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Morphology of Fern Spores from Phu Phan National Park

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ABSTRACT

Morphological characteristics of fern spores collected from Phu Phan National Park were examined using a scanning electron microscope and a light microscope. A total of 36 species of ferns, were studied. Two types of spores, monolete and trilete, are observed. Spore size ranged from 15 to 130 μm. *Ceratopteris thalictroides* (L.) Brongn. has the largest spores. The spore surface patterns vary from cristate, fold, granulate, perforate, reticulate, rugate, rugulate, tuberculate to verrucate. Some combinations of these patterns were also observed. A subequatorial flange is common in *Pteris*.

Key words: fern spores, monolete, morphology, Phu Phan National Park, trilete

INTRODUCTION

Spores, the main agent of dispersal carrying the essential genetic material for sexual reproduction of ferns and persistence of the species, are single, airborne cells with complex walls. The two commonly recognized spore types are monolete and trilete. Monolete spores are bilaterally symmetrical, and mostly ellipsoidal with a linear aperture. Trilete spores are radially symmetrical with a triradiate aperture. They are mostly tetrahedral with a hemispheric distal face that is somewhat globose.

Although there are some morphological studies of fern spores, studies to determine spores of native ferns to Thailand have not been extensive. This study provides original information on morphological characters of fern spores collected from Phu Phan National Park, Thailand. The ferns in which studies here are homosporous, rare and endemic species are included. The morphogical data of spores may be useful for palynologists and allergic studies.

MATERIALS AND METHODS

Spores were collected from 36 species in 23 genera, 16 families of ferns in Phu Phan National Park, Thailand. The classification generally followed the system in Tagawa and Iwatsuki (1979, 1985, 1988, 1989). Spores were removed from either herbarium sheets or living specimens collected in the field. Prepared slides were studied and specimens photographed with Olympus BX 51 compound and digital camera attachment. The exposures were at a magnification of 400X. Spore size ranges were based on measurements of 10 spores of each species in a single preparation. Where polar and equatorial axes were distinguishable, measurements were given for both, the length of the polar axis appearing first, followed by the longer and if present, the shorter equatorial axis. The size classes followed the system as given by Erdtman (1957): very small < 10 μm, small 10-25 μm, medium 25-50 μm, large 50-100 μm, very large 100-200 μm, and gigantic > 200 μm. Spore surface was also

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examined and photographed with Leo 1450 VP scanning electron microscope, at 15-20 KV. Dry spores were fixed on stubs with double-sided adhesive tape and coated with palladium-gold in a Polaron Range SC 7620 sputter coated for 30-40 seconds. The definition of descriptive terms applicable to spore surface followed that of Tryon and Lugardon (1990).

RESULTS AND DISCUSSION

The results of scanning electron microscope and light microscope studies divide the the spores of 36 species of fern into 2 groups, the trilete type and the monolete type. Trilete spores are found in 16 species representing 10 genera. Monolete spores are found in 20 species representing 13 genera. The colour of fern spores is yellow, brown, or black-brown. Most of the trilete spores are tetrahedral and those of 2 species are globose. Monolete spores are ellipsoidal. Most of spores are found in the size classes: medium and large. The spore surface includes exospore and perispore. The perispore forms the outer surface and often the characteristic contours of the spores. The morphology revealed here via scanning electron microscopy and light microscopy expands upon previous knowledge of fern spores (Tryon and Lugardon, 1990). The spores of endemic species to Thailand, *Cheilanthes siamensis* (S.K. Wu) K. Iwats. are trilete, and cristate with granulate surface. The rare species, *Bolbitis copelandii* Ching ex C. Chr. & Tardieu has monolete spores and long, undulate folds with a papillate surface. Marked differences in surface spore, and seen in *Bolbitis appendiculata* (Willd.) and K. Iwats. and *B. copelandii* Ching ex C. Chr. & Tardieu. Most *Lygodium* species have spores that are trilete, and spheroid-tuberculate surface. The surface of *Drynaria* species varies from echinate with acuminate apices in *Drynaria bonii* Christ, and *D. quercifolia* (L.) J. Sm. to echinate with blunt apices and globules in *D. rigidula* (Sw.) Bedd. *Pteris* species have the unique spores, most have a flange, usually near the equatorial region. Tryon and Lugardon (1990) comment that the unique spores of *Pteris* species may be useful evidence for depicting alliance within the genus. The morphological characters of each species reported here, include the type, shape, colour, size and surface (Table 1 and Figure 1).

