Diversity and distribution of the genus *Arachniodes* Blume (Dryopteridaceae) in North-East India

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Abstract

The present study is mainly based on the field work conducted from 2008-2013 to different parts of North East India. Altogether six species of *Arachniodes* Blume collected from North East India which *Arachniodes miqueliana* (Maximowicz ex Franchet & Savatier) Ohwi. is collected for the first time from India and it is reported as new record for India. Detailed key for all the species, descriptions and photos for easy identification. All the collected species have been deposited at Botanical Survey of India, Western Regional Centre, Pune. Detailed description, key for each species, GIS mapping for each and every species and Photographs are also provided for easy identification.

Key words: Biodiversity, Conservation, Pteridophytes, Dryopteridaceae

INTRODUCTION

The North-East region has been under focus for its high biodiversity and the region has been a priority for investment by the leading conservation agencies of the world. The region's lowland and montane moist to wet tropical forests are considered to be the northernmost limit of true tropical rainforest in the world (Proctor *et al.* 1998). The ferns originated in ancient tropical habitats and have been successful in many types of environments for thousands of millennia. According to Rothwell and Stockey (2008) ferns first appeared in the fossil record during the Middle Devonian 390 million years ago. Ferns have continued to evolve and diversify up to the recent ages. However, according to Chapman (2006) about 15 % of all fern and lycophyte species may not yet be known to science. The total number of known ferns is estimated at about 12,000 species worldwide belonging to 225 – 230 genera (Kramer 1990) and 37 families (Smith *et al.* 2006).

Dryopteridaceae is of cosmopolitan distribution although with a strong concentration in the temperate regions of the Northern Hemisphere, particularly in the hills and mountains of eastern Asia. The Family was known only by 134 taxa under 15 genera from India. So far, 12 genera have been reported in North East India. The genus *Arachniodes* Blume is consisted to have 50 – 70 species distributed in tropical, subtropical and southern temperate regions of the world (Kramer *et al.* 1990). In India 12 species have been reported by Chandra (2000). But several workers have done lot of works in North East India. Though several regional revisions were carried out in last decades (on *Azolla* and *Salvinia*, Griffith 1845; Cryptogamsic plants, Roxburgh 1844; Hooker (Species Filicum Vol 1-5, 1844 – 1864); Beddome (Ferns of Brit Ind. 1865-1870, Suppl. Ferns Brit. India 1876; Handb. 1883; with suppl. 1892; New ferns

collected from Manipur, 1888); Clarke (A review of ferns of Northern India, 1880 and On the ferns of Nagaland and Manipur, 1888); Hooker and Baker (Synopsis Filicum, 1864, 1874); Clarke and Baker (Notes on ferns of Northern India, 1888), Burkill (the botany of Abor Exped., 1924); Fisher (The ferns of Lushai Hills, 1938); Kachroo (Ferns of Assam, 1975); Panigrahi (Pteridophytes of Eastern India, 1962); Panigrahi and Patnaik (Enumeration of correct nomenclature of Polypodiaceae in Eastern India, 1961), Panigrahi and Chowdhury (Enumeration and distribution of fern allies in Eastern India, 1962). Widén *et al.* (1996), with 24 species of those genera being noted as occurring in Arunachal Pradesh. Vasudeva *et al.* (1990) compiled a list of 73 species of Dryopteridaceae from North Eastern India, but few records were known to them from Arunachal Pradesh. Biswas (1941) reported 4 species collected by Bor in Kameng, Srinivasan (1959) reported 5 species from Kameng, Chandra (1980) reported 19 species from Kameng, Rao and Hajra (1980) reported 32 species from Kameng, Deb and Dutta (1972) reported 4 species from Tirap; Chauhan and Wadhwa (1996) reported 7 species from Tirap; Singh and Panigrahi (2005) recorded 15 species from Tirap district and Rawat *et al.* (2009) reported 21 species from Mehao Wildlife Sanctuary, Lower Dibang Valley. The main aim of study is to bring out a detailed account on the genus *Arachniodes* Blume from North East India.

