



Research article

Aspleniaceae and Polypodiaceae from the coastal regions of Riau, Indonesia and their palynological study

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Abstract: The fern inventORIZATION in the coastal area of Riau, Indonesia have never been reported. This study aimed to identify Aspleniaceae and Polypodiaceae species from the coastal region of Riau and examined their morphology and palynology. Samples were collected from the field using exploration method and were then prepared for palynological study. Spore observation was carried out using Scanning Electron Microscopy. A total of 7 species were identified in this study (3 Aspleniaceae species and 4 Polypodiaceae species), with 2 species are new record in the peridoflora checklist from Riau, *i.e.* *Asplenium longissimum* and *Asplenium glaucophyllum*. We observed monolete spore from all of the examined species.

Keywords: Paku - Riau pesisir - Pteridophyte - Spore.

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INTRODUCTION

Aspleniaceae L. (Spleenwort) (Smith *et al.* 2006a) and Polypodiaceae Bercht. & J. S. Presl. are fern families within Order Polypodiales, Class Polypodiopsida (Smith *et al.* 2006a, Lashin 2012, Silva & Schwartzburd 2017). The members of Aspleniaceae are characterized by their monomorphic blade (Smith *et al.* 2006b), linear sori with a flap-like indusium along the margin (Lashin 2012) and comprises approximately 750 species worldwide (Smith *et al.* 2006a, Ohlsen *et al.* 2014). While Polypodiaceae has creeping rhizome, monomorphic or dimorphic blade (Smith *et al.* 2006b) and commonly abaxial roundish or elongated sori without indusium (Silva & Schwartzburd 2017). This family consists of *ca.* 50 genera and 1.200 species (Smith *et al.* 2006a).

The record of pteridophyte checklist in Riau, Sumatera Island, Indonesia had been reported by Sofiyanti (2013), Sofiyanti *et al.* (2015a,b), Marpaung *et al.* (2016), Yusna *et al.* (2016), Wulandari *et al.* (2016) and Sofiyanti *et al.* (2016). While the spore morphology of fern from Riau only reported on members of Family Pteridaceae (Marpaung *et al.* 2016). Up to the present, there is no record had been reported on fern study from the coastal regions of Riau Province that located on the eastern part of Riau. The districts in this coastal region, also consisted of many islands such as Halang, Rupert, Selat Panjang, and Rangsang Island that facing the Malaca Strait. During our field works at these areas in 2017, we observed the occurrence of Aspleniaceae and Polypodiaceae species. The aim of this study was to report members of both families, as well as examined their morphology and palynology.

MATERIALS AND METHODS

Samples collection

We carried out explorations on 4 districts located in coastal regions of Riau Province, Indonesia, *i.e.* Rokan Hilir, Dumai, Siak and Kepulauan Meranti. The specimens were collected from the fields and then photographed before being prepared for the herbarium. The synonym was checked using theplantlist.org. All of the specimens were deposited in Herbarium Riauensis, Department of Biology, Faculty of Math and Natural Science, Universitas Riau. The morphological characterizations followed Piggott & Piggott (1988) and Sofiyanti *et al.* (2015a).

Palynological study

Spore specimens were coated using gold (Au) based on Regalado & Saânche (2002). The coating process was conducted without any pre-treatment following Regalado & Saânche (2002) and Moran *et al.* (2007). The specimens were then observed using ZEISS Scanning Electron Microscope EVO MA 10 (PT. Vanadia). The measurement of spore size was based on 15 grains. The determination of spore characteristic followed the definition of Erdtman (1957), Nayar & Devi (1964), Pal & Pal (1970), Regalado & Sanchez (2002), Lashin (2012) and Wei & Dong (2012).

RESULTS AND DISCUSSION*Taxonomic Treatment*

ASPLENIACEAE

Asplenium glaucophyllum Alderw. Bull. Jard. Bot. Buitenzorg Ser. 2, VII. 6. 1912. (Figs. 1A–C)

Uncommon. Epiphyte on Oil Palm tree. Rhizome creeping, black, hairy. Stipe and rachis dull, black. Laminae bipinnatifid, *ca.* 85 cm. Pinnule with several lobes. Sorus linear almost curved toward margin of pinnule.

Note: We only found this species in one region (Siak), as epiphytic fern on Oil Palm tree (*Elaeis guineensis* Jack, Arecaceae). *Asplenium glaucophyllum* is abundant at the tree base. No record had been reported on this species in Riau, Sumatera Island. Beukema & van Noordwijk (2004) had reported the occurrence of this species in Sumatera island, from Jambi Province.

