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## RESEARCH ARTICLE

## *Heliotropium rottleri* Lehm. : A lesser known endemic taxa in vulnerable hydrogeomorphic gap areas of Southern Western Ghats, Kerala, India

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### Abstract

*Heliotropium rottleri* Lehm. (Boraginaceae) is a less known endemic taxa recorded from scrub jungles and dry deciduous forests near the gap areas of Southern Western Ghats, Kerala, India. Even though preliminary taxonomic accounts are available, no attempt has been made to assess the distributional range, morpho-anatomical, palynological and ecological features of this endemic taxon. Populations distributed in the vulnerable ephemeral niches determined by specific hydrogeomorphic conditions of rocky plateaus in the gap areas showed morphological variations. The morphometric analysis along with anatomical features including stomatal and trichome traits and pollen features showed less variations except in macro morphology. Leaf trichomes were uniseriate and stomata were anomocytic. The stomatal index varied between 155 to 168 among populations and stomatal density ranged from 15.0-16.6 per square centimetre. The scanning electron microscopic analysis of the pollen grains revealed them to be brevipentacolporate with micro punctate exine ornamentation. As the vulnerable microhabitats where the taxon is being distributed faces serious threats of mining, land conversion and grazing, the species might get disappeared in near future due to the narrow ecological amplitude possessed by the taxon.

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## INTRODUCTION

The genus *Heliotropium* L. belongs to the family Boraginaceae, with about 131 genera (Brummitt, 1992) and 2500 species, majority of them being annual or perennial herbs, shrubs, a few trees and lianas (Mabberley, 1997). *Heliotropium rottleri* Lehm. is a less known endemic taxa recorded from rocky plateaus of scrub jungles and dry deciduous forests near the gap areas of Southern Western Ghats. Taxonomic treatment of this taxon is meagre (Lehmann, 1818; Dalzell and Gibson 1861; Hooker, 1872 - 1897; Gamble, 1915-1936; Chandrabose and Nair, 1986; Sasidharan, 2010) and no attempt has been made to reveal its distributional status, ecological significance, anatomical and palynological traits. Though several studies on morpho-anatomy and palynology of various species of the genus *Heliotropium* has been carried out (Pal, 1963; Abbasi et al., 2011; Alwahibi and Bukhary, 2013; Singh, 1931; Erdtmann, 1966; Sahay, 1973; Semia et al., 2005), studies on this rare endemic species, *Heliotropium rottleri* Lehm. is lacking. There is lacuna in assessing its pharmacognostic properties and phytochemical constituents. Though *Heliotropium rottleri* have been described to be an endemic endangered species in Southern Deccan by Nayar (1996, 1997), further reports on this taxon from Peninsular India is lacking. The species is listed in Catalogue of Life but has not yet been assessed for the IUCN Red List, despite the fact that the species is having very restricted distribution.

It is in this backdrop, the present attempt with emphasis on the morpho-anatomical, palynological and ecological traits of *Heliotropium rottleri* Lehm. has been undertaken.

## 2. Materials and Methods

Populations of *Heliotropium rottleri* were sampled between June 2013 – September 2014 from five different vulnerable hydro-geomorphic rocky ecosystems in the Palakkad gap region of southern Western Ghats with distribution ranging between 10°33'57.6"N - 10°49'59.8"N latitude and 76°14'07.1"E - 76°37'21.1"E longitude. Specimens from different locations were analysed using morphological, anatomical and palynological parameters to find out whether any ecotypic variations existed among the populations. Fresh plant specimens were used for morphometric analysis. Micro morphological studies of stomata as well as trichomes were made from epidermal peeling taken from leaves and stem. Stomatal index and stomatal density were calculated (Metcalf and Chalk, 1979). Pollen grains were subjected to acetolysis (Erdtmann, 1952; Nair, 1960) and acetolysed grains were described (Punt et al, 2007) and photographed using scanning electron microscope (JSM, JOEL SEM) at NIIST, Thiruvananthapuram.

