

## Diversity, Distribution and Conservation Status of the Genus *Tectaria* Cav. from Deccan Peninsula and Western Ghats of India

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### Abstract

The halberd fern genus *Tectaria* Cav., is terrestrial, medium to large size herb, growing along the cut edges of hills and hillocks or edges of river. It is characterized by the presence of erect, creeping or suberect rhizome with dimorphic, subdimorphic or monomorphic fronds and anastomosing to free veins. Generally, it occurs in different habitats of the tropical to subtropical region of the world. Different members are exploited for various purposes in traditional medicinal system by local tribes. However, the diversity, distribution, conservation status and state of the knowledge about *Tectaria* (Tectariaceae) is not uniform worldwide including India. Therefore, the present investigation aims to study the diversity, distribution and conservation status of this genus from Peninsula and Western Ghats of India. Out of 24 species reported from India, nearly nine species occur in Deccan Peninsula and Western Ghats. A detailed distribution and conservation status with the identification key to the species of *Tectaria* distributed in this region is provided herewith.

**Keywords:** biogeography; homosporous; near threatened; pteridophytes; Tectariaceae

### Introduction

The genus *Tectaria* Cav. (Tectariaceae) is a perennial, herbaceous, homosporous fern, well distributed in tropical and subtropical regions with most species growing terrestrially in rain forests along the cut surfaces or hilly slopes. The genus is dryopteroid in its morphology, but has been placed in a separate family Tectariaceae based on molecular cladonomic studies (Smith *et al.*, 2006, 2008).

The estimated number of species range from 150 (Tryon and Tryon, 1982; Kramer *et al.*, 1990) to 230 (Holtum, 1991; Ding *et al.*, 2013). Holtum (1991) recognized 105 species of *Tectaria* from Malesia and deduced that South East Asia is its center of origin. In India, the genus *Tectaria* Cav. is having 24 species and a variety

(Fraser-Jenkins, 2008). This genus from Peninsula and Western Ghats was studied by various pteridologists during different times. Beddome (1883) has reported four species from South India. Blatter and d'Almeida (1922) reported six species from Bombay presidency. Manickam and Irudayaraj (1992) have reported only three species from the Western Ghats of South India. Fraser-Jenkins (2008) has revised pteridophytic flora of Indian subcontinent and reported six species viz., *T. coadunata*, *T. gemmifera*, *T. paradoxa*, *T. polymorpha*, *T. trimenii*, *T. zeylanica*. Recently, Patil *et al.* (2014), Antony *et al.* (2014) and Dubal *et al.* (2016) have added three more species viz. *T. fuscipes*, *T. puberula* and *Tectaria polymorpha* from Deccan Peninsula and Western Ghats respectively. Based on the present investigation, authors are reporting nine species viz., *T. coadunata*, *T. fuscipes*, *T. gemmifera*, *T. paradoxa*, *T. polymorpha*, *T. puberula*, *T. trimenii*, *T. wightii* and *T. zeylanica* for Deccan Peninsula and Western Ghats of India. Maximum diversity was observed in Western Ghats (09) whereas Deccan Peninsula nestled 05 species.

## Materials and Methods

### Study area

The Deccan Peninsula and Western Ghats are biogeographic zones of India, which covers 35-40% of biodiversity of India. The Deccan Peninsula is a central highland comprises the Vindhya and Satpura hill ranges, Chhota Nagpur Plateau, Karnataka Plateau, Eastern Ghats and Tamil Nadu Plains (Gupta *et al.*, 2000). The zone is relatively homogenous and ranges from semi-arid to moist deciduous or semi-evergreen type of climate. Whereas the Western Ghats runs from Tapi river in north to Kanyakumari in the south, along the west coast of peninsular India through the states *viz.*, Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Lakshminarayana *et al.*, 2001). It is one of the 25 biodiversity 'hotspots' in the world (Myers *et al.*, 2000) and is one of the major tropical evergreen forest regions in India, revealing enormous plant diversity. It is also considered as a major genetic estate with a rich biodiversity of ancient lineage.