Specimens: INDONESIA, Riau, Siak, Koto Gasip, Elevation 52 m, N 01°00'32.2" E 102°42'38.5", July 5th 2017, Nery Sofiyanti, AGL1, AGL2, AGL3 (HR).

Asplenium longissimum Blume. Enum. Pl. Javae 2: 178 1828. (Figs. 1D–F)

Common. Terrestrial. Rhizome short, scaly. Stipes *ca.* 25 cm or more, purplish black. Laminae elongated, *ca.* 1 m long or more, consisted of up to 50 pairs of pinna, bulbil present near apex. Pinnae dark green, slightly serrate, gradually narrowing toward apex. Sori linear, little curved.

Note: This species is commonly found on shady place or under the tree, especially on moist habitat. No record had been reported in Riau pteridoflora checklist.

Specimens: INDONESIA, Riau, Bengkalis, Elevation 5 m, N 00°40'35.5" E 101°48'05.3", July 6th 2017, Nery Sofiyanti, ALO1, ALO2, ALO3, ALO4 (HR).

Asplenium nidus L. Sp. Pl. 2: 1079 1753. (Figs. 1G–I)

Asplenium australasicum (J. Sm.) Hook. Fil. Exot. t. 88 1854.

Asplenium ficifolium Goldm. Nov. Act. 19: 461 1843.

Neottopteris australasica J. Sm. Cult. Ferns 49 1857.

Neottopteris mauritiana Fée. Mem. Foug., Gen. Filic. 203 1850.

Common. Epiphytic, sometimes lithophytic. Rhizome short, dark brown, scaly. Fronds rossete. Stipes up to 5 cm long, black, scaly at the base. Laminae simple, up to 120 cm long or more, upto 25 cm wide or more, gradually narrowing towards base and apex, light green. Sori elongate along veins.

Note: This species is epiphytic fern on roadside trees or tree forest (such as Diptocarpaceae tree, Oil Palm tree (*Elaeis guineensis* Jack, Arecaceae)), and well known with local name “Paku Sarang or Paku Sarang Burung” that commonly used for ornamental plant. The occurrence of this species in Sumatera island, Including Riau Province had been reported in previous studies (Sofiyanti *et al.* 2015a,b, Pranita *et al.* 2017).

Specimens: INDONESIA, Riau, Rupert, Rokan Hilir, Elevation 5 m, N 01°47'34.5" E 101°22'44", May 6th 2017, Syafroni Pranata, AN11, AN12 (HR).

POLYPODIACEAE

Drynaria sparsisora (Desv.) T. Moore. Index Fil. 348 1862. (Figs. 2A–B)

Drynaria linnei Bory ex Bedd. Ferns Brit. India, pl. 315 1869.

Polypodium sparsisorum Desv Ges. Naturf. Freunde Berlin Mag. Neuesten Entdeck. Gesamten Naturk. 5: 315 1811.

Common. Epiphyte. Rhizome creeping, densely scale. Scale lighter brown towards the apex. Dimorphic. Sterile leaves sessile, oval, lobed *ca.* 20 × 19 cm or more. Fertile leaves with pinnatifid laminae, oblong, light green, lobed, up to 100 cm long and 40 cm wide. Sori round, sparsely distributed.

Note: We observed that this species found Oil Palm tree (*Elaeis guineensis* Jack, Arecaceae). However, we also recorded the occurrence on other Dipterocarpaceae species.

Specimens: INDONESIA, Riau, Siak, Elevation 5 m, N 01°28'24" E 101°57'27", July 5th 2017, Nery Sofiyanti, DS1 (HR); Riau, Bagan, Rokan Hilir, May 6th 2017, Syafroni Pranata, Elevation 5 m, N 01°47'07" E 101°22'26", AN11, AN12 (HR).