METHODS

The present work is based on extensive collections made regularly from several areas in different parts of North East India. These areas were visited periodically in different season during 2008-2013. In presenting the account here, the classification followed here is basically according to Pichi-Sermolli's (1977) with minor changes following Fraser-Jenkins (2010). The taxonomic treatment includes explicit keys to genera and species under family along with detailed description for each species. In general, the descriptions of species were made from either herbarium or from live specimens and similarly species under general are also arranged alphabetically. In determining name of taxa, an effort has been made to present, as far as possible, the nomenclature accepted as valid in current literature. In this connection all the literature available to the authors are consulted. Only important synonyms which have relevance to Indian works. Original citation of both accepted name and synonyms are provided. Distribution Map and Colored Photograph also provided for easy identification.

Key to the 12 Genera known to occur in North-eastern India

- 1a. Swollen base of stipe bearing glossy scales; axes of frond bearing short unicellular hairs only ----- *Hypodematum*
- 1b. Base of stipe not swollen. scales usually on other parts also hairs on axes of fronds mostly not unicellular ----- 2
- 2a. Rhizome usually creeping, frond approximate ----- *Arachniodes*
- 2b. Rhizome erect, short suberect, frond tufted ----- 3
- 3a. Costae and costules densely scaly in abaxial surface ----- *Ctenitis*
- 3b. *Ctenitis* hairs are absent ----- 4
- 4a. Veins anastomosing ----- *Tectaria*
- 4b. Veins others ----- 5
- 5a. First pinnule of all pinnae except the lowest anadromous, rachis usually more or less zig zag ----- *Acrorumohra*
- 5b. First pinnule of all pinnae except the lowest catadromous ----- 6
- 6a. Lamina with a tooth in each sinus, the teeth elevated on adaxial surface - - - *Pleocnemia*

- 6b. Lamina margin without any teeth ----- 7
 7a. Stipe and rachis purple, lamina bear intesitiniiform hair like setae ----- *Nothoperenema*
 7b. Stipe and rachis brown or straw coloured, intesitiniiform setae absent -- -8
 8a. Indusium globose, stalked ----- *Perenema*
 8b. Indusium reniform ----- 9
 9a. Veins anastomosing, scattered sori ----- *Cyrtomium*
 9b. Veins free ----- 10
 10a. Pinnules with stiff, aristae margin; indusial peltate, centrally attached -- *Polystichum*
 10b. Pinnules without stiff ----- 11
 11a. Indusium reniform attached by a sinus, margin of pinnule serrate proliferating buds
 absent ----- *Dryopteris*
 11b. Indusium not as above ----- *Phanerophebiopsis*

TAXONOMIC TREATMENT OF THE GENUS *Arachniodes* Blume

Key to the Species

- 1a. Rhizome with dense tuft brown scales ----- *Arachniodes superba*
 1b. Rhizome otherwise ----- 2
 2a. Lamina rigescent, Sori terminal on veinlets ----- 3
 2b. Lamina soft, shinning green, Sori on veinlets ----- *Arachniodes henryii*
 3a. Fronds 4 pinnate in basal part ----- 4
 3b. Fronds 5 pinnate in basal part ----- *Arachniodes coniifolia*
 4a. Veins abaxially scattered with brown bullate basal scales ----- *Arachniodes miqueliana*
 4b. Veins abaxially not scattered without scales ----- 5
 5a. Rhizome long creeping, ultimate pinnule 1.5cm long ----- *Arachniodes rhomboidea*
 5b. Rhizome short creeping, ultimate pinnule 3.5cm long ----- *Arachniodes assamica*

