Diversity of the genus *Tectaria* Cav. (Polypodiaceae) in Eastern Himalaya and North East India

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Abstract

While revising the genus *Tectaria* Cav. (Polypodiaceae), in India, 15 species have been recorded from Eastern Himalaya and North East India, of which 11 species are exclusively distributed in this region. On the other hand, *T. coadunata*, *T. fuscipes*, *T. multicaudata* and *T. polymorpha* are also distributed in different parts of India. In the present paper diversity, distribution, nomenclature, identification key, conservation status and ecology of *Tectaria* species have been provided.

Key words: *Tectaria*, Biogeography, Identification, Endemic, Hotspot

INTRODUCTION

The Eastern Himalaya include the entire Arunachal Pradesh and Sikkim states of India, which occupies 2.5 % geographical area. This biogeographic area represents the transition zone between Indo-China-Bhutan region. Similarly, North East India includes Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura states of India. It embodies the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions. Therefore, it is one of the biodiversity hotspots which show diverse set of habitats coupled with long term geological stability that has allowed the development of significant levels of endemism in the flora and fauna. (Balasubramanian 2017).

Beddome (1883, 1892) explored Eastern Himalaya and North East India and recorded several fern species from Assam and other adjoining regions. Subsequently, Gammie (1895) collected ferns from Lakhimpur district of Assam, Gage (1901) from South Lushi Hills, Burkill from Abor Hills and Bor (1938) from Aka hill. After independence of India, Panigrahi (1960), Panigrahi & Chowdhury (1961, 1962), Panigrahi & Patnaik (1961a, 1961b) studied the ferns from North East India and Eastern Himalaya and documented 350 species. Concomitantly, Mehra and Bir (1964) and Hara *et al.* (1966, 1971) studied the pteridophytes diversity of Darjeeling hills. Kachroo (1975) documented fern diversity of Assam including adjoining states like Nagaland, Manipur, Meghalaya and part of Arunachal Pradesh and came up with “Fern flora of Assam” which included phytogeography of 279 species belonging to 104 genera. Thereafter, several pteridologists, studied fern diversity of North East and Eastern Himalaya (Bir *et al.*, 1989; Kachroo *et al.* 1989; Handique & Konger 1986; Vasudeva *et al.* 1990; Fraser-Jenkins 2008; Chandra 2000; Ghosh *et al.* 2004; Singh & Panigrahi 2005; Rawat & Sahu 2009; Benniamin 2010, 2012). Recently, Singh *et al.* (2012), enlisted total 113 taxa in the Nokrek Biosphere reserve of Meghalaya. Baruwati and Gogoi (2013) studied the pteridophytic flora of Sivasagar district of Assam. Singh *et al.* (2015) also studied the pteridophytes of Thorangtlang and Tawi Wildlife Sanctuary, Mizoram. Benniamin *et al.* (2015) added two fern species to the pteridophytic flora

of Nagaland. Recently, Sharma *et al.* (2018) have added four species to the pteridophytic flora of Mizoram.

The genus *Tectaria* Cav. (Polypodiaceae) was known as *Aspidium* Sw. since long. However, this name was not according to the rules and therefore treated as an illegitimate name. At that time the name *Aspidium* was used for different genera viz., *Dryopteris* Adans., *Polystichum* Roth, or *Nephrolepis* Schott, (in addition to *Tectaria*). Therefore, it became the source of confusion. Like other ferns, *Tectaria* also shows variation in their morphological characters, which led to origin of many new genera such as *Sagenia* C. Presl, *Pleocnemia* C. Presl, *Dictyopteris* C. Presl, *Bathmium* C. Presl ex Link, *Dryomenis* Fee ex J. Sm., *Podopeltis* Fee, *Cardioclachna* Fee, and *Arcypteris* Underw., on the basis of venation characters. Approximately 200 species of *Tectaria* are accepted worldwide (PPG I), of which twenty-seven species are reported from India (Fraser-Jenkins *et al.* 2020). In the present investigation authors report fifteen species of *Tectaria* from Eastern Himalaya and North-East India. Their diversity, distribution conservation status and taxonomic note are given along with identification key to the species occurring in Eastern Himalayas and North-East India.

MATERIAL AND METHODS

Field visits were carried out during the year 2017 – 2019 in different regions of Eastern Himalaya and North East India. The collected specimens were processed under the laboratory for the preparation of herbariums specimens as per standard methods. Dried herbarium specimens were poisoned using 4% formalin and affixed on the herbarium sheets by using glue. All the collected specimens were identified using standard literature viz., Panigrahi and Singh, (2005), Patil *et al.* (2014, 2019a, 2020) and Fraser-Jenkins (2018). The voucher specimens were deposited in BARO herbarium of the Department of Botany, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat. The conservation status of all the species was studied using IUCN Version 2019-1. Herbarium specimens of all the species reported in the present study are deposited in BARO herbarium of the Maharaja Sayajirao University of Baroda, Vadodara 390002.