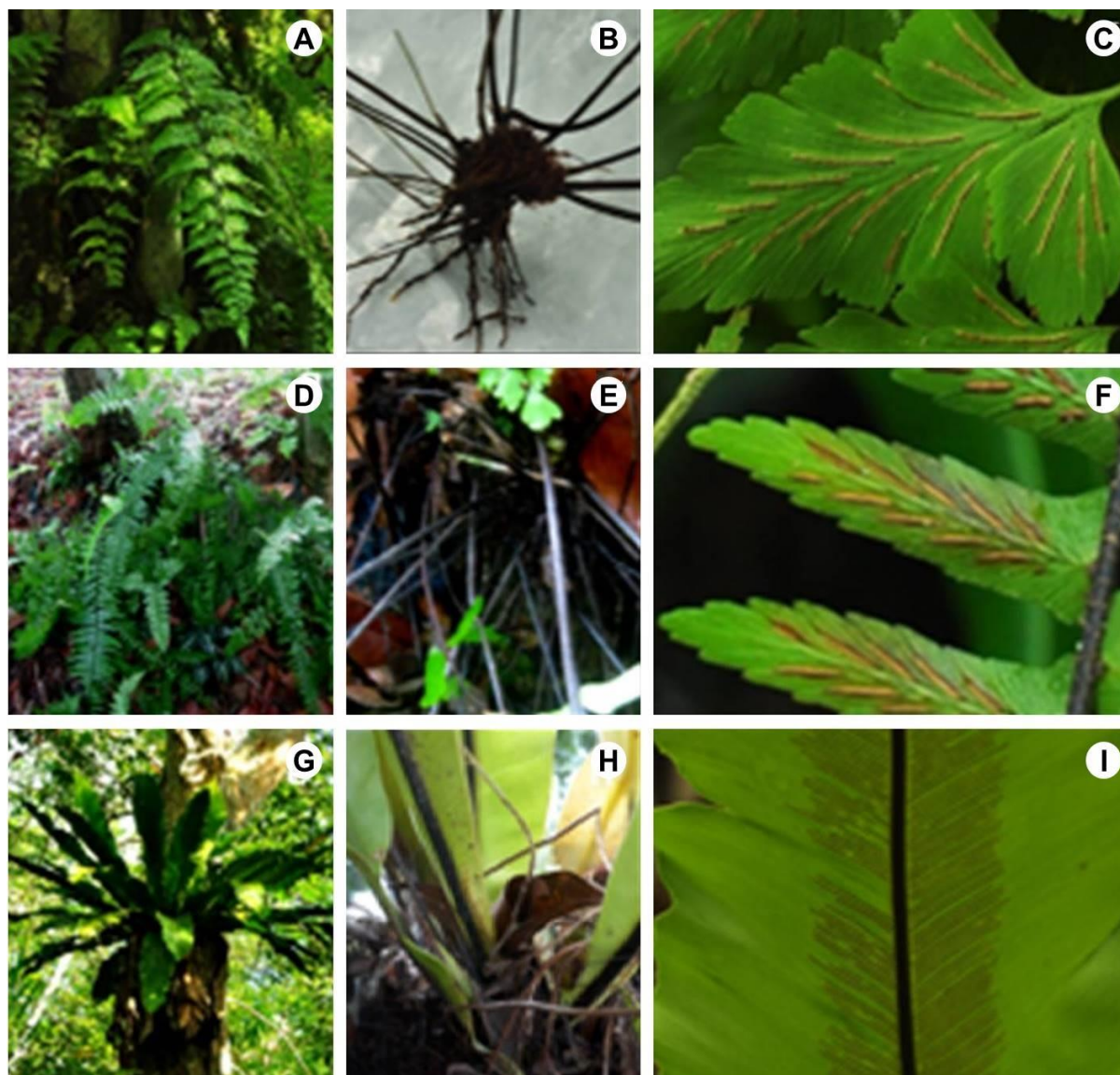


Figure 1. Aspleniaceae species from coastal regions of Riau (Left- Habitus, Center- Rhizome and base of frond, Right- Mature leaves showing sori): **A–C**, *Asplenium glaucophyllum*; **D–F**, *Asplenium longissimum*; **G–I**, *Asplenium nidus*. [Scale bars: F = 1 cm; C = 2 cm; B, E & H = 5 cm; A, D = 10 cm; G & I = 20 cm]

Microsorium punctatum (L.) Copel. Univ. Calif. Publ. Bot. 16(2): 111 1929.

(Figs. 2C–D)

Acrostichum punctatum L. f. Suppl. Pl. n. 444 1781.

Microsorium sessile Fée. Mém. Foug. 5: 268 1852.

Phymatodes polycarpus (Cav.) C. Presl. 198, t. 8, f. 19 1836.

Polypodium millisorum Baker. J. Linn. Soc., Bot. 15(83): 109 1877.

Common. Epiphyte. Rhizome creeping. Fronds closely spaced on the rhizome, single. Stipes dark brown. Laminae lanceolate, light green, apex acute, up to 100 long or more and 15 cm wide, midrib rise, wavy margin. Sori numerous, round, small.

Note: We observed that this species occurs on Rambutan tree (*Nephelium lappaceum* L., Sapindaceae) and Oil Palm tree (*Elaeis guineensis* Jack, Arecaceae).

Specimens: INDONESIA, Riau, Halang, Rokan Hilir, May 6th 2017, Syafroni Pranata, Elevation 5 m, N 01°47'07" E 101°22'26", MPI1 (HR).