CONCLUSIONS

Fern spores examined are trelete type (16 species) and monolete type (20 species). Spore colour are brown, yellow, or black-brown. Trilete spores are mainly tetrahedral except those in *Ophioglossum reticulatum* L. and *Ceratopteris thalictroides* (L.) Brongn. which are globose. Spores generally range between 15 and 130 μm. and the largest spores are found in *Ceratopteris thalictroides* (L.) Brongn. (80-110 x 100-130 μm). Various types of spore surface are found including cristate, fold, granulate, perforate, reticulate, rugate, rugulate, tuberculate and verrucate or some combination of these. A flange, usually near the equatorial region is common in *Pteris*.

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Table 1 Type, shape, colour, size and surface of spores of 36 species of ferns. Spore size reported here was based on the length of the polar axis X the longer and if present, the shorter equatorial axis, followed by the size class.

Family / Species	Type / Shape / Colour	Size (μm)	Surface
ASPLENIACEAE			
Asplenium apogamus Murakami & Hatanaka	Monolete, Ellipsoidal, Brown	25-33 × 35-43 × 25-33, Medium	Echinulate winged folds
A. crinicaule Hance	Monolete, Ellipsoidal, Black-brown	20-28 × 32-38 × 20-25, Medium	Winged folds
A. nidus var. *nidus* L.	Monolete Ellipsoidal, Black-brown	25-30 × 42-50 × 25-30, Medium	Echinulate winged folds
ATHYRIACEAE			
Anisocampium cumingianum C. Presl	Monolete, Ellipsoidal, Brown	25-20 × 35-40 × 25-30, Medium	Fimbriate winged folds with papillate surface
CYATHEACEAE			
Cyathea gigantea (Wall.ex Hook.) Holttum	Trilete, Tetrahedral, Brown	27-33 × 30-38 Medium	Reticulate rodlets with irregular granulate deposit
DAVALLIACEAE			
Davallia denticulata (Burm. f.) Mett. ex Kuhn	Monolete, Ellipsoidal, Yellow	20-38 × 47-58 × 30-38, Medium	Prominently verrucate with papillae
DRYOPTERIDACEAE			
Tectaria impressa (Fée) Holttum	Monolete, Ellipsoidal, Brown	15-25 × 30-43 × 22-30, Medium	Echinulate winged folds
GLEICHENIACEAE			
Dicranopteris linearis (Burm. f.) var. *tetraphylla* (Rosenst.) Nakia	Trilete, Tetrahedral, Yellow	22-30 × 30-38 Medium	Low rugulate with perforate surface
LINDSAEACEAE			
Lindsaea ensifolia Sw.	Trilete, Tetrahedral, Brown	27-33 × 27-38 Medium	Perforate with granulate surface
Sphenomeris chinensis (L.) Maxon var. c*hinensis*	Monolete Ellipsoidal, Brown	27-40 × 47-60 × 25-35, Medium	Granulate
LOMARIOPSIDACEAE			
Bolbitis appendiculata (Willd.) K. Iwats.	Monolete, Ellipsoidal, Brown	22-30 × 30-38 × 25-28, Medium	Reticulate folds with papillate surface

Table 1 (Continued).