### Plant collection and processing

*Tectaria* Cav., species were collected from Deccan Peninsula and Western Ghats of India and processed under laboratory. The collected specimens were poisoned by dipping into 0.4% formalin for a day. They were dried and affixed on the herbarium sheets by using fevicol glue. The specimens were identified by using literature *viz.*, Beddome (1883); Blatter and Almedia (1922) and Manickam and Irudayaraj (1992) and doubtful specimens were sent also to Prof. S. P. Khullar and Mr. Fraser-Jenkins to obtain their expert opinion.

## Results and Discussion

The genus *Tectaria* is having great variation in its morphology *viz.*, some species are having erect rhizome (*T. fuscipes*, *T. paradoxa* and *T. polymorpha*), some are having short to long creeping rhizome (*T. coadunata*, *T. gemmifera*, *T. puberula*, *T. trimenii*, *T. wightii* and *T. zeylanica*), few are dimorphic-subdimorphic (*T. fuscipes*, *T. paradoxa*, *T. polymorpha*, *T. trimenii* and *T. wightii*), few are monomorphic (rarely subdimorphic) fronds (*T. coadunata*, *T. gemmifera*, *T. puberula* and *T. zeylanica*), many of them are having anastomosing veins with or without included veinlets (*T. coadunata*, *T. gemmifera*, *T. polymorpha*, *T. puberula*, *T. trimenii*, *T. wightii* and *T. zeylanica*) while some are having free veins along the costa (*T. fuscipes* and *T. paradoxa*).

### Key to Decan Peninsula and Western Ghats *Tectaria* species

- 1a. Fronds simply pinnate ..... 2
- 1b. Fronds bipinnate or more pinnate ..... 3
- 2a. Rhizome short creeping, lower pinnae bifurcate.....*T. polymorpha*
- 2b. Rhizome long creeping, lower pinnae not bifurcate..... *T. wightii*

- 3a. Plants monomorphic..... 4
- 3b. Plants sub-dimorphic or dimorphic ..... 5
- 4a. Plants produce gemmae on the rachis...*T. gemmifera*
- 4b. Plants do not produce gemmae on the rachis.....6
- 5a. Lamina pinnate-bipinnatifid; twined sori present.....

### *T. puberula*

- 5b. Lamina bipinnatifid to quadripinnatifid; twined sori absent.....*T. coadunata*

- 6a. Rhizome long creeping.....*T. zeylanica*
- 6b. Rhizome erect-short creeping .....7
- 7a. Areoles present along the rachis and costa ..... 8
- 7b. Areoles absent .....*T. paradoxa*
- 8a. Fertile lamina winged ..... *T. trimenii*
- 8b. Fertile lamina not winged..... *T. fuscipes*

1. *Tectaria coadunata* (J.Sm.) C. Chr., Contrib. U. S. Natl. Herb. 26(6):331. 1931; Sledge, Kew Bull. 27:418. 1972; Manickam & Irudayaraj, Pterid. Fl. W. Ghats, 255-257.1992; Khullar, Illu. Fern Fl. West Him. Vol. II, 432-434. 2000; Pullaiah *et al.*, Pterid. A. P. India, 140-141. 2003. Fraser-Jenkins, Tax. Rev. three hundred Ind. Subcont. Pterido. 315. 2008.

Deccan Peninsula & Western Ghats: Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu and West Bengal.

Ecological Note: It is very common species found above the >500 m altitude (rarely < 500 m) collected along the roadside or water current, growing below 32 °C temperature and >25% atmospheric humidity.

Conservation status: *T. coadunata* is collected from different localities in Deccan Peninsula and Western Ghats. About 300-500 individuals were recorded per locality and the area of occupancy (AOO) is 200-350 km<sup>2</sup>. Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned species for Deccan Peninsula and Western Ghats.

2. *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr. Contr. U.S. Natl. Herb. 26:290. 1931; Ching, Sinensia 2:14. 1931; Tagawa & K. Iwats. South East Asian Stud. 5: 97. 1967; Fraser-Jenkins, Tax. Rev. Three hundred Ind. Subcont. Pterido. 315. 2008; Patil *et al.*, J. Jap. Bot. 187-188. 2014.