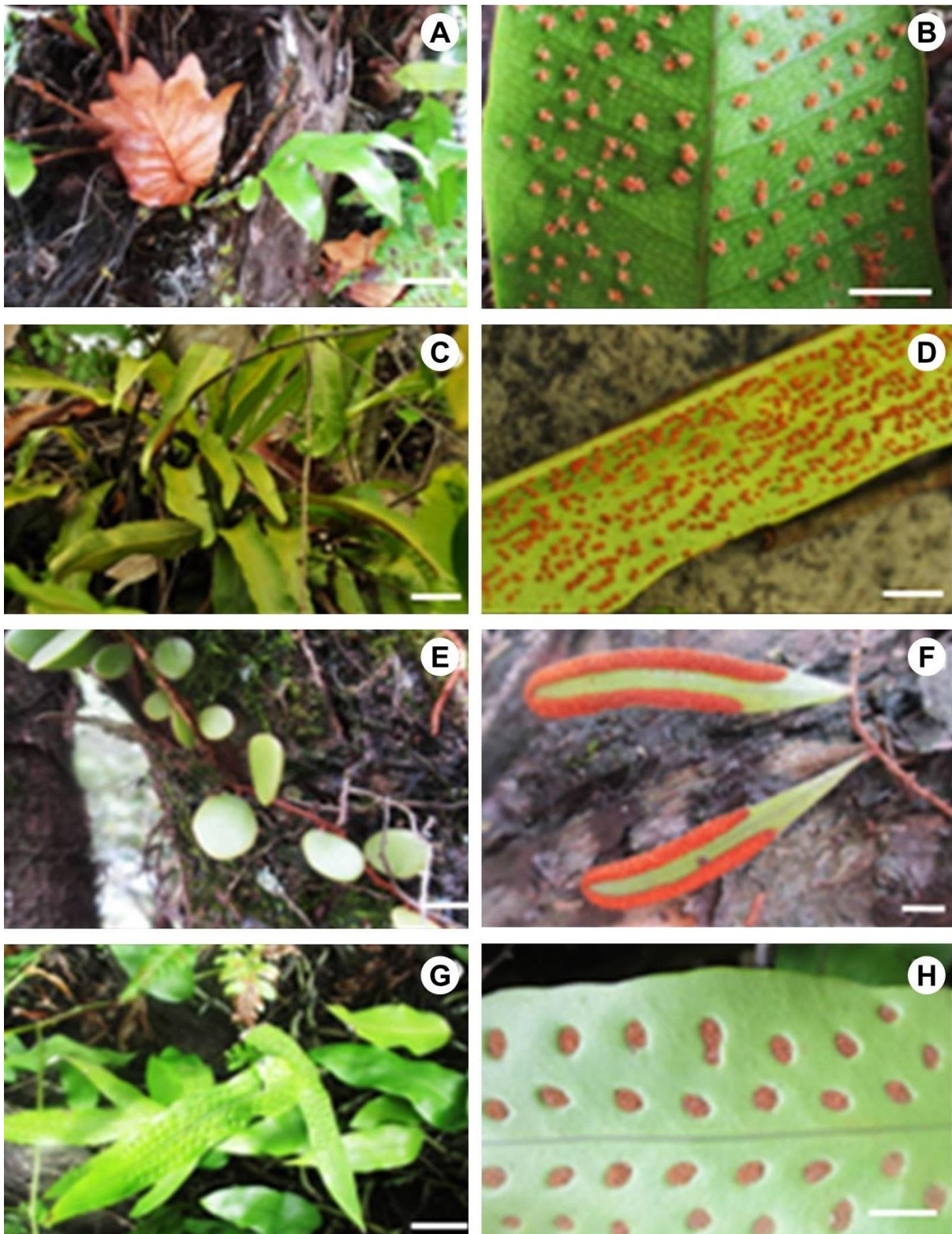


Figure 2. Polypodiaceae species from Riau coastal area (Left- Habitus, Right- Mature leaves showing sori): **A–B**, *Drynaria sparsisora*; **C–D**, *Microsorium punctatum*; **E–F**, *Pyrrosia piloselloides*; **G–H**, *Phymatosorus scolopendria*. [Scale bars: A, C & G = 5 cm; B, D, E, F & H = 1 cm]

Pyrrosia piloselloides (L.). M.G. Price.

(Figs. 2 E–F)

Common. Epiphyte. Rhizome long, creeping *ca.* 0.5 cm diameter. Dimorphic. Frond simple. Stipes short. Sterile laminae almost circular to oval, light green, *ca.* 1 × 1.5 cm or more, margin entire, fleshy. Fertile laminae lanceolate, *ca.* 15 cm × 0.8 cm wide, apex rounded. Sori elongated forming marginal line.