Arachniodes assamica (Kuhn) Ching, Acta Bot. Sin. 10(3): 256. 1962; Ohwi, J. Jap. Bot. 37: 76. 1962; N.C. Nair *et* Chandra, Bull. Bot. Surv. India 11(1&2): 185. 1969; *Aspidium assamicum* Kuhn, Linnaea 36: 108. 1869. *Aspidium aristatum* var. *assamicum* (Kuhn) Baker, in Hooker & Baker, Syn. Fil., ed.2, 493. 1874. *Polystichum aristatum* var. *assamicum* (Kuhn) C.Chr., Index Fil. 579. 1906. *Dryopteris assamica* (Kuhn) Rosenst., Med. Rijks Herb. 31: 6. 1917. *Dryopteris speciosa* var. *assamica* (Kuhn) C.Chr., Contrib. U. S. Natl. Herb. 26(6): 282. 1931. *Rumohra assamica* (Kuhn) Ching, Sinensia 5(1-2): 47-49, t. 6. 1934. *Arachniodes assamica* (Kuhn) Ching, Act. Bot. Sin. 10(3): 256. 1962, *Aspidium yoshinagae* Makino, Bot. Mag., Tokyo 13: 57. 1899. *Polystichum yoshinagae* (Makino) Makino, Bot. Mag., Tokyo 23: 144. 1909. *Arachniodes yoshinagae* (Makino) Ching, Act. Phytotax. Sin. 9: 383. 1964. *Rumohra assamica* forma *simplicipinnata* Ching, Sinensia 5(1-2): 49. 1934.

Rhizome short creeping, Stipe up to 45 cm long, scaly on lower part, scales brown, lanceolate, acuminate, entire, sparsely fibrillose upwards. Lamina lamina deltoid, bipinnate or tripinnatifid glabrous, lustrous green, thin, chartaceous simple pinnate form; pinnae 6-8 pairs, lanceolate acuminate inciso-cuspidate, stalked under pinnatifid apex, in bipinnate or tripinnatifid form; acuminate, lateral pinnae 4-6 pairs, stalk long, oblique, basal pinnae over 20 cm long, pinnate with about 10 pairs of the deltoid lanceolate, oblique pinnules, unequally

Figure 1. *Arachniodes assamica* (Kuhn) Ohwi

Figure 2. *Arachniodes ciniifolia* (T.Moore) Ching

lobed, 4-6 cm long, 1-1.5 cm broad, obliquely truncate, and slightly auriculate on anterior side, cuneate below, margin incised half way down or serrate with about 4-7 large teeth with mucronate point; veins and veinlets, anterior basal veinlet of each group terminated by a large rounded sorus some distances below the sinus; sori uniseriate, indusium large, reddish, entire, round-reniform, (Figure 1; Map 1)

Ecology: It grows on forest floor from 1500 to 2000 m amsl.

Distribution: INDIA: North-east India: (Assam, Manipur), Sikkim, West Bengal, CHINA, JAPAN, MYANMAR.

Specimen examined: Arunachal Pradesh: W. Siang, Mechuka, *A. Benniamin* 25294, dated November 2008, XCH; Tirap, Langsang Forest, *D.B. Deb* 26172, dated 26.06.1961, ARUN.

Arachniodes coniifolia (T. Moore) Ching, Acta Bot. Sin. 10(3): 257. 1962; N.C. Nair, Bull. Bot. Surv. India 11(1-2): 186. 1969; *Lastrea coniifolia* T. Moore, Ind. Fil. lxxxviii. 1857.; Bedd., Ferns Brit. Ind. t. 261. 1868; Handb. 230. T. 118. 1883; Suppl. 50. 1892. *Rumohra wallichii* (D. Don) Ching, Sinensia 5: 56, pl. 9. 1934. *Aspidium coniifolium* Wall. ex Kunze in Linnaea 24: 293. 1891; non C. Presl, 1822; Lowe, Ferns Brit. & Exot. 6. t. 39. 1871. *Nephrodium coniifolium* C. Hope, J. Bombay Nat. Hist. Soc. 14: 720. 1903 (in part). *Lastrea aristata* var. *coniifolia* T. Morre, Ind. Fil. 88. 1858. *Aspidium aristatum* var. *coniifolium* Hook., Sp. Fil. 4: 28. 1862; Syn. Fil. 255. 1867.