Deccan Peninsula & Western Ghats: Karnataka

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

Conservation status: *T. fuscipes* is collected from Castle Rock, Ulvai, Dandlei, Anshi, Sirsi, Agumbe forest of Western Ghats. About 200-300 individuals were recorded at each locality. However, other regions yet to be explored completely and might be the species were distributed in similar ecological conditions. Hence, more floristic surveys are indeed to determine and document the full range of distribution of *T. fuscipes*. Therefore, according to IUCN (2012) criteria, at present this species is considered as data deficient (DD) for Deccan Peninsula and Western Ghats.

3. *Tectaria gemmifera* (Fee) Alston, Journal of Bot. 77:288. 1939; Fraser-Jenkins, Tax. Rev. three hundred Ind. Subcont. Pterido. 315. 2008.

Deccan Peninsula & Western Ghats: Kerala.

Ecological note: It is a unique species found above the 500 m altitude (rarely < 500 m) collected along the roadside, growing below 25 °C temperature and >50% atmospheric humidity.

Conservation status: *T. gemmifera* is collected from Wayanad, Western Ghats. About 50-100 individuals were recorded at the locality. However, other regions yet to be explored completely and might be the species were distributed in similar ecological conditions. Hence, more floristic surveys are indeed to determine and document the full range of distribution of *T. gemmifera*. Therefore, according to IUCN (2012) criteria, at present this species is considered as data deficient (DD) for Deccan Peninsula and Western Ghats.

4. *Tectaria paradoxa* (Fée) Sledge, Kew Bull. 27:413. 1972; Manickam & Irudayaraj, Pterid. Fl. W. Ghats, 255-257. 1992; Fraser-Jenkins, Taxon. Revis. Ind. Subcont. Pterid. 626.2008.

Deccan Peninsula & Western Ghats: Karnataka, Kerala and Tamil Nadu.

Ecological note: It is an endemic species found above the 500 m (rarely below the 500 m) collected along the water current, growing below 25 °C temperature and above 50% atmospheric humidity.

Conservation status: *T. paradoxa* is an endemic species collected from Karnataka, Kerala and Tamil Nadu forest regions of Western Ghats. Populations of 100-150 individuals were observed per locality and the area of occupancy (AOO) is 100-150 km<sup>2</sup>. It is an endemic to Deccan peninsula and Western Ghats therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is evaluated as Near Threatened (NT).

5. *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); Dubal et al., Indian Fern J. 33:206-211. 2016.

Deccan Peninsula & Western Ghats: Andhra Pradesh, Chhattisgarh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha and Tamil Nadu.

Ecological 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.

Conservation status: *Tectaria polymorpha* (Wall. ex Hook.) Copel. is collected from different North-East India, Eastern Himalaya's and Western Ghats. About 100-200 individuals were found per locality and the area of occupancy (AOO) 100-150 km<sup>2</sup>. Therefore, as per IUCN categories and criteria (IUCN ver. 2017-1), it is assessed as least concerned (LC) species for Deccan peninsula and Western Ghats.

6. *Tectaria puberula* (Desv.) C. Chr., Dansk Bot. Ark. 7:67. 1932; Antony et al., Indian Fern J. 31:139-142.

Deccan Peninsula & Western Ghats: Kerala.

Ecological note: It is a rare species found at an altitude 1100 m collected along the earth bank in evergreen forest at temperature < 25 °C and > 50% atmospheric humidity.

Conservation status: *Tectaria puberula* is collected only

from Moozhiyar forests of Pathanamthitta district, Kerala, comes under Western Ghats region. Furthermore, we assume that this African element might be dispersed in similar ecological conditions. Hence, more floristic explorations are needed to define and document the full range of distribution of *Tectaria puberula*. Therefore, according to IUCN (2017 ver.-1) criteria, at present this species is considered as data deficient (DD).

7. *Tectaria trimenii* C. Chr., Index Filic. Suppl. 1. 1934; Sledge, Kew Bull. 27(3):422-423. 1972.

Deccan Peninsula & Western Ghats: Karnataka, Kerala and Tamil Nadu.

Ecological note: This species is endemic to South India and Sri Lanka, which reported from evergreen forest of Nelliampathy, Hills and Agasthyamala for the Western Ghats.