Note: Occur on many tree species, *i.e.* Cemara (*Thuja occidentalis* L, Cupressaceae), Coconut (*Cocos nucifera* L., Arecaceae), Mango tree (*Mangifera indica* L., Anacardiaceae), Oil Palm tree (*Elaeis guineensis* Jack,

Arecaceae) and Rambutan tree (*Nephelium lappaceum* L., Sapindaceae). The occurrence of this species in Riau had been recorded by Sofiyanti *et al.* 2015a,b at conservation forest Taman Hutan Raya Sultan Syarif Hasyim.

Specimens: INDONESIA, Riau, Bengkalis, July 6th 2017, Nery Sofiyanti, Elevation 5 m, N 01°33'26" E 102°18'19", PPI1, PPI2 (HR).

Phymatosorus scolopendria (Burm. F.) Pic. Serm. (Figs. 2G–H)

Chrysopteris phymatodes (L.) Link. Fil. Spec. 122 1841.

Microsorium scolopendria (Burm. f.) Copel. Univ. Calif. Publ. Bot. 16(2): 112 1929.

Phymatodes scolopendria (Burm. f.) Ching. Contr. Inst. Bot. Natl. Acad. Peiping 2(3): 63 1933.

Polypodium phymatodes L. Mant. Pl. 306 1771.

Common. Terrestrial. Rhizome long creeping, light green, scaly. Scale dark. Stipes up to 40 cm or more at maturity. Dimorphic. Laminae oblong to ovate, subdeltoid, simple or pinnatifid, *ca.* 40 cm long or more. Sori round to oval, sparsely distributed on the lower surface.

Note: As epiphytic fern on Oil Palm tree (*Elaeis guineensis* Jack, Arecaceae). Traditionally used for treating ulcer, cough, rheumatic and skin wound. Local name: Paku Sisik Naga, Paku Duduwitan, Picisan.

Specimens: INDONESIA, Riau, Bengkalis, July 6th 2017, Nery Sofiyanti, Elevation 5 m, N 01°26'54" E 101°10'54", PSO1, PSO2 (HR); Riau, Halang, May 6th 2017, Syafroni Pranata, Elevation 5 m, N 01°47'54" E 101°23'50", PSO3, PSO4 (HR).

Identification key

A key to identify the species of Aspleniaceae and Polypodiaceae families, specifically for the coastal regions of Riau, Indonesia has been provide here,

1. a. Sori linear, sometimes little curved 3
- b. Sori round, oval or forming marginal line 4
2. a. Frond pinnate or bi-pinnate 3
- b. Fronds simple, rossete, sori linear *Asplenium nidus*
3. a. Fronds pinnatifid, pinnae lancet, sori *ca.* 10 each pinna, bulbil present
..... *Asplenium longissimum*
- b. Fronds bipinnatifid almost triangular, sori *ca.* 20 per pinnula, bulbil absent
..... *Asplenium glaucophyllum*
4. a. Fronds dimorphic 5
- b. Fronds monomorphic *Microsorium punctatum*
5. a. Fertile laminae up to 40 cm long or more, margin lobed 6
- b. Fertile laminae *ca.* 20 cm, margin entire, fleshy *Pyrrosia piloselloides*
6. a. Sterile fronds sessile, sori pale yellow..... *Drynaria sparsisora*
- b. Sterile fronds closed spaced, sori dark brown and clearly present.....
..... *Phymatosorus scolopendria*

Palynological study

Table 1. Spore characteristics of examined species.

| Species | Spore grains | Spore type | Surface pattern | P/E ratio | Shape class | Spore size (µm) | Size Class |
|----------------------|--------------|------------|----------------------|-----------|---------------|-----------------|------------|
| Aspleniaceae | | | | | | | |
| AG | Monad | Monolete | Rugulate | 0.64 | Oblate | 40.05 ± 5.50 | Medium |
| AL | Monad | Monolete | Costate | 0.58 | Oblate | 48.67 ± 1.33 | Medium |
| AN | Monad | Monolete | Lophate | 0.76 | Subspheroidal | 33.90 ± 2.10 | Medium |
| Polypodiaceae | | | | | | | |
| DS | Monad | Monolete | Baculate | 0.43 | Peroblate | 36.39 ± 2.20 | Medium |
| MP | Monad | Monolete | Psilate | 0.62 | Oblate | 54.20 ± 5.20 | Large |
| PS | Monad | Monolete | Rugulate | 0.61 | Oblate | 50.57 ± 6.35 | Large |
| PP | Monad | Monolete | Scabrate echinate | 0.56 | Oblate | 57.88 ± 2.12 | Large |

Note: P- Polar axis; E- Equatorial axis; AG- *Asplenium glaucophyllum*; AL- *Asplenium longissimu*, AN- *Asplenium nidus*; DS- *Drynaria sparsisora*; MP- *Microsorium punctatum*; PH- *Phymatosorus sclopendria*; PP- *Pyrrosia piloselloides*.