RESULTS

A total of fifteen species viz., *Tectaria chattagramica* Ching, *T. coadunata* (J. Sm.) C. Chr, *T. decurrens* (C. Presl.) Copel., *T. fauriei* Tagawa, *T. fuscipes* (Wall. ex Bedd.) C. Chr., *T. griffithii* (Baker) C. Chr., *T. heterocarpa* C.V. Morton, *Tectaria impressa* (Fée) Holttum, *T. ingens* (Atk. ex C.B. Clarke) Holttum, *T. multicaudata* (C.B. Clarke) Ching, *T. polymorpha* (Wall. ex Hook.) Copel., *T. pseudosiifolia* Fraser-Jenkins & Wangadi, *T. simonsii* (Baker) Ching, *T. subconfluens* (Bedd.) Ching and *T. vasta* (Blume) Copel., were collected from Eastern Himalaya and North-East India. The most common species include *T. coadunata*, *T. fuscipes*, *T. heterocarpa*, *T. impress*, *T. polymorpha* and *T. subconfluens* (Figures 1-3).

Key to Specie of *Tectaria* from Eastern Himalaya and North-East India

- 1a. Fronds unipinnate to pinnatifid-Pinnatisect 2
- 1b. Fronds bipinnate-tetrapinnate 8
- 2a. Pinnae pinnatisect-pinnatifid 3
- 2b. Pinnae unipinnate 6
- 3a. Gemma present on pinnae *T. fauriei*
- 3b. Gemma absent on pinnae 4
- 4a. Sori small in size, in two rows *T. decurrens*
- 4b. Sori large in size, scattered *T. vasta*

Figure 1: A. *Tectaria chattaogramica*, B. normal *T. coadunata*, C. enlarged rachis and pinnae of normal *T. coadunata*, D. densely hairy *T. coadunata*, E. enlarged rachis and pinnae of densely hairy *T. coadunata*, F. *T. decurrens*, G. Sori of *T. decurrens*, H. *T. fuscipes*, I. dark black scale of *T. fuscipes*.
Scale Bar: A-F & H = 5 cm, G = 5 mm & I = 1 cm

5a. Stipe, rachis and costa with densely hairy	<i>T. pseudosiiifolia</i>
5b. Stipe, rachis and costa not densely hairy	8
6a. Pinnae without axil bulbils	7
6b. Pinnae with axil bulbils	<i>T. heterocarpa</i>
7a. Lower pinnae bifurcate	<i>T. polymorpha</i>
7b. Lower pinnae bipinnate-pinnatifid	<i>T. simonsii</i>
8a. Fronds tetrapinnate	<i>T. ingens</i>
8b. Fronds less than tetrapinnate	9
9a. Veins free with coastal areoles	<i>T. fuscipes</i>
9b. Veins anastomosing	10
10a. Plant dimorphic	11
10b. Plant monomorphic or subdimorphic	13
11a. Fronds broadly lobed	<i>T. subconfluens</i>
11b. Fronds narrowly lobed	12
12a. Lower pinnae lacking free pinnules	<i>T. chattagramica</i>
12b. Lower pinnae having free pinnules	<i>T. impressa</i>
13a. Pinnae glabrous-sparsely hairy beneath	13
13b. Pinnae sparsely-densely hairy beneath	<i>T. coadunata</i>
14a. Costa and costule areole absent	<i>T. griffithii</i>
14b. Costa and costule areole present	<i>T. multicaudata</i>

1. *Tectaria chattagramica* (C.B. Clarke) Ching, Sinensia 2: 35, t. 14. 1931.

Lectotype, BANGLADESH, Chittagong (Dist.), Burkhul, 250 ft., 12/2/1873, C. B. Clarke (19879A), K001080708.

Distribution: World: Bangladesh, Myanmar, India and Thailand. INDIA: Assam, Sikkim, Manipur, Meghalaya, Mizoram, Sikkim and Tripura.

Eastern Himalaya: Sikkim

North-East India: Assam, Manipur, Meghalaya, Mizoram, Sikkim and Tripura.

Conservation Status: *T. chattagramica* is collected from North-East and Eastern Himalaya along the cut edges or hilly slopes. A population of 50 – 100 individuals were observed per square kilometre and the area of occupancy (AOO) is 200–400 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) species for North-East and Eastern Himalayas of India.

Ecology: Uncommon species collected an altitude <300 m (rarely up to 500m) along the roadside, cut edges, or dense to dry deciduous forest growing below <25 °C temperature and >50 % atmospheric humidity.

Specimen Examined: India – Assam, Karbi Anglong dt., Nambar forest, near the hot springs, 01/1890, Beddome, R.H (#s.n.) K001080710; Kamrup Metropolitan dt., Garbhanga, 210 m, 26/02/2018, S. M. Patil (3001) BARO; BANGLADESH: Chittagong (Dist.), Kasalong, 10/01/1869, C.B. Clarke, (177) K001080707; Ruttumpoea, 07/02/1873, C.B. Clarke, (19767) K001080709.

2. *Tectaria coadunata* (J.Sm.) C. Chr., Contrib. U. S. Natl. Herb. 26 (6): 331. 1931.

Lectotype, NEPAL, Kathmandu (Dist.), Hetauda & Bhimphedi, 1820, N. Wallich (377.1), K001080706.

World: Bhutan, China, India, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam, Africa, Madagascar. INDIA: Throughout.