Conservation status: *Tectaria trimenii* C. Chr. is collected from Nelliampathy Hills, Yana Forest and Agasthyamala of Western Ghats. Furthermore, we assume that the species might be dispersed in similar ecological conditions. Hence, more floristic explorations are needed to define and document the full range of distribution of *Tectaria trimenii*. Therefore, according to IUCN (2017 ver.-1) criteria, at present this species is considered as data deficient (DD).

8. *Tectaria wightii* (C.B. Clarke) Ching, Sinensia 2:28, t. 10. 1931; Sledge, Kew Bull. 27(3):422-423. 1972; Nayar & Kaur, Comp. Bedd., Handb. 51(1974); Dixit, Census 145(1984); Manickam & Irudayaraj, Pterid. Fl. W. Ghats, 258-259.1992; Pullaiah et al., Pterid. AP., India, 142-143. 2003. Fraser-Jenkins, Tax. Rev. three hundred Ind. Subcont. Pterido., 317. 2008.

Deccan Peninsula & Western Ghats: Karnataka, Kerala and Tamil Nadu.

Ecological note: the species is collected at an altitude 200 -900 m, growing on cut surfaces along the roadside or on rock cervices at < 25 °C and > 50% atmospheric humidity.

Conservation status: *T. wightii* is an endemic species collected from Karnataka, Kerala and Tamil Nadu forest regions of Western Ghats. About 100-200 individuals were found per locality and the area of occupancy (AOO) is 100-250 km<sup>2</sup>. It is an endemic to Deccan peninsula and Western Ghats therefore, as per IUCN categories and criteria (IUCN ver. 2017-1) it is evaluated as Near Threatened (NT).

9. *Tectaria zeylanica* (Houtt.) Sledge, Kew Bull. 27(3): 422-423. 1972; Sukumaran et al., Indian J. Forestry 30(3):331-332. 2008.

Deccan Peninsula & Western Ghats: Kerala and Tamil Nadu.

Ecological note: A unique species producing rosette pinnae and trilobed fertile frond which makes unique in the genus.

Conservation status: *T. zeylanica* is collected from Western Ghats. Furthermore, we assume that the species might be dispersed in similar ecological conditions. Hence, more floristic explorations are needed to define the full range of distribution of *Tectaria zeylanica*. Therefore, according to IUCN (2017 ver.-1) criteria, at present species is considered as data deficient (DD).

*Taxonomic note*

The occurrence of *T. fuscipes* and *T. polymorpha* in Western Ghats and Deccan Peninsula is questionable (Fraser-Jenkins, 2008). According to him species *Tectaria fuscipes* and *T. paradoxa* are two smaller species with dark or blackish stipe-base scales, which have often been confused under various other names and with each other. Therefore, neither *T. fuscipes* occurred in South India nor *T. paradoxa* occurred in North India. Similarly, *T. wightii* is a species related to *T. polymorpha*, and has often been reported under that name, especially from S. India. Therefore, *T. wightii* entirely replaces the *T. polymorpha* in S. India. However, during present investigation authors were collected the all the species viz., *Tectaria fuscipes*, *T. paradoxa*, *T. polymorpha* and *T. wightii* from different regions of Western Ghats and Deccan Peninsula of India.

In *T. fuscipes* rhizome is suberect-erect rhizome, having dark black stipe scale, dimorphic-subdimorphic fronds, with free veins and areoles along the costa whereas in *T. paradoxa* rhizome is erect, brown stipe scale, dimorphic-subdimorphic fronds, with free veins without areoles along

the costa (Fig. 1). The main difference between these two species is presence of absence of areoles along the costa. If areoles are present species is *T. fuscipes* and if absent species is *T. paradoxa*.

Similarly, *T. polymorpha* is having short creeping to suberect rhizome, black-brown colored rhizome and stipe scales, subdimorphic-dimorphic fronds, with bifurcate lower pinnae. In contrast *T. wightii* is having short to long creeping, branched rhizome, black-brown rhizome and stipe scales, subdimorphic-dimorphic fronds, without bifurcate lower pinnae. The main differences in between these species are having short creeping-suberect or short-long creeping rhizome and bifurcate lower pinnae (Fig. 1). If the plants with short creeping-suberect rhizome and lower pinnae are bifurcate the species is *T. polymorpha* and if the plants with short-long creeping rhizome and without bifurcate lower pinnae the species is *T. wightii*. Therefore, authors herewith confirmed the occurrence of all the above said species were in South India especially in Western Ghats and Deccan Peninsula regions of India.