The palynology term comes from Greek “to sprinkle” that resembles pollen or spore that sprinkled as dust (Vernal 2014). The pollen and spore characteristic plays an important role in plant identification (Sofiyanti & www.tropicalplantresearch.com

Yen 2010), classification (Talip *et al.* 2017) as well as other systematics works (Vernal 2014). The spore study of Aspleniaceae members had been reported on *Asplenium* from India (Nayar & Devi 1964), Cuba (Regalado & Sanchez 2002), Saudi Arabia (Lashin 2012), China (Wei & Dong 2012) and Java (Indonesia) (Pranita *et al.* 2017). While spore studies of Polypodiaceae had been reported on Genera *Phymatodes*, *Microsorium*, *Crypsonus*, *Lepisorus* and *Campyloneurum* from India (Pal & Pal 1970). Morbelli & Giudice (2010) also reported the spore morphology of Polypodiaceae, genera *Campyloneurum*, *Microgramma*, *Pecluma*, *Phlebodium*, *Pleopeltis* and *Serpocaulum* from Argentina. The spore morphology of Aspleniaceae and Polypodiaceae species examined in this study has been shown in figure 3 and 4 respectively. On the other hand the spore characteristics of each examined species have been shown in table 1.

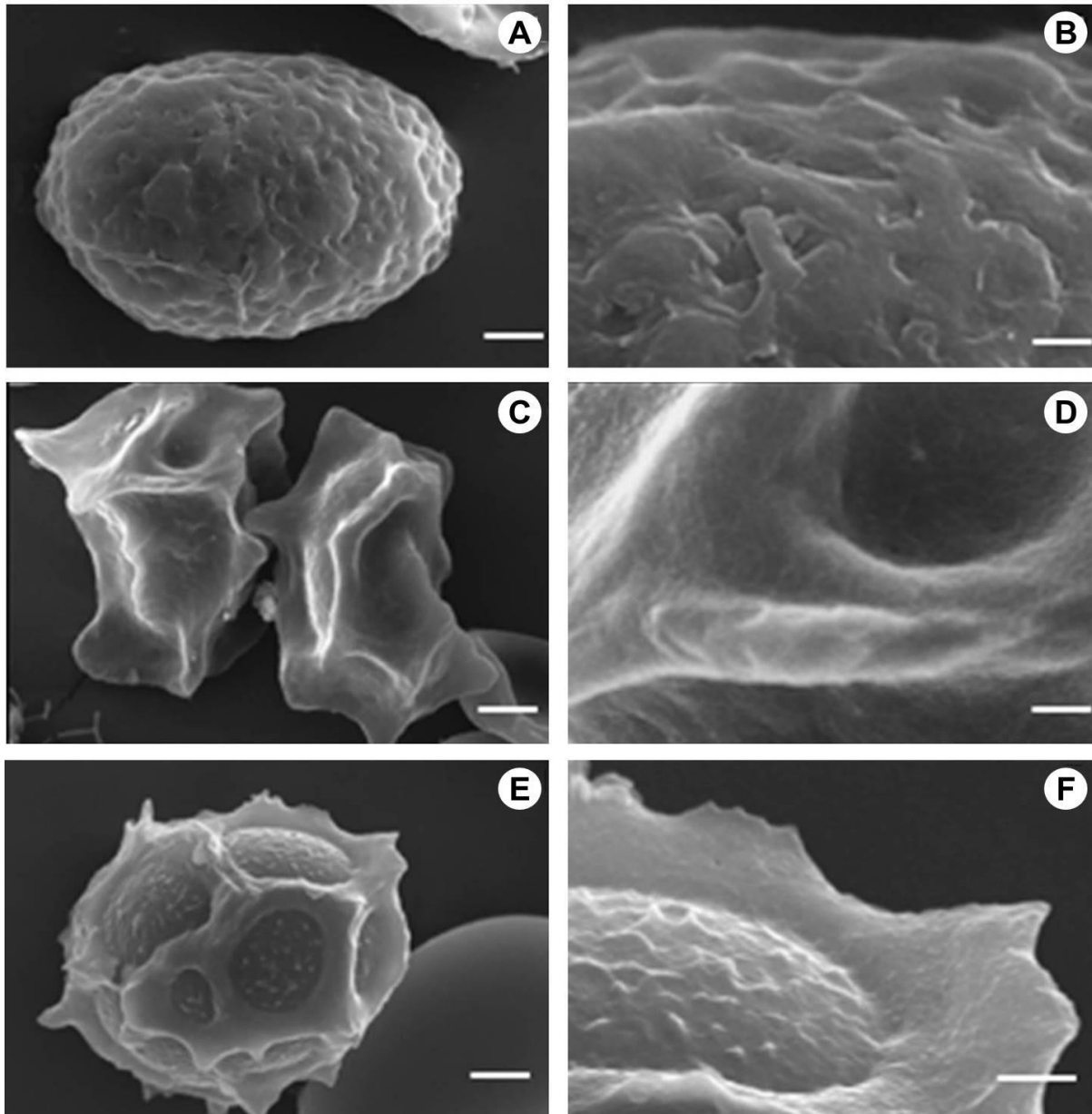


Figure 3. Spore feature of Aspleniaceae species: **A–B**, *Asplenium glaucophyllum*; **C–D**, *Asplenium longissimum*; **E–F**, *Asplenium nidus*. [Scale bars: A, C & E = 5 μ m; B, D, F = 2 μ m]

General type and size of spore

In this study, we observed monad spore grain from all of the examined species. Monad spore grain is not attached each other but release in single grain (Sofiyanti & Yen 2010). The observation of spore features also show the similar basic spore type for all of the species examined, *i.e.* monolete spore. This type is found in all of Aspleniaceae and Polypodiaceae species. Monolete spore is one of basic type of fern spore that characterized by its bean-shaped and has laesura in proximal part (Sofiyanti *et al.* 2017). The monolete spore was also reported on other Aspleniaceae species, especially from Genus *Asplenium* by Regalado & Sanchez (2002), Lashin (2012), Mazooji & Salimpour (2014) and Vijayakanth & Sathis (2016).