Rhizome erect, stipe tufted, rhizome and base of stipe densely scaly; rhizome scales ovate-lanceolate, long acuminate, margin fimbriate apex, stipe stramineous, up to 65 cm long; lamina 5-pinnate, large, ovate, up to 100 cm long, pinnae up to 40 cm long, ovate lanceolate, upper pinnae oblique enlarged towards basiscopic side, other pinnae 15 cm broad, second pinnae 25 cm long, 10 cm broad, oblique, 15 pairs, apex long acuminate, tertiary pinnae up to 6 cm long, 2 cm broad, pinnae of the 4th order 1.5 cm long, 0.5 cm broad, rhomboid, pinnae lobed at base; lobation reach up to midrib, ultimate segments, small, 5 mm long, 2 mm broad, margin at upper portion with 4-5 arista. Sori large, terminal on veinlets, indusium round-reniform. (Figure 2; Map -1)

Ecology: It grows on forest floor from 1000 to 2500 m amsl.

Distribution: INDIA: North East India: (Arunachal Pradesh, Manipur, Meghalaya), Sikkim, Peninsular India, BHUTAN, CHINA, NEPAL.

Specimen Examined: Arunachal Pradesh: Upper Subansiri, Daporijo, *A. Benniamin* 22787, dated 10.06.2008, ARUN; Kurungkumey, Serley [Sarli], *A. Benniamin* 26459, dated December 2008. **Nagaland:** Mokochungdist, Changkiforest area, *A. Benniamin*, 2835023, dated July.2011, ARUN; **Manipur:** Sennapathi dist, Jackamma hills, *A. Benniamin* 26845, dated 18.02.2010, ARUN. Sheroy hills, *A. Benniamin*, 26743, 26729, dated 14.02.2011 ARUN; Nagaland: Tuensang dist, Nongchugang forest area, *A. Benniamin* 28388, 23.07.2011, ARUN.

Arachniodes henryi (Christ) Ching, Acta Bot. Sin. 10(3): 258. 1962. *Polystichum henryi* Christ in Lecomte, Not. Syst. 1: 36. 1909; *Rumohra henryi* (Christ) Ching, Sinensia 5: 57, pl. 10. 1934. *Byrsopteris henryi* (Christ) C.V.Morton in Am. Fern J. 50: 154. 1960. *Dryopteris henryi* (Christ). C. Chr., Contr. U.S. Nat. Herb. 26:282. 1930.

Rhizome long creeping, stipe distant, rhizome thick a finger and 1 cm dia., rhizome and base of stipe densely covered with subulate-lanceolate, 5-6 mm long, blackish brown undulate,

Figure 3. *Arachniodes henryi* (Christ) Ching

Figure 4. *Arachniodes miqueliana* (Maxim. ex Franch & Sav.) Ohwi

Figure 5. *Arachniodes rhomboidea* (Wall.) Ching

subadpressed scales, stipe scales 7-5 mm long, lanceolate subulate, brown, stipe up to 55 cm long, brownish; lamina 4-5 pinnate at base pinnate above, soft, shining green, large up to 50 cm or more long, broadly deltoid, primary pinnae 13 pairs, stalked, remote lowest pinnae largest, about 25 cm long, deltoid oblong, acuminate; secondary pinnae 12 pairs, stalked, elongate-acuminate, basal secondary pinnae largest, 12 cm long, 5 cm broad, acute, tertiary pinnae acute up to 3 cm long, deltoid; ultimate segments 1 cm long, 5 mm broad, inciso serrate, lobe aristate, dentate; Sori dorsal on veinlets closer to costule than the margin, Indusium reniform, brown, undulate (Figure 3; Map-1).

Ecology: It grows under shade from 1200 to 2000 m amsl.

Distribution: INDIA: Eastern India (Meghalaya, Manipur, Mizoram, Nagaland), Nepal, China

Specimen examined: Arunachal Pradesh: Kurungkumey, *A. Benniamin* s.n., ARUN; Siang, Mechuka, *A. Benniamin* XCH s.n. 25113, 25330, dated 18.11.2008, ARUN.