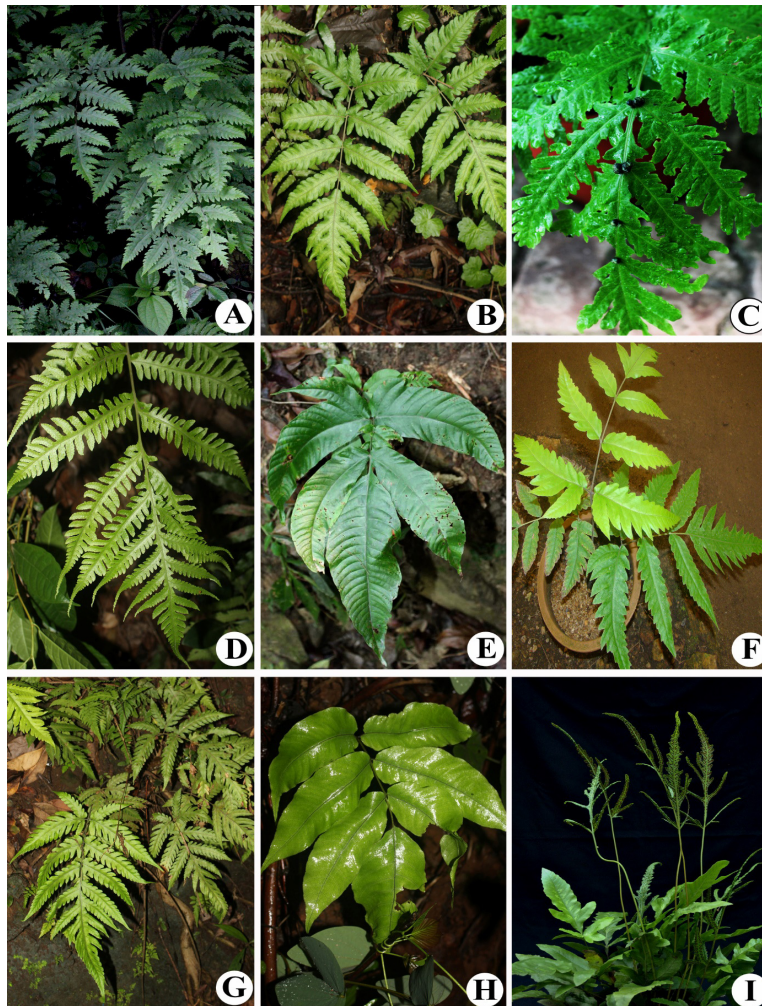


Fig. 1. Habit of different species of *Tectaria* collected from various parts of Peninsular and Western Ghats of India. A: *Tectaria coadunata*, B: *T. fuscipes*, C: *T. gemmifera*, D: *T. paradoxa*, E: *T. polymorpha*, F: *T. puberula*, G: *T. trimenii*, H: *T. wightii* and I: *T. zeylanica*



### Distribution of *Tectaria* species

As far as distribution concerned, the species were found from low altitude to high altitude, high to low moisture content, low to high temperature and along the roadside, earth bank or water current. The species viz., *T. coadunata*, *T. polymorpha* and *T. wightii* are found in both regions whereas *T. fuscipes*, *T. gemmifera*, *T. puberula*, *T. paradoxa*, *T. zeylanica* and *T. trimenii* are restricted to Western Ghats (Fig. 2). Amongst these *T. paradoxa*, *T. trimenii* and *T. wightii* are endemic species to South India and Sri Lanka whereas *T. puberula* and *T. gemmifera* are African species

now naturalized in South India. All the species were growing happily in between 200 m to 1300 m (except *T. coadunata* grows up to 2000 m) and if found above or below the given range the population is very low. Similarly, all the species were alive happily in between 13-25 °C temperature and above 50% atmospheric humidity except *T. coadunata* grows up to 32 °C and survives happily up to 25% atmospheric humidity. Therefore *T. coadunata* is most common and distributed throughout the Western Ghats and Deccan peninsula.