Figure 2: A-D. variations within the fertile fronds of *Tectaria fuscipes*, E. enlarged pinnae of *T. fuscipes* showing costal areole, F. enlarged pinnae of *T. fuscipes* without costal areole, G-I. habit, rhizome and fertile frond of *T. heterocarpa* respectively. **Scale Bar:** A, C, G, I = 5 cm, B, D, H = 3 cm & E, F = 1 cm

Eastern Himalaya: Arunachal Pradesh and Sikkim

North-East Indian: Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Conservation Status: *T. coadunata* is collected from different localities in Eastern Himalaya and North-East India. A population of 100–200 individuals were observed per square kilometre and the area of occupancy (AOO) is 300–500 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) species for North-East and Eastern Himalayas of India.

Ecology: Most common species collected above >500 m from different habitats viz., along the roadside, hilly slopes, cut edges, in dense to dry deciduous forest or along the water channels and rivers, growing up to 35° C temperature and 30 % atmospheric humidity.

Specimen Examined: INDIA – Arunachal Pradesh, Papam Pare dt., Ganga Lake, Itanagar, 230 m, 14/02/2018, S. M. Patil (3003) BARO; Upper Subansiri District, 10.06.2008, A. Benniamin (22759) ARUN12556; Dibang Valley Dt., Checkopani-Tiwarigoan Road, Mehao Wildlife Sanctuary, 17.11.2000, A. Benniamin (9206) ARUN; Assam, Kamrup Metropolitan dt., Kamakya Temple road, 210 m, 26/02/2018, S. M. Patil (3004) BARO; Meghalaya, North Khasi Hills, Nongpoh, 520 m, 19/02/2018, S. M. Patil (3005), BARO; Mizoram, Mamit dt., Dampa Tiger Reserve, A. Benniamin (28481) ARUN 14877; Maharashtra, Satara Dt, Mahabaleshwar, alt. 1000 m., 26/12/1964, M. R. Almeida BLAT 248; Karnataka, North Kanara, Castle Rock, 03/01/1966, M. R. Almeida BLAT 804; Andhra Pradesh, East Godavari Dt., Maredumilth, tiger camp, alt. 1200 m., 17/08/1995, Mohanan MH105036.

3. *Tectaria decurrens* C. Presl, Reliq. Haenk. 1: 28. 1825.

Holotype, PHILIPPINES, Luzon, Sorzogon, T. Haenke, herb. C. Presl

Distribution: World – Bangladesh, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam. INDIA: Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Meghalaya and Tamil Nadu.

Eastern Himalaya: Arunachal Pradesh

North-East India: Assam and Meghalaya.

Conservation Status: *T. decurrens* is collected from different localities in Eastern Himalaya and North-East India. A population of 50–100 individuals were observed per square kilometre and the area of occupancy (AOO) is 300–500 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) species for North-East and Eastern Himalaya of India.

Note: Uncommon fern collected at an altitude <1500 m (rarely up to 2000m) along the water current or streams in dense forest areas, growing below <25° C temperature and >50 % atmospheric humidity.

Specimens Examined: India – Meghalaya, East Khasi Hills dt., Shillong, Elephant falls, 12.10.2010, A. Benniamin (26160), ARUN; Arunachal Pradesh, West Siang dt., Kane WLS, S. S. Dash (32255) ARUN 20994.

4. *Tectaria fauriei* Tagawa, J. Jap. Bot. 14(2): 102-104. 1938.

Holotype, TAIWAN, Pere U.J. Faurie 67, KYO.

Distribution: World – China, India, Japan, Malaysia, Myanmar, Taiwan, Thailand, Vietnam. INDIA: Arunachal Pradesh, Assam, Meghalaya.

Eastern Himalaya: Arunachal Pradesh.

Figure 3: A-C. range of variation in *T. heterocarpa*, D-F. habit, rhizome and fertile frond of *T. impressa* respectively, G-H. habit and fertile frond of *T. ingens*, I. *T. multicaudata*.
Scale Bar: A-D G, I = 3 cm & E, F, H = 1 cm

North-East India: Assam and Meghalaya.

Conservation Status: *T. fauriei* is reported from North East India and Eastern Himalaya. Authors have not collected this species, however, it was listed in recent literature hence documented here. At present, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as data deficient (DD) species for Eastern Himalayas and North East India.

Note: Uncommon fern collected at an altitude <1500 m (rarely up to 2000m) along the water current or streams in dense forest areas, growing below <25° C temperature and >50 % atmospheric humidity.

5. *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr., Contr. U.S. Natl. Herb. 26: 290. 1931.

Lectotype, INDIA, Assam State, Cachar Hills, C. B. Clarke (7050). K001080698

World: Bangladesh, Bhutan, China, India, Indonesia, Myanmar, Nepal, Taiwan, Thailand, Tibet and Vietnam. INDIA: Arunachal Pradesh, Assam, Karnataka, Manipur, Mizoram, Meghalaya, Nagaland, Sikkim, Tripura, West Bengal.

Eastern Himalaya: Arunachal Pradesh.

North-East India: Assam, Manipur, Mizoram, Meghalaya, Nagaland, Sikkim, Tripura

Conservation Status: *T. fuscipes* is collected from different forest regions of North East India and Eastern Himalaya. A population of 200 – 300 individuals were observed per square kilometre and the area of occupancy (AOO) is 500 – 700 km². At present, as per IUCN categories and criteria (IUCN ver. 2017-1) it is assessed as least concerned (LC) for North-East and Eastern Himalaya of India.

