Spore morphology of *Parahemionitis arifolia* (Cheilanthoideae, Pteridaceae)

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**Keywords**: Cheilanthoideae, China, Parahemionitis, Pteridaceae, spore, sculpture of perispore, scanning electronic microscopy (SEM).

**Summary.** A study of spores of the single species of the genus *Parahemionitis* Panigrahi was performed using the method of scanning electronic microscopy (SEM). Spores of *Parahemionitis arifolia* (Burm. f.) Panigrahi are tetrahedral trilet, roundish-triangular in polar position, with micro-wrinkled exospore and sculptured perispore. Sculpture of perispore is cristate-reticulate, cristae are quite regularly distributed and form reticulum with small mostly closed polygonal luminae of different shape. Laesura arms are often obscured by numerous cristae. Size of spores is 53–63 × 40–42 μm. Spores of *P. arifolia* are similar in perispore sculpture with those of species of some cheilanthoid ferns.

The genus *Parahemionitis* Panigr. was described by G. Panigrahi in 1993 on the base of single species *Asplenium arifolium* Burm. f. selected as the type of this new genus. In turn, *Asplenium arifolium* was first proposed by N. L. Burmann in “Flora Indica” (Burmann, 1768). Later, it was transferred to *Hemionitis* L. by T. Moore (1859), who suggested a new combination *Hemionitis arifolia* (Burm. f.) T. Moore. In 1974 C. V. Morton and then in 1997 C. R. Fraser-Jenkins rejected the name *Asplenium arifolium* as based on the type specimen determined by A. Alston (Aug. 1952, *in scheda*) as belonging to another species – *Acrostichum aureum* L. If so, C. V. Morton (1974) suggested *Hemionitis cordata* Roxb.
C. R. Fraser-Jenkins (1997) used this name as basionym for new suggested combination *Parahemionitis cordata* (Roxb. ex Hook. et Grev.) Fras.-Jenk.

The problem with correct name for discussed species was resolved by J. Mazumdar (2015). He found out, that figures by Petiver’s (1702, t. 50, f. 12) and van Rhede tot Drakestein’s (1692–1703, Tabula 10, Fig.) showing auriculate sinusous fronds were mentioned in the N. L. Burmann’s protologue and his diagnosis was based on these figures. Therefore J. Mazumdar (2015) selected figure by van Rhede tot Drakestein’s from “Hortus Indicus Malabaricus” (1703) as lectotype. On the cause of no collection data is available for the specimen on which this drawing was based, J. Mazumdar (2015) selected epitype; it is the herbarium specimen collected by him: “India. West Bengal: Burdwan, Kanchanagar, near bridge above canal, 30 m, 21 Nov 2007, J. Mazumdar 59” (CAL). In this case, the name *Asplenium arifolium* Burm. f. is correct basionym for considered taxon, and the genus *Parahemionitis* based on this species is valid.

C. R. Fraser-Jenkins (1997) in his large publication “New species syndrome in Indian pteridology and the ferns of Nepal” wrote that J. T. Mikel (1974) had suggested the possibility of description of a new genus for this species, but considered this inappropriate and related it to the genus *Hemionitis*. But T. Ranker (1989) has shown the Indian fern definitely does not belong to true *Hemionitis*. J. T. Mikel and T. Ranker had not formalized their idea about separate genus by publishing a new genus. More reasons for description of a new genus on the base of “*Hemionitis* arifolia” gave R. Tryon. He has written that it is “a morphologically isolated species of uncertain affinity” (Tryon, 1986, p. 186) and “not readily included in any recognized genus” (Tryon et al., 1990, p. 245). Later A. Tryon and B. Lugardon (1991, p. 173) mentioned that “the widely distributed Asiatic *Hemionitis arifolia* (Bur.) Moore is an apogamous tetraploid that is excluded from *Hemionitis* on the basis of its distinctive morphology”. They considered also that specific of flavonoid composition of this species, found out by D.E. Giannasi and J.T. Mikel (1979), was the important reason for its excluding from *Hemionitis* (Tryon and Lugardon, 1991). *Hemionitis arifolia* contains only three of the 16 flavonoid compounds recognized in other species of *Hemionitis* and only four flavonoids that occur in “*Hemionitis* arifolia” are absent in others (Giannasi, 1974; Giannasi, Mikel, 1979; Tryon, Lugardon, 1991).


In the last Pteridophyta systems *Parahemionitis* is considered as a member of the Pteridaceae (Smith et al., 2006). M. J. M. Christenhuz et al. (2011) consider *Parahemionitis* as synonym of the large genus *Hemionitis*, which is attributed to the subfamily Cheilanthoideae of the large family Pteridaceae. “A community-derived classification for extant lycophytes and ferns” (Pteridophyte Phylogeny Group, 2016) includes *Parahemionitis* as the separate genus belonging to subfamily Cheilanthoideae of Pteridaceae family.