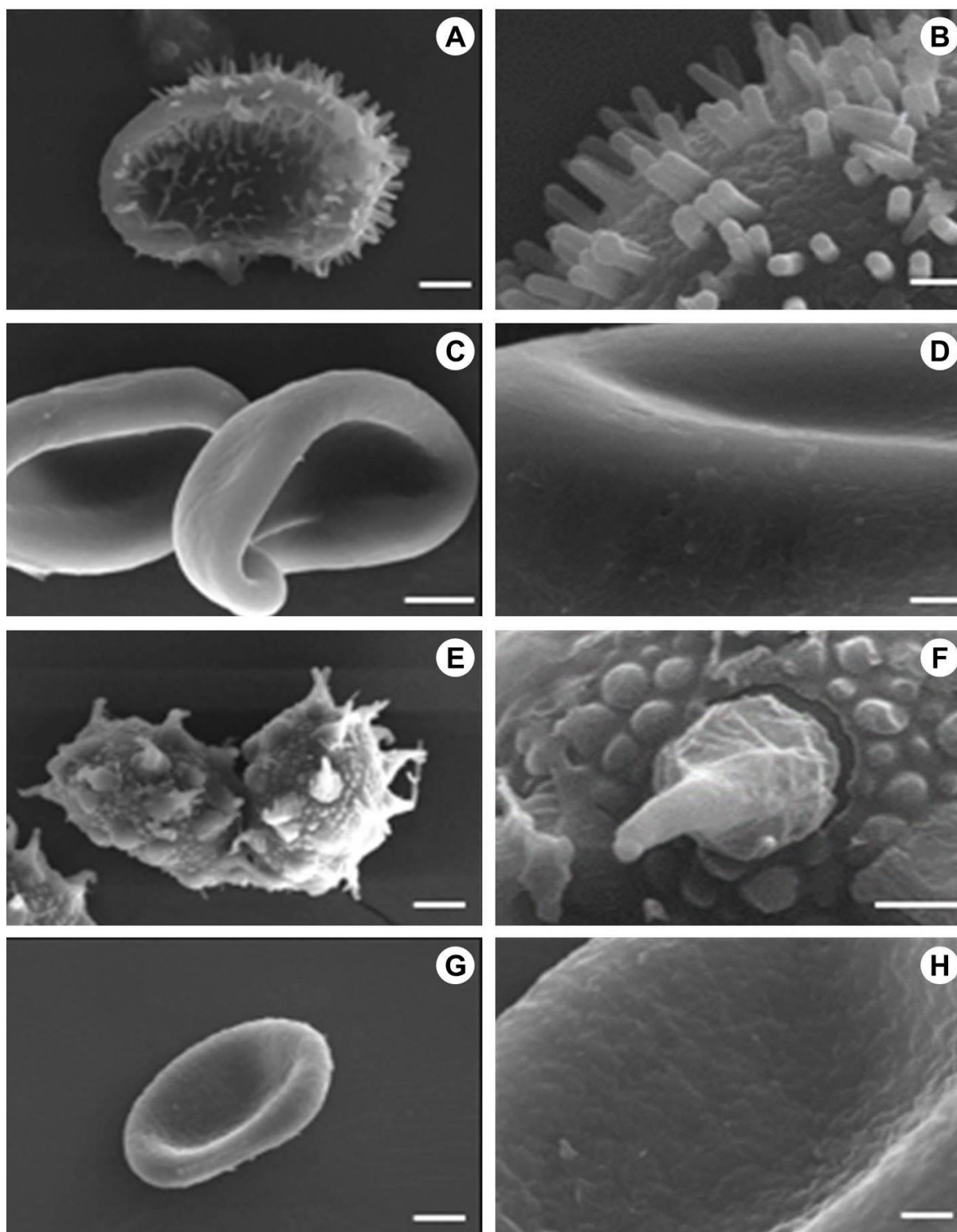


Figure 4. Spore morphology of Polypodiaceae species (Left- Spore grains, Right- Close up on spore surface): **A–B**, *Drynaria sparsisora*; **C–D**, *Microsorium punctatum*; **E–F**, *Pyrrosia piloselloides*; **G–H**, *Phymatosorus scolopendria*. [Scale bars: A & F = 5 μ m; B, D & H = 2 μ m; C, E & G = 10 μ m]

The spore classification based on the spore size proposed by Erdtman (1957) recorded 6 types. However, we only observed two spore type observed in this study *i.e.* medium and large. Medium spore has the longest measurement ranged from 25 to 50 μ m (Erdtman 1957) and observed on all of Aspleniaceae species (*Asplenium glaucophyllum*, *Asplenium longissimum* and *Asplenium nidus*). This result supports the previous studies that reported the medium spore size on most of *Asplenium* species (Nayar & Devi 1964, Regalado & Sanchez 2002, Lashin 2012, Vijayakanth & Sathish 2017). However, the large spore size (spore size range from 50 to 100 μ m) also reported on few *Asplenium* members, such as *Asplenium griffithianuni* Hook (Nayar & Devi 1964), *Asplenium aethiopicum* and *Asplenium trichomanes* (Lashin 2012).

For Polypodiaceae species, one out of four examined taxa (*Drynaria sparsisora*) showed medium spore, while three other taxa had large spore, with 50–100 µm spore size (Erdtman 1957). The large spore type was observed from three Polypodiaceae species, *Microsorium punctatum*, *Pyrrhosia piloselloides* and *Phymatosorus scolopendria*. The largest spore size (57.88±2.12 µm) was observed on *Phymatosorus scolopendria*.