Note: It is an uncommon species found below 1200 m altitude (rarely >1500 m) collected along the roadside or water current, growing below <25 °C temperature and >50 % atmospheric humidity.

Specimens Examined: India – Arunachal Pradesh, Lower Subansiri dt., Doimukh forest, 13.11.1978, G. D. Pal (70230) ARUN; Upper Subansiri dt., Pasighat Forest Area, 12.07.2008, A. Benniamin (22543) ARUN12505; Tripura, Dumpur Forest Area, 18.06.2011, A. Benniamin (28192) ARUN14143; Arunachal Pradesh, Papam Pare dt., Itanagar, 210 m, 12/02/2018, S. M. Patil (3008) BARO; Meghalaya, North Khasi Hills dt., Nongpoh, 550 m, 19/02/2018, S. M. Patil (3009) BARO; Assam, Kamrup Metropolitan dt., Kamakya temple road, 230 m, 26/02/2018, S. M. Patil (3010) BARO; Mizoram, Aizawal dt., Tawi Wildlife Sanctuary, 09.11.2011, A. Benniamin (28568) ARUN15459; Manipur, Tamenglong dt., 28.09.2012, A. Benniamin (28883 A) ARUN20754.

6. *Tectaria griffithii* (Baker) C. Chr., Index Fil. Suppl. 3: 180. 1934.

Holotype, MYANMAR, W. Griffith, K001080693.

World: Bangladesh, Cambodia, China, India, Laos, Malaysia, Myanmar, Philippines, Taiwan, Thailand and Vietnam. INDIA: Arunachal Pradesh, Assam, Nagaland, Tripura.

Eastern Himalaya: Arunachal Pradesh.

North-East India: Assam, Tripura

Conservation Status: *T. griffithii* is reported from Eastern Himalaya and North-East India. Authors have not collected this species, however, specimens are available in herbaria and also listed in recent literature hence documented here. At present, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as data deficient (DD) species for Eastern Himalayas and North East India.

Figure 4: A. *Tectaria pseudosiiifolia*, B. densely hairy rachis & pinnae of *T. pseudosiiifolia*, C. normal habit of *T. polymorpha*, D-E. variations in rhizome structure of *T. polymorpha* (long & short creeping respectively), F-H. range of variations in frond of *T. polymorpha* (bifurcate each pinnae, tetrafurcate basal pinnae and enlarged portion of rachis and pinnae respectively), I-J. habit and rhizome of *T. subconfluens*.
 Scale Bar: A, C, F, I = 3 cm, B, D, E, G, H, J = 1 cm

Note: It is an uncommon species found <1200 m altitude collected along the roadside or water current, growing below <25 °C temperature and >50 % atmospheric humidity.

Specimens Examined: India – Arunachal Pradesh, Lower Subansiri dt., On the way to Old Ziro, (Arunachal Pradesh), 04.06.2008, A. Benni. (22886) ARUN12586; Kurung Kumey dt., Koloriang, 07/12/2008, A. Benni. (26424) ARUN 12590; Lower Dibang Valley dt., Mayodia pass, 12/06/2010, A. Benni (26863) ARUN 12584.

7. *Tectaria heterocarpa* (Bedd.) C. V. Morton, Contrib. U. S. Natl. Herb. 38 (6): 270. 1973.

Holotype, INDIA, Meghalaya, Khasi Hills, Dr. T. Thomson, Herb. Beddome, K.

World: Bangladesh, India, Myanmar, Nepal. INDIA: Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland, Tripura, West Bengal, Tripura.

Eastern Himalaya: Arunachal Pradesh.

North-East India: Assam, Meghalaya, Mizoram, Nagaland, Tripura, Tripura.

Conservation Status: *T. heterocarpa* is collected from different regions of North-East and Eastern Himalaya. A population of 100 – 200 individuals were observed per square kilometre and the area of occupancy (AOO) is 100 – 250 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) for Eastern Himalayas and North East India.

Note: It is a common species found below 800 m altitude (rarely up to 1000 m) collected along the cut edges or hill slopes and water current, growing below <25°C temperature and >40 % atmospheric humidity.

Specimens Examined: India, Arunachal Pradesh, Papumpare dt., Itanagar, 400-500 m alt., 17/02/2018, S. M. Patil & K. S. Rajput 3015 (BARO); Naharlagun Dam Site, 06.11.1978, G.D. Pal 70147 (ARUN); Ganga Lake, Itanagar, 25.01.2009, CRFJ & A. Benni. 33616 (ARUN); Tripura, North Tripura dt., Kanchanpur forest Area, 04.07.2011, A. Benni. 28227 (ARUN); Dumpur forest Area, 15.06.2011, A. Benni. (28184) ARUN14548; Mizoram, 03.11.2011, A. Benni. 28438 (ARUN).

8. *Tectaria impressa* (Fee) Holttum, Kew Bull. 43(3): 483. 1988.

Lectotype INDIA, Meghalaya, W. Griffith 34

World: Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Taiwan, Thailand, Vietnam. INDIA: Assam, Meghalaya, Mizoram, Nagaland, Tripura, West Bengal, Tripura.