Arachniodes miqueliana (Maximowicz ex Franchet & Savatier) Ohwi, J. Jap. Bot. 37: 76. 1962. *Aspidium miquelianum* Maxim. ex Franch. & Sav., Enum. Pl. Jap. 2: 240. 1876. *Nephrodium miquelianum* (Maxim. ex Franch. & Sav.) Kom., Fl. Manchur. 1: 123. 1901. *Dryopteris miqueliana* (Maxim. ex Franch. & Sav.) C. Chr., Index Fil. 278. 1905. *Rumohra miqueliana* (Maxim. ex Franch. & Sav.) Ching, Sinensia 5: 67, t. 17. 1934. *Leptorumohra miqueliana* (Maxim. ex Franch. & Sav.) H. Itô, in Nakai & Honda, Nov. Fl. Jap. 4: 119. 1939. *Polystichopsis miqueliana* (Maxim. ex Franch. & Sav.) Tagawa, J. Jap. Bot. 33: 94. 1958. *Aspidium fargesii* Christ, Bull. Soc. Bot. France 52, Mém. 1: 42. 1905. *Dryopteris fargesii* (Christ) C. Chr., Index Fil. 264. 1905. *Leptorumohra fargesii* (Christ) Nakaike & A. Yamam., J. Nat. Hist. Mus. Inst. Chiba 3(2): 144. 1995. *Arachniodes borealis* Seriz., J. Jap. Bot. 61(2): 48. 1986.

Rhizome long creeping, densely clothed with brown lanceolate scales along growing parts. Frond 0.4 -1.3m; stipes 25x54 cm and 3-5 mm in diam., brownish stramineous, copiously scaly throughout primary rachis; lamina herbaceous, obscurely green to yellowish green when dried, deltoid-pentagonal, 35-52 x 26-35 cm, apex acuminate, 4-pinnate; pinnae 6-10 pairs, alternate, obliquely spreading, lowest pinna deltoid-ovate, 29-32 x 22-25 cm, apex acuminate, 3-pinnate; first order pinnules 18 pairs, obliquely spreading, deltoid-lanceolate, basal basiscopic one 15 x 7 cm, 2-pinnate; penultimate pinnules 6-7 pairs, stalked, blunt deltoid to oblong, ca. 3.5 x 2.5 cm, base broadly cuneate, apex obtuse, 1-pinnate; ultimate pinnules 3-4 pairs, ovate or rhombic, to 1.2 x 0.9 cm, apex obtuse or acute, margin deeply pinnatifid or obtusely serrate; upper pinnae gradually reduced; axes and main veins adaxially with pale grey unicellular acicular hairs, veins abaxially scattered with brown, ovate scales. Sori 1-3 per ultimate segment; indusia brown, entire. (Figure 4; Map 1).

Ecology: Under broad-leaved or mixed forests, on earth or occasionally on shaded moist and moss covered rock surface at 1200 – 1450 m amsl.

Distribution: INDIA: North East India: (Arunachal Pradesh), JAPAN, KOREA.

Specimen examined: Arunachal Pradesh: Kameng, Jang, Tawang, *A. Benniamin* 28050, 2010, dated 10.08.2010, ARUN.

Arachniodes rhomboidea ((Wall. ex C. Presl) Ching, Act. Phytotax. Sin. 9(4): 383 – 384. 1964. *Polystichum rhomboideum* Schott, Gen. Fil. t. 9. 1834. *Aspidium rhomboideum* (Wall. ex C. Presl) Mett., Abhandl. Seckenb. Naturf. Ges. 2(4): 350. 1857. *Polystichum*

Figure 6. *Arachniodes superba* Fraser-Jenk.

controversum (Hance) Ching, Coll. Dept. Biol. Coll. Sci. Sun Yatsen Univ. 6: 7. 1933. *Byrsopteris amabilis* var. *yakusimensis* (H.Itô) Sa.Kurata, in Namegata & Kurata, Enum. Jap. Pterid. 283, 339. 1961. *Arachniodes amabilis* var. *yakusimensis* (H.Itô) Ohwi, J. Jap. Bot. 37: 76. 1962. *Arachniodes rhomboidea* var. *yakusimensis* (H.Itô) W.C.Shieh, Fl. Taiwan 1: 365. 1975. *Arachniodes yakusimensis* (H.Itô) Nakaike, New Fl. Japan Pterid. 839. 1992. *Arachniodes amabilis* var. *fimbriata* K.Iwats., Act. Phytotax. Geobot. 30(1-3): 42. 1979.