Family / Species	Type / Shape / Colour	Size (μm)	Surface
B. copelandii Ching ex C. Chr. & Tardieu	Monolete, Ellipsoidal, Black-brown	20-33 × 27-38, Medium	Long, undulate folds with papillate surface
OLEANDRACEAE			
Nephrolepis biserrata (Sw.) Schott	Monolete, Ellipsoidal, Brown	17-20 × 30-35 × 17-22, Medium	Irregularly tuberculate
Oleandra wallichii (Hook.) C. Presl	Monolete, Ellipsoidal, Brown	25-38 × 42-60 × 30-33, Medium	Reticulate folds with finely echinulate
OPHIOGLOSSACEAE			
Ophioglossum reticulatum L.	Trilete, Globose, Brown	27-38 × 32-40 Medium	Reticulate with granulate surface
PARKERIACEAE			
Adiantum caudatum L.	Trilete, Tetrahedral, Brown	30-38 × 32-45 Medium	Rugate
A. erryllia C. Chr. & Tardieu	Trilete, Tetrahedral, Brown	25-33 × 20-35 Medium	Rugulate
A. phillippense L.	Trilete, Tetrahedral, Brown	22-30 × 30-38, Medium	Rugulate
Ceratopteris thalictroides (L.) Brongn.	Trilete, Globose, Brown	80-110 × 100-130, Very large	Branched ridges with rodlet surface
Cheilanthes siamensis (S.K. Wu) K. Iwats.	Trilete, Tetrahedral, Black-brown	37-50 × 50-63 Large	Cristate with granulate surface
PTERIDACEAE			
Pteris ensiformis Burm. f.	Trilete, Tetrahedral, Brown	32-55 × 37-55, Large	Tuberculate and subequatorial flange
Pteris heteromorpha Fée	Trilete, Tetrahedral, Brown	42-55 × 45-50, Large	Tuberculate and subequatorial flange
P. mertensioides Willd.	Trilete, Tetrahedral, Brown	22-38 × 30-58, Large	Tuberculate and subequatorial flange

Table 1 (Continued).

Family / Species	Type / Shape / Colour	Size (μm)	Surface
POLYPODIACEAE			
Drynaria bonii Christ	Monolete, Ellipsoidal, Yellow	32-40 × 42-68 × 30-43, Large	Echinate with acuminate apices
D. quercifolia (L.) J. Sm.	Monolete, Ellipsoidal, Yellow	27-33 × 47-58 × 30-35, Large	Echinate with acuminate apices
D. rigidula (Sw.) Bedd.	Monolete Ellipsoidal, Yellow	25-38 × 45-63 × 22-38, Large	Echinate with blunt apices and globules
Microsorum punctatum (L.) Copel.	Monolete, Ellipsoidal, Yellow	27-38 × 45-63 × 32-40, Large	Shallow verrucate
Platycerium holttumii de Jonch.& Hennipman	Monolete, Ellipsoidal, Brown	35-40 × 52-63 × 32-40, Large	Scattered globules
Pyrrosia adnascens (Sw.) Ching	Monolete, Ellipsoidal, Brown	32-45 × 47-73 × 30-45, Large	Verrucate
P. longifolia (Burm. f.) Morton	Monolete Ellipsoidal, Brown	30-35 × 55-63 × 27-38, Large	Verrucate
SCHIZAEACEAE			
Lygodium flexuosum (L.) Sw.	Trilete, Tetrahedral, Brown	62-78 × 57-70, Large	Spheroid-tuberculate
L. japonicum (Thumb.) Sw.	Trilete, Tetrahedral, Brown	47-60 × 60-63, Large	Spheroid-tuberculate
L. microphyllum (Cav.) R. Br.	Trilete, Tetrahedral, Brown	50-65 × 60-80, Large	Coarsely reticulate
L. polystachyum Wall. ex Moore	Trilete, Tetrahedral, Brown	40-63 × 55-68, Large	Spheroid-tuberculate
THELYPTERIDACEAE			
Thelypteris terminans (Hook.) Tagawa & K. Iwats.	Monolete Ellipsoidal, Black-brown	20-30 × 32-43 × 22-30, Medium	Fimbriate winged folds
VITTARIACEAE			
Vittaria elongata Sw.	Monolete, Ellipsoidal, Yellow	25-33 × 52-63 × 25-33, Large	Finely undulate