North-East India: Assam, Meghalaya, Mizoram, Nagaland, Tripura, Tripura.

Conservation Status: *T. impressa* is collected from different regions of North-East and Eastern Himalayas. A population of 100–150 individuals were observed per square kilometre and the area of occupancy is 200 – 400 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) for North-East and Eastern Himalayas of India.

Note: It is a common species found below 600 m altitude, collected along the cut edges along the roadside or hilly slopes and water current, growing below <25°C temperature and >40 % atmospheric humidity.

Specimens Examined: India, Assam, Kamrup Metropolitan dt., Kamakhya temple road, 200 m alt., 26/10/2018, S. M. Patil and K. S. Rajput (3023) BARO12345700103; Guwahati, Zoo cum Botanical Garden, 300 m alt., 26/10/2018, S. M. Patil and K. S. Rajput (3024)

BARO12345700104; Meghalaya, Shilong to Nongpoh road, 500 m alt., 27/02/2018, S. M. Patil and K. S. Rajput (3025) BARO12345700105.

9. *Tectaria ingens* (Atk. ex C.B. Clarke) Holttum, Revis. Fl. Malaya 2: 503. 1955.

Lectotype, INDIA, West Bengal, Darjeeling, Rungbee, 3000 ft., 27.9.1869, C.B. Clarke 9295 (K).

World: Bangladesh, Bhutan, China, India, Nepal, Tibet, Vietnam. INDIA: Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, West Bengal.

Eastern Himalaya: Arunachal Pradesh, Sikkim, West Bengal.

North-East India: Manipur, Meghalaya, Mizoram, Nagaland.

Conservation Status: *T. ingens* is collected from different regions of North-East and Eastern Himalaya. A population of 100 – 150 individuals were observed per square kilometre and the area of occupancy (AOO) is 100 – 250 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) for North-East and Eastern Himalayas.

Note: It is a common species found below 700 m altitude, collected along the forest floor or hilly slopes growing below <25° C temperature and >60 % atmospheric humidity.

Specimen Examined: India, Arunachal Pradesh, Papam Pare Dist., Ganga Lake, 20/02/2018, S. M. Patil & K.S. Rajput, 3026 (BARO).

10. *Tectaria multicaudata* (C.B. Clarke) Ching, Sinensia 2: 20. 1931.

Holotype, BANGLADESH, Sylhet, 250 ft., 30.11.1872, C.B. Clarke 18427C, K.

Distribution: World: Bangladesh, India, Malaysia, Myanmar, Nepal, Thailand. INDIA: Arunachal Pradesh, Assam, Maharashtra, Meghalaya and Sikkim.

Eastern Himalaya: Arunachal Pradesh, Sikkim.

North-East India: Assam, Meghalaya.

Conservation Status: *T. multicaudata* is collected from different regions of North-East and Eastern Himalayas. A population of 100–150 individuals were observed per square kilometre and the area of occupancy (AOO) is 100–250 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) for North-East and Eastern Himalayas.

Specimens Examined: India, Maharashtra, Kolhapur Dt., Panhala, alt. 800 m, 13/08/2018, S. M. Patil & K. S. Rajput 3036, BARO; Tripura, North Tripura Dt., Churaibari, alt. 600 m, 18/06/2011, A. Benniamin 28203, 22886, 26424, 14687, ARUN.

11. *Tectaria polymorpha* (Wall. ex Hook.) Copel. Philipp. J. Sci., Sect. C, Botany 2:413. 1907; Christensen, Contr. U.S. Natl. Herb. 26: 330. 1931; Sledge, Kew Bull. 27:419 (1972) & Bot. J. Linn. Soc. 84:18 (1982); Nayar & Kaur, Comp. Bedd., Handb. 51(1974); Dixit, Census 144 (1984); Rajagopal & Bhat, Indian Fern J. 15:21 (1998).

Lectotype, NEPAL, N. Wallich Num. List no. 382, K

Distribution: World: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam. INDIA: Throughout

Eastern Himalaya: Arunachal Pradesh, Sikkim.

North-East India: Assam, Meghalaya, Mizoram, Nagaland, Tripura and Manipur

Conservation status: *T. polymorpha* is collected from different North-East India, Eastern Himalaya and Western Ghats. About 100–200 individuals were observed per square kilometre and the

area of occupancy (AOO) is 400–500 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) species for North-East and Eastern Himalaya of India.

Note: It is a common species found at an altitude the 100 – 1200 m (rarely >1200 m), collected along the roadside, growing in rock crevices or on cutting edges at temperature < 25 °C and > 50% atmospheric humidity.

Specimens Examined: India, Karnataka, Dt., North Kananda, Castle Rock alt., 1100 m, 13/08/2018, S. M. Patil & K. S. Rajput 3041, BARO; Dt., Udupi, Sringeri, alt., 300 m, 08/06/2018, S. M. Patil & K. S. Rajput 3042, BARO; Arunachal Pradesh, Dt., Papam Pare, Itanagar, Ganga Lake, 18/02/2018, S. M. Patil & K. S. Rajput 3043, BARO; Meghalaya, Jowai Hills, 26/02/2018, S. M. Patil & K. S. Rajput 3043, BARO; Dawki, 03/06/2019, S. M. Patil & K. S. Rajput 3044, BARO; Assam (NEFA), Foothill Camp, alt., 800 m, G. Panigrahi, 5830A (ASSAM); Tripura, Dt., North Tripura, Jampui Hills, alt., 900 m, 26/06/2011, A. Benniamin, 28249 (ARUN); Mizoram, Dampa Tiger reserve, alt., 900 m, 03/11/2011, A. Benniamin, 28441 (ARUN).

