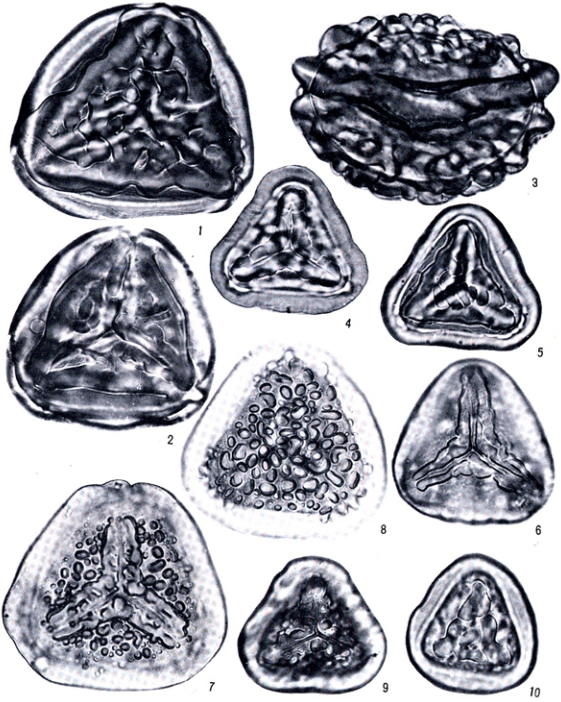

Plate 10. *Pteris.* 1-3, *P. scabristipes;* 4-5, *P. setuloso-costulata;* 6, *P. tokioi;* 7-8, *P. venusta;* 9-10, *P. wallichiana.*

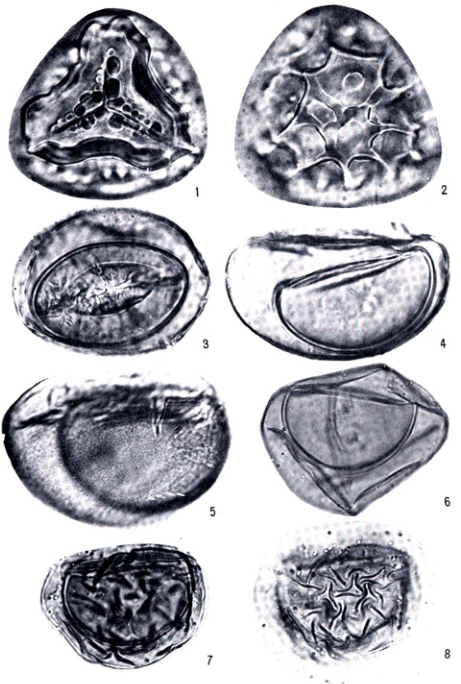

Plate 11. *Pteris*, *Sphenomeris* and *Tapeinidium*. 1-2, *Pteris vittata*; 3-4, *Sphenomeris chusana*; 5, *S. biflora*; 6, *Tapeinidium pinnata*; 7-8, *T. biserratum*.