E. Schuepfelz et al. (2007) determined phylogenetic relationships within the Pteridaceae using three plastid genes (rbcL, atpB, and atpA). *Parahemionitis arifolia* is nested in the large cheilanthoid clade, which corresponds to subfamily Cheilanthoideae, and is sister to the clade formed by *Hemionitis* species. Similar results were obtained by G.-M. Zhang et al. (2009). They conducted special study of the systematic position of *Parahemionitis arifolia* (under the name *Parahemionitis cordata*) based on the analysis of rbcL-gene sequence. Their study confirmed removing discussed species from *Hemionitis* to the separate genus *Parahemionitis*.

Thus, the nomenclatural citation for this genus is: *Parahemionitis* Panigrahi, 1993, Amer. Fern J. 83(3): 90. Type: *Parahemionitis arifolia* (Burm. f.) Panigrahi (*Asplenium arifolium* Burm. f.). The genus *Parahemionitis* is monotypic, represented by the single species – *P. arifolia*, growing in India and Sri Lanka throughout continental South-East Asia to southern China, Taiwan and the Philippines (Winter, Amoroso, 2003). The nomenclatural citation for the species is the following: *Parahemionitis arifolia* (Burm. f.) Panigrahi, 1993, Amer. Fern J. 83(3): 90. – *Asplenium arifolium* Burm. f., 1768, Fl. Ind.: 231. – *Hemionitis arifolia* (Burm. f.) T. Moore, 1859, Index Fil.: 114. – *Hemionitis cordata* Roxb. ex Hook et Grev., 1828, Icon. Fil. 1: 64. – *Parahemionitis cordata* (Roxb. ex Hook. et Grev.) Fras.-Jenk., 1997, New species syndrome in Indian pteridology and the ferns of Nepal: 187. Lectotype (Mazumdar, 2015: 91); “van Rhede tot Drakestein, Hortus Indicus Malabaricus 12: 21, tabula 10, 1703 (Fig. 2)”; Epitype (Mazumdar, 2015: 91): “India.
West Bengal: Burdwan, Kanchannagar, near bridge above canal, 30 m. 21 XI 2007. J. Mazumdar 59”.

The aim of this study is to provide details of morphology and ornamentation of spores of *Parahemionitis arifolia* using scanning electronic microscopy (SEM) to reveal features useful for systematics and phylogenetics.

**Materials and methods**

Spores were obtained from herbarium specimen of *Parahemionitis arifolia*, stored in PE (Chinese National Herbarium, Chinese Academy of Sciences, Beijing). Mature spores were used for SEM observations. Spores were mounted on SEM stubs using double-sided carbon adhesive tape and coated with gold in a “Quorum Q150R S” sputter-coater. Stubs were viewed and photographed with the scanning electron microscope “Mini-SEM SNE-4500M” in the Laboratory of Structural and Molecular Analysis of Plants (Tomsk State University, Tomsk, Russia). Spore surface was scanned in a high vacuum at voltage of 20 kV, through 2000–2500× magnification. Equatorial diameter (distal or proximal position of spore), polar axis (equatorial position of spore), length and width of laesura arms (proximal position of spore) were measured. All measurements were made on SEM-micrographs of spores using the computer program “Image J”. For terminology of sculpture elements, we primarily followed A. Tryon and B. Lugardon (1991), shape of the distal and proximal sides was described using terms by B. K. Nayar and S. Devi (1966). Spelling of the names of taxa and authors is given according to “The International Plant Name Index” (http://www.ipni.org).

**Results and discussion**

*Parahemionitis arifolia* forms typical for Pteridaceae tetrahedral trilete spores (Fig. 1). Spores are roundish-triangular in polar position, with convex sides and wide-rounded corners. In equatorial position, the distal side is hemispherical, proximal side is broadly conical. Spores have plain exospore and sculptured perispore. Exospore is micro-wrinkled, visible in case of destruction of fragile perispore. Perispore on the proximal and distal sides is cristate-reticulate, the cristae are more or less long and thin (1.5 μm in mean), with uneven upper margin, quite regularly distributed and form reticulum with small mostly closed polygonal luminae of different shape. Equatorial diameter ranges from 53.2 to 63.5 μm (mean 56.9 μm), polar axis is 40.3–41.5 μm (mean 41.4 μm), inner size of luminae is 3.4–8.1 μm (mean 4.6 μm). Laesura arms are straight, 20.0–23.5 μm (mean 21.3 μm) in length and 0.9–2.2 μm (mean 1.5 μm) in width, often obscured by numerous cristae.

**Acknowledgements**

We are grateful to curators of the Herbarium of Institute of Botany, Chinese Academy of Sciences (PE, Beijing) for the possibility of obtaining of spores from the herbarium material. The study was supported by RFBR (project No. 16-04-00513) and by the Tomsk State University competitiveness improvement program.
Fig. 1. SEM-micrographs of spores of *Parahemionitis arifolia* (Burm.) Panigrahi: A – proximal side of spore, laesura arms are obscured by numerous cristae; B – distal side of spore; C, D – spore in equatorial position, laesura above. Spores on C and D have fragment of destroyed perispore, where wrinkled exospore is visible. Scale bars: A, B, D – 30 μm, C – 20 μm.

REFERENCES