12. *Tectaria pseudosiifolia* Fraser-Jenk. & Wangdi, Fraser-Jenkins, Kandel & Pariyar, Ferns Fern-allies Nepal 1: 31. 2015.

Holotype, BHUTAN, 3 km N. of Samdrup Jongkhar, 2 km S. of Pinchinang Check-post, C.R. Fraser-Jenkins, T. Wangdi, S. Lungten & T. Dorji 33930 (FN 16), 20.5.2009, TAIF.

Distribution: World: Bhutan, India. INDIA: Arunachal Pradesh, Sikkim, Meghalaya.

Eastern Himalaya: Arunachal Pradesh, Sikkim.

Conservation status: *T. pseudosiifolia*, is collected from Eastern Himalaya's only. About 100–200 individuals were observed per square kilometre. However, other forest areas of India are yet to be explored thoroughly and more floristic explorations are needed to determine and document the full range of distribution. Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as data deficient (DD).

Note: It is a unique species found at an altitude the below 1200 m (rarely >1200 m), collected along the roadside, growing on cutting edges at temperature < 25 °C and > 50% atmospheric humidity.

Specimens Examined: Arunachal Pradesh, Dt., Papam Pare, Itanagar, Ganga Lake, 18/02/2018, S. M. Patil & K. S. Rajput 3034 (BARO); Sanki Park, 21/02/2018, S. M. Patil & K. S. Rajput 3035 (BARO); Naharlagun to Ziro road, 02/12/2018, S. M. Patil & K. S. Rajput 3035 (BARO); Subansiri dt., Ziro, 31/05/2008, A. Benni. 12861 (ARUN); West Siang dt., On the way of Mechuka-tato, 20/11/2008, A. Benni. 12864 (ARUN); Upper Siang dt., Megging to tuting road, 18/01/2013, A. Benni., 20252 (ARUN).

13. *Tectaria simonsii* (Baker) Ching, Sinensia 2(2): 32 – 33, t. 8. 1931.

Lectotype, INDIA, Assam or Nagaland, “Mikir [“Nuku Hills” of Holttum (1981)] and Naga Hills”, C.J. Simons 301, Jany. (c. 1853), K.

Distribution: Bangladesh, China, India, Japan, Malaysia, Myanmar, Taiwan, Thailand, Vietnam. INDIA: Arunachal Pradesh, Assam, Meghalaya, Nagaland and Sikkim

Eastern Himalaya: Arunachal Pradesh, Sikkim

North-East India: Assam, Meghalaya, Nagaland.

Conservation status: *T. simonsii*, is reported from North-East India and Eastern Himalaya. Authors have not collected this species however specimens are available in herbaria and also listed in

recent literature hence documented here. At present, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as data deficient (DD) species for Eastern Himalaya and North East India.

Note: It is a unique species found along the roadside, growing on cutting edges or in rock crevices.

Specimens Examined: Arunachal Pradesh, Dt., Papam Pare, Itanagar, Sanki Park, 21/02/2018, S. M. Patil & K. S. Rajput 3048 (BARO); Papampare Dt., Doimukh, 13/11/1978, G. D. Pal 702229 (ARUN); Assam, Sonitpur Dt., Potasali, 17/02/1957, G. Panigrahi, 5287.

14. *Tectaria subconfluens* (Bedd.) Ching, *Sinensia* 2: 27, t. 8. 1931.

Holotype, INDIA, Meghalaya, Khasi Hills, below Umwai, 3000 ft., C.B. Clarke [19340A, 7.11.1872], herb. R.H. Beddome, K.

Distribution: Bangladesh, India. INDIA: Arunachal Pradesh, Assam State, Meghalaya.

Eastern Himalaya: Arunachal Pradesh, Sikkim

North-East India: Assam, Meghalaya, Nagaland,

Conservation status: *T. subconfluens*, is reported from North-East India and Eastern Himalaya. About 100–200 individuals were observed per square kilometre and the area of occupancy (AOO) 100–200 km². Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as Vulnerable (VU) species for North-East and Eastern Himalayas of India.

Note: It is a unique species found along the roadside, growing on cutting edges or in rock crevices.

Specimens Examined: Arunachal Pradesh, Dt., Papam Pare, Itanagar, Sanki Park, 21/02/2018, S. M. Patil & K. S. Rajput 3048 (BARO); Ganga Lake, 21/02/2018, S. M. Patil & K. S. Rajput 3048 (BARO); Itanagar lake area, 19/04/1985, B. Ghosh 59690 (CNH); Kameng, 21/11/1970, A. S. Rao 50525 (CNH); West Siang dt., On the way of Mechuka-tato, 20/11/2008, A. Benni. 20341 (ARUN).

15. *Tectaria vasta* (Blume) Copel., *Philipp. J. Sci.* 2(6): 411. 1907.