Spore class observed on Aspleniaceae species were oblate (*Asplenium glaucophyllum* and *Asplenium longissimum*) and suphroidal (*Asplenium nidus*). Oblate spore class was also observed on three polypodiaceae species in this study (*Microsorium punctatum*, *Phymatosorus scolopendria* and *Pyrrhosia piloselloides*). On the other hand, *Drynaria sparsisora* had peroblate spore (see table 1 for detail).

Surface pattern

The surface pattern of fern spore provides taxonomical information (Regalado & Sanchez 2002, Morbelli & Giudice 2010). The spore surface of *Asplenium* in this study shows distinct pattern among the examined species *i.e.* rugulate (*Asplenium glaucophyllum*), costate (*Asplenium longissimum*) and lophate (*Asplenium nidus*). Rugulate spore surface has very low warty spore (Atri *et al.* 2014). Costate spore has broader base of perispore with convex side arranged in an irregular pattern (Regalado & Sanchez 2002), while lophate pattern has costate to cristate perispore (Lin & Viane 2013).

The surface pattern of spores belong to Family Polypodiaceae show the variation within the species, *i.e.* baculate (*Drynaria sparsisora*), psilate (*Microsorium punctatum*), regulate (*Phymatosorus scolopendria*) dan scabrate echinat (*Pyrrhosia piloselloides*). Figure 4 presents the spore morphologies of four Polypodiaceae species. According to Morbelli & Giudice (2010), the spore ornamentation of Polypodiaceae varies within examined taxa.

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