Rhizome long creeping, densely scaly, scales brown, stipe 30-40 cm long, brownish, slender; lamina 30-50 cm long, bipinnate, subcoriaceous, ovate oblong, pinnae 5-12 pairs, lateral pinnae similar, pinnae up to 15 cm long, 3.5 cm broad, all pinnae stalked, basal basioscopic pinnules of the lowest pinnae again pinnate, pinnules stalked, rhomboid, 1.5 cm long, subfalcate, acute subauriculate or none, margin spinulose serrated except lower base. Sori in single row at sinus of the serrate, close to the margin, terminal. Indusium reniform, fringed. (Figure 5; Map 1).

Ecology: It grows from 1000 to 1200 m altitude in semi shade forest area.

Distribution: INDIA: North East India: (Mizoram, Meghalaya), CHINA, NEPAL, TAIWAN.

Specimen examined: Mizoram: Murlen National Park, A.Benniamin, 22083, 2012, ARUN.

Arachniodes superba Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 39. 1997. *Aspidium foeniculaceum* Hook., Sp. Fil. 4: 36, t. 237. 1862. *Lastrea foeniculacea* (Hook.) Bedd., Ferns Brit. India t. 36. 1865. *Polystichum foeniculaceum* (Hook.) J.Sm., Hist. Fil. 220. 1875. *Diacalpe foeniculacea* (Hook.) C.B.Clarke, Trans. Linn. Soc. London, 2 Bot., 1: 434. 1880. *Dryopteris foeniculacea* (Hook.) Kuntze, Revis. Gen. Pl. 2: 812. 1891. *Lithostegia foeniculacea* (Hook.) Ching, Sinensia 4: 2. 1933. *Peranema foeniculacea* (Hook.) B.K.Nayar & S.Kaur ex S.Chandra & S.Kaur, Nomencl. Guide Beddome's Ferns S. Brit. India 38. 1987.

Rhizome short oblique, stout, densely scaly, stipe tufted, 18-40 cm long or more, rufo stramenous, angular below, scaly scales dense, 1 cm long, brown, lanceolate, long acuminate, margin more or less fimbriate; lamina large, 45-80 cm long, 30-50 cm broad, deltoid acuminate, 4-5 pinnate with very ultimate division; Primary pinnae about 14 pairs, alternate, stalked, oblique, basal pairs largest, 18-30 cm long, 15-25 cm broad, deltoid, acuminate, anadromous, rachilets fibrillose scaly; secondary pinnae oblong lanceolate, up to 10 cm long, 3-4 cm broad, petiolulate, oblique, pinnae of third order shortly petiolulate, 2.2-5 cm long, 1-1.5 cm broad, base unequal, oblong ovate, oblique, pinnae of the 4th order, 1 cm long, 6 mm broad, pinnate, up to 1-3 pairs, oblique, linear, sharply pointed, ultimate segments, 2-3 mm long, 1-1.5 mm broad, entire, provided with one simple veinlets, veinlets ended far below apex, texture softly subcoriaceous, under side of costules, veins and ultimate segments with twisted, brown, soft, long hair like fibrillose scales, clavate tip of veinlets prominent on the upper side of segment; sori small, rounded, indusiate, one to each segments; indusium thick, coriaceous, or almost dark purple, ovate, oblong, entire, covering the entire sori at first, splitting into 2-3 turned aside, subrounded lobes with exterior connate lateral side is persistently attached to receptacle (Figure 6; Map 1).

Ecology: It grow as terrestrial between 1400 and 1880 m amsl.

Distribution: INDIA: North East India (Arunachal Pradesh), Sikkim, West Bengal, CHINA

Specimen examined: Arunachal Pradesh: Mechuka, *A. Benniamin* 26094, dated November 2008, ARUN.

DISCUSSION

The taxonomy of the genus *Arachniodes* Blume in North India is intensively studied last several years. The main aim of the study is to provide a comprehensive list of the genera of Dryopteridaceae grow in North-East India and to enumerate the species of *Arachniodes* of the region along with their detailed description and colorful photographs. Based on literature review stated that no much work is paid on cytology, and molecular identity of the genus. Hence it is necessary to study the Cytology, Palynology and molecular studies of this genus from India and that is an urgent need for understang the taxon in a better way.

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