Holotype, INDONESIA, Java, C.L. von Blume, L.

Distribution: Bangladesh, China, India, Indonesia, Laos, Malaysia, Myanmar, Thailand, Vietnam. INDIA: Andaman & Nicobar Islands (Nicobars), Arunachal Pradesh, Assam State, Manipur, Meghalaya, Mizoram, Nagaland and Tripura

Eastern Himalaya: Arunachal Pradesh

North-East India: Assam, Meghalaya, Nagaland,

Conservation status: *T. vasta* is reported from North-East India and Eastern Himalaya. Authors have not collected this species, however, specimens are available in herbaria and also listed in recent literature hence documented here. At present, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as data deficient (DD) species for Eastern Himalayas and North East India.

Note: It is a unique species found along the water channels at an elevation 300 – 800 m.

Specimens Examined: India, Assam, Cachar Dt., Bihara, 06/10/2011, HAB 700 (ASSAM); Arunachal Pradesh, Upper Subansiri dt., 26/09/1959, Panigrahi 19578 (ASSAM); Upper subansiri dt., A. Benni., 22707 (ARUN); Changlang dt., Diban bulbulia bridle path, G.D. Pal, 7376 (ARUN); West Siang dt., Kane Wildlife Sanctuary, S.K. Das, 20994 (ARUN).

DISCUSSION

On the basis of morphology, all the collected species of *Tectaria* are grouped into three complexes (Patil *et al.* 2019a). The *complex-I* includes the species which having uni-pinnate, pinnatifid or pinnatisect fronds with highly anastomosing veins with branched included veinlets viz., *Tectaria decurrens*, *T. fauriei*, *T. heterocarpa*, *T. polymorpha*, *T. pseudosiiifolia* and *T. vasta*. The *complex-II* includes the species having bipinnate to tripinnate or tripinnatifid fronds with partly anastomosing veins with or without unbranched included veinlets viz., *Tectaria chattaigramica*, *T. coadunata*, *T. griffithii*, *T. impressa*, *T. multicaudata*, *T. simonsii* and *T. subconfluens*. The *complex-III* includes the species which are having bipinnate to tetrapinnate fronds with free veins without included veinlets viz., *Tectaria fuscipes* and *T. ingens*.

Amongst these 11 species viz., *Tectaria decurrens*, *T. fauriei*, *T. heterocarpa*, *T. ingens*, *T. pseudosiiifolia*, *Tectaria chattaigramica*, *T. griffithii*, *T. impressa*, *T. simonsii* and *T. subconfluens* are restricted in this region. The most common species are *T. coadunata*, *T. fuscipes*, *T. heterocarpa*, *T. impressa* and *T. polymorpha*. Leaf morphology along with venation pattern was studied by Sledge (1972), Salgado (1982) and Holttum (1983). Salgado (1982) made a detailed study on the venation patterns of tectarioid ferns of Phillipines. Banerjee (Mukherjee) and Mukhopadhyay (2008) also made a detailed study on the venation patterns of 22 Indian tectarioid ferns. They designated four different types of venation patterns, out of which the free veined type was marked as the primitive type and the reticulate type with included veinlets which may be branched or unbranched.

T. chattaigramica is characterised by short creeping rhizome, fronds clustered, dimorphic, lamina bipinnate-bipinnatifid, pubescent, basal pinnae deeply lobed of which the basal lobe at the basiscopic side is comparatively larger, veins anastomosing, basal portion of the pinnae forming few, large, areoles without any included veinlets, sori scattered, situated on apical free portion of veins (Figure 1A). As shown in Figure 1B-E, *Tectaria coadunata* collected from north-east and Himalayan regions are either less hairy or densely hairy and having less dissected lamina. Hence, north east and eastern Himalayan *T. coadunata* is misreported as *T. cicutaria* and *T. macrodonta* by Vasudeva *et al.* (1990), Borthakur *et al.* (2000) and, Singh and Panigrahi (2005). The *T. decurrens* is wrongly identified as *Leptochilus insignis* (= *Microsorium insignis*) by Balakrishnan (Bull. Bot. Surv. India 22(1-4): 136-137. 1981) and Dixit & Sinha (Pterid. Andaman Nicobar Isl. 48. 2001), because of similar sterile fronds phyllotaxy (Figure 1F-G). Its occurrence is also documented in South India, which is based on single specimen deposited at Kew by Beddome. Later on, Indian pteridologists have usually not mentioned South India in its range (Fraser-Jenkins 2018). *Tectaria decurrens* is smaller in size than *T. vasta* and has large sized sori, arranged in definite manner with large, elliptical indusia. *T. fauriei* is a little-known species often misreported or overlooked as *T. vasta* because having simple or pinnatisect, decurrent lamina. However, presence of axillary gemma on the lamina makes different from the *T. vasta* (Fraser-Jenkins *et al.* 2018).