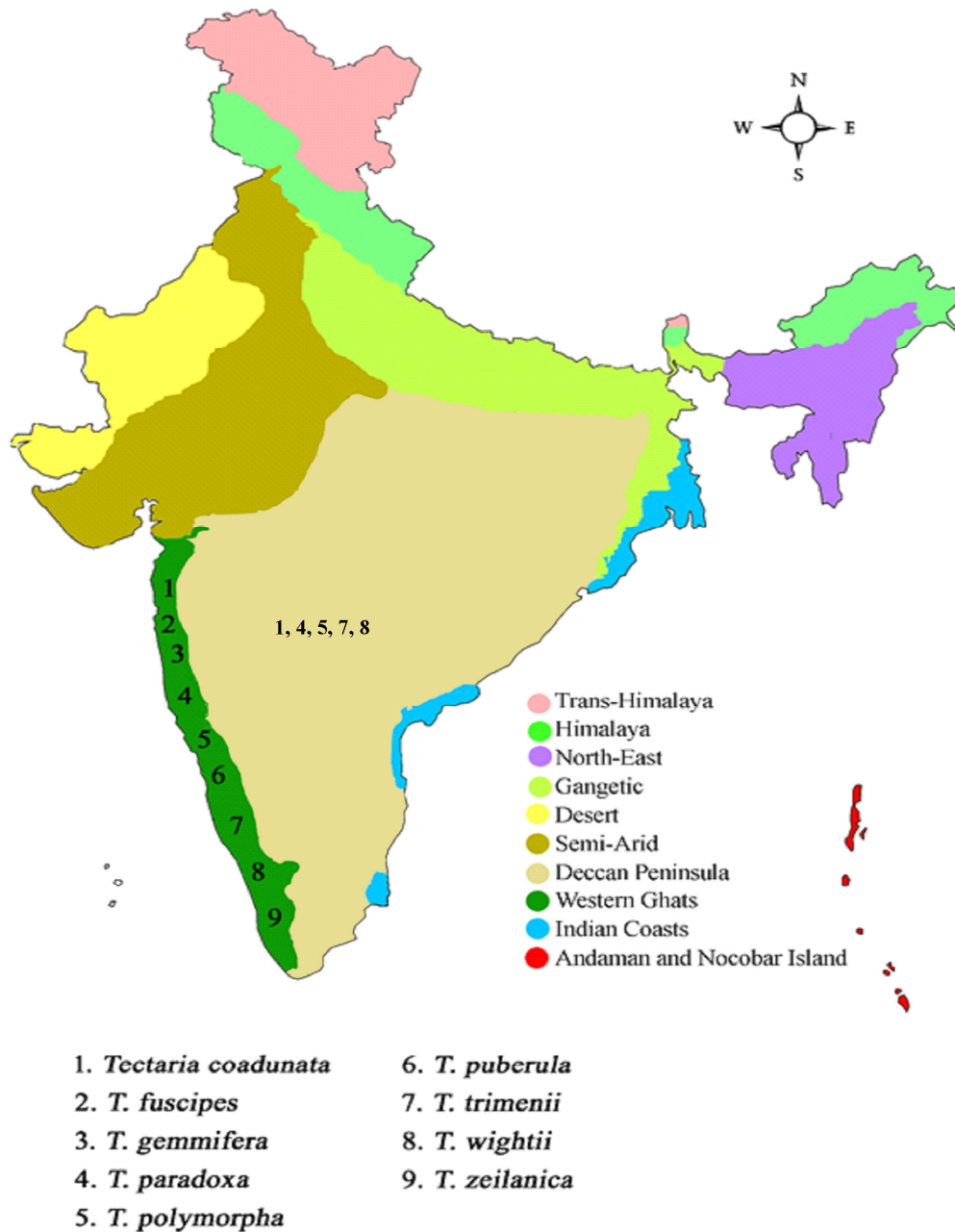


Fig. 2. Diversity and distribution of *Tectaria* species in Western Ghats and Deccan Peninsula

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## Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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