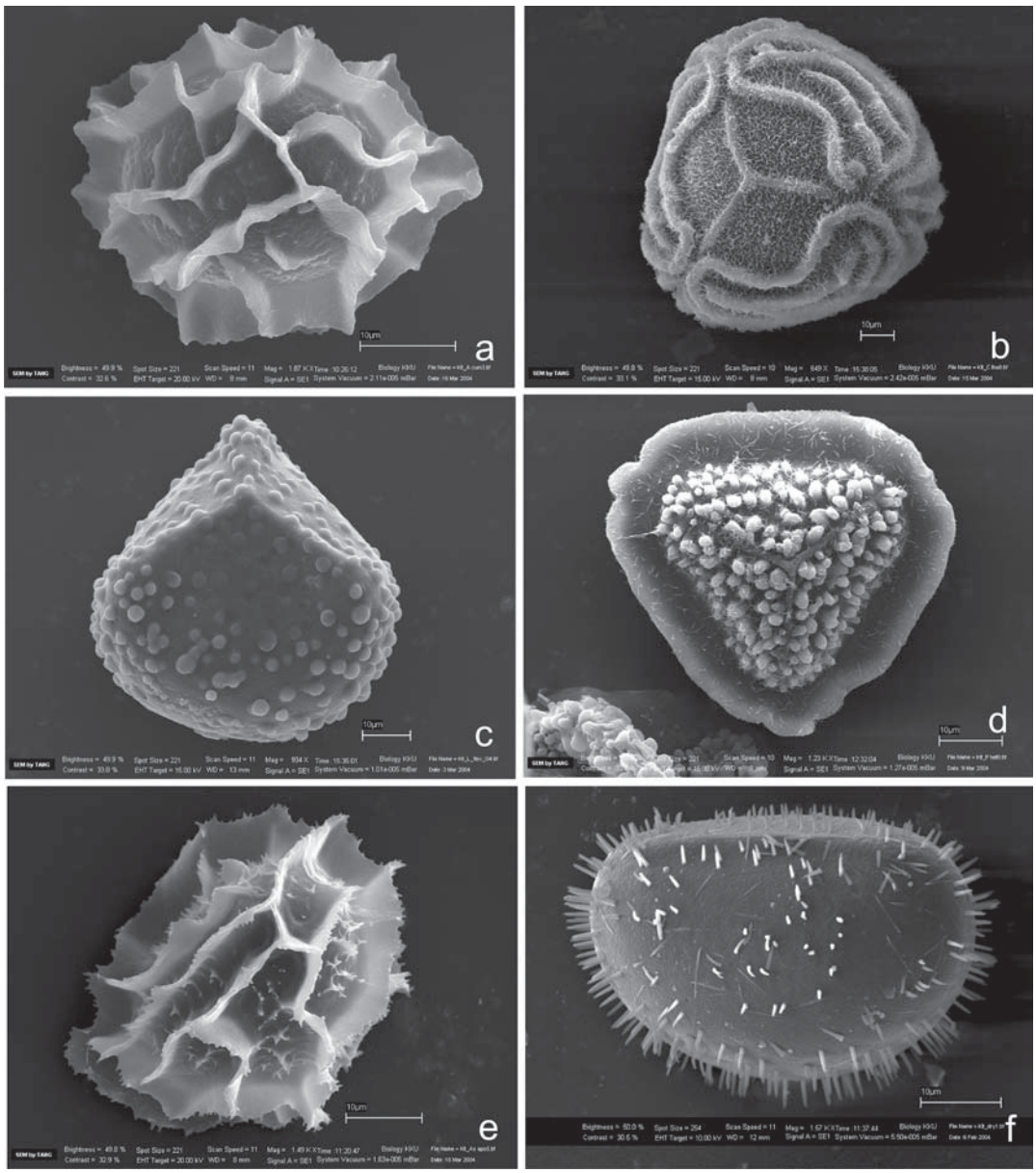

Figure 1 Scanning electron micrographs of fern spores:

a. Monolete, ellipsoidal; fimbriate winged folds with papillate surface, *Anisocampium cuminganum* C. Presl
b. Trilete, globose; branched ridges with rodlet surface, *Ceratopteris thalictroides* (L.) Brongn.
c. Trilete, tetrahedral; spheroid-tuberculate, *Lygodium flexuosum* (L.) Sw
d. Trilete, tetrahedral; tuberculate and subequatorial flange *Pteris heteromorpha* Fée
e. Monolete, ellipsoidal; echinulate winged folds, *Asplenium apogamus* Murakami & Hatanaka
f. Monolete, ellipsoidal; echinulate with acuminate apices, *Drynaria quercifolia* (L.) J. Sm.

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