T. fuscipes is characterised by presence of erect to suberect rhizome, dark black scales, dimorphic fronds, fertile fronds longer and narrow than sterile one (Figure 1H-I and Figure 2 A-F). However, it was collected from Dawki, Jawoi Hills, Nangpoh, Ganga Lake and some collection of Dr. A. Benniamin from Tripura and Mizoram doesn't have costal or costular areole (Figure 2E-F) but they are having dark black scales of typical *T. fuscipes* types (Figure 1I). Due to lack of costal and costular areole, Vasudeva *et al.* (1990) and Borthakur *et al.* (2000) identified it as *T. paradoxa*. Moreover, it also shows fertile lamina is broad as sterile one whereas in some, having very narrow fertile lamina (Figure 2B & D).

According to Patil *et al.* (2020) many collections deposited in ASSAM and ARUN herbaria under the name *Tectaria griffithii* is of *T. multicaudata*. Both the species having difference

in scale distribution pattern, phyllotaxy, costal and costular areole (Patil *et al.* 2020). In *T. griffithii* the stipe is scaly only at the base, it has alternate to-subopposite phyllotaxy and costal and costular areoles are absent whereas in *T. multicaudata*, the stipe scaly up to rachis or even up to costa, has opposite to subopposite phyllotaxy and costal and costular areoles are present, which differentiate the *T. multicaudata* and *T. griffithii*.

Tectaria heterocarpa has short erect rhizome, fronds compound, oblong-lanceolate, pinnae 5-15 per frond, terminal pinnae broader than lateral pinnae, apex long acuminate, sparsely pubescent, veins anastomosing with included veinlets, sori scattered, indusiate, spores monolete and margin spinulose (Figs. 2G-H, 3A-C). The *Tectaria heterocarpa* (Figure 3, A-C) is misidentified as *T. pandurifolia* (C. Chr. g) C. Chr., (1934:183) by Singh & Panigrahi (Ferns Fern-Allies Arunachal Pradesh 2: 651-652, t. 242. 2005). At the younger stage *T. heterocarpa* produce a single, broadly ovate, stalked, terminal pinnae (sometimes fertile) which looks like a *T. pandurifolia* (Fraser-Jenkins *et al.* 2018). *T. heterocarpa* was also misreported as *T. nightii* because both the species doesn't produce basal bifurcate pinnae. However, *T. nightii* is differs from *T. heterocarpa* in having long creeping rhizome, lamina ovate-lanceolate pinnae are of same sized, sori in two rows (sometime scattered), exindusiate, spores monolete and margin spinulose (Patil *et al.* 2019a). *T. impress* is characterised by suberect-erect rhizome, fronds dimorphic, fertile fronds longer and narrower than sterile one, lamina bipinnatifid-tripinnatifid, pubescent, veins anastomosing, forming copious subhexagonal areoles with simple included veinlets, sori indusiate, in row on both side of veins (Figure 3D-F). *T. ingens* is characterised by erect-suberect rhizome, fronds dimorphic, lamina tripinnate-quadripinnatifid, veins free, once or twice forked, reaching up to the margins, sori indusiate, present on tip of veins on both side of costule (Figure 3G-H). *T. pseudosiifolia* appears more or less similar to *T. polymorpha*. As shown in Figure 1A-B, it differs in having the dense white hairs on the stipe, rachis, pinnae and lobes. The lamina is bright green coloured, larger indusiate sori, subdimorphic, slightly smaller fertile frond, with dark stipes as compared to *T. polymorpha*.

In general, *T. polymorpha* is characterised by suberect or short creeping rhizome, bifurcation of only lower pinnae and sparsely hairy (Singh & Panigrahi 2005; Fraser-Jenkins 2008; Kholia 2014 and Patil *et al.* 2019b). These characters of *T. polymorpha* can be verified even in the specimens growing in other part of the country including Western Ghats. However, considerable variations were observed in the morphology of individuals of this species growing in Meghalaya and Arunachal Pradesh, which showed long, stout, creeping rhizome, all pinnae bifurcated or sometimes lower pinnae shows quadrifurcate and less hair (Figure 4C-H).

Tectaria khonsaensis Singh & Panigrahi, is described from Khonsa village, Arunachal Pradesh by Singh and Panigrahi (2005), which is similar to *T. polymorpha* but differs from later species by presence of hairs. Careful observation of line diagram and type photographs of *T. khonsaensis* provided by Singh and Panigrahi (2005) in Flora of Arunachal Pradesh showed absence of hairs. Authors of the present work tried to rectify the ambiguity by consulting the type specimen submitted to CNH but the type specimen could not be traced. Fraser-Jenkins (2008) when working on the check list on pteridophytes of Indian subcontinents, and "An annotated checklist of Indian Pteridophytes Part-2" Fraser-Jenkins *et al.* (2018), kept *T. khonsaensis* Singh & Panigrahi under *T. polymorpha*.

Tectaria simonsii is characterised by creeping-suberect rhizome, fronds clustered; stipe dark brown or castaneous to black, pubescent throughout; lamina bipinnate to tripinnatifid, veins anastomosing, forming subhexagonal areoles with simple or forked included veinlets; sori exindusiate, orbicular arranged in irregular rows. *T. subconfluens* is characterised by suberect, stout rhizome with frond traces (Figure 4I-J), fronds clustered, dimorphic, stipe and rachis scaly, lamina bipinnate-bipinnatifid, decurrent, lower pinnae bipartite, fertile frond longer and narrower than sterile one, veins anastomosing with forked included veinlets, sori indusiate, scattered, situated on veinlets.

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