## 3. Results

### 3.1. Distributional range, habitat specificity and ecology

During the monsoon season, the rocky plateaus and hillocks where *Heliotropium rottleri* colonized consisted of a mosaic of floristically different habitats determined by hydro-geomorphic factors. The prevalence of unique microclimate in the sampling locations resulted in the formation of seasonal micro habitats for emergence of different associated herbaceous flora (Figure:1). The growth of the taxa is correlated with slight elevation gradients that provide more mesic habitat than nearby saturated soils. In Chathampara (CP), Kollengode range forests (10°33'57.6"N 76°14'07.1"E), the population of *Heliotropium rottleri* was heteromorphic with medium sized plants measuring up to 25 - 30 cm and profusely branched larger plants measuring upto 40 - 45 cm and was seen associated with *Chamaecrista absus*, *Leucas aspera*, *Lindernia ciliata* and *Biophytum sensitivum*. In the hillock of Vengappara (VP), Kollengode range forests (10°35'27. 3"N 76°34'46.6"E), *Heliotropium rottleri* population consisted of profusely branched larger plants measuring upto 40 - 45 cm and was associated with *Indigofera uniflora*, *Catharanthus pucillus*, *Xenostegia tridentata* and *Cyanotis papilionacea*. In the hillock of Nemmara (NM) (10°35'26.4"N 76°34'46.4") under Alathur range forests, populations exhibited heteromorphy with medium sized plants measuring upto 25-30 cm and smaller sized plants measuring upto 8-12cm. The taxon was seen associated with *Oldenlandia diffusa*, *Polycarpha tomentosa* and *Commelina wightii*. In Kawa (MP), Malampuzha (10°49'11.5"N 76°43'07.1"E) under Olavakkode range, the population showed medium sized plants measuring upto 25-30 cm and was seen associated with *Cyanotis papilionacea* and *Cajanus rugosus*. In Dhoni (DI), Palakkad (10°49'59.8"N 76°37'21.1"E) under Olavakkode range, populations with medium sized plants measuring upto 25-30 cm were observed and associations of *Polygala bulbothrix*, *Polygala arvensis* and *Utricularia lazulina* were observed. Even though the populations from different regions showed slight differences in size and branching patterns, no significant variations could be noticed while analysing micro morphological and anatomical observations. The successive field visits showed a marked reduction in the population of *Heliotropium rottleri* at Vengappara (VP), Kollengode due to the intensive mining prevailing there. In Dhoni (DI) also the species suffered habitat loss to some extent due to mining and habitat modification. The remaining study areas didn't showed any significant reduction in the population.

### 3.2. Status and phenology

The species is endemic to Peninsular India and grows immediately after monsoon between June – September.

### 3.3. Specimens examined

INDIA, Kerala, Palakkad District, Dhoni, 10 June 2013, Maya C Nair, Soumya M, Divya K G, 8001 (ERRCH). Palakkad District, Vengappara 14 July 2013, Soumya M, Divya KG, Suresh V, Sojan Jose, Maya C Nair 8071 (ERRCH). Palakkad District, Malampuzha, Kawa, 7 June 2014, Sandhya V. Kumar 8198 (ERRCH). Palakkad District, Chatamppara, Kollengode, 15 June 2014, Soumya M, Sandhya V 8214 (ERRCH). Nemmara, 29 June 2014, Soumya M 8256 (ERRCH). Chatamppara Kollengode 27 September 2014, Soumya M, Soumya R 8284 (ERRCH). (ERRCH : Herbarium of Environmental Resources Research Centre).

### 3.4. Systematic treatment

Perennial herbs with woody root stock with size ranging from 8 - 45 cm, clothed with white appressed strigose hairs. Branches stout, divaricating, usually spreading from near the root. Leaves alternate, 0.5-1.1 × 0.2-0.5 cm, linear - lanceolate with reflexed margin. Densely clothed with appressed hairs on both sides; abundant

on adaxial side. Petioles very short, less than 0.1cm. Flowers 0.5 cm in short axillary and terminal bracteate 1.5 - 3 cm long spikes. Bracts conspicuous, foliaceous, lanceolate, scattered along the rachis. Calyx 5 lobed, green 0.4 cm long, hairy on both sides; sepals slightly unequal, lanceolate. Corolla 0.4 cm long; white with yellowish centre, tube cylindrical, hairy outside, glabrous inside; hairy towards throat, lobes small, spreading in flower. Stamens 0.1cm inserted below the middle of the corolla tube. Filaments very short less than 0.1cm. Anthers yellow, lanceolate, at first jointed at their apex to form a small globule, afterwards separating, each anther taking away a part of the globule as a small disc at its tip. Gynoecium 0.15cm, stigma apex bluntly conical. The stigmatic ring large and prominent. Ovary ovoid. Fruit 0.15cm sub-globose, pubescent, separating into 4 nut lets with a much rounded back. Seeds 0.01cm, brown and sparsely hirsute (Figure 2: A-J).

### 3.6. Related taxa

*H. rottleri* shows similarity with *H. marifolium* with respect to the presence of conspicuous bracts and appressed hairs. In *H. rottleri* branches are decumbent, leaf margin reflexed, corolla tubular/cylindrical and fruit sub globose in shape while in *H. marifolium* branches are procumbent, leaf margin flat, corolla salver shaped and fruit globose in shape.

### 3.7. Anatomy

Epidermis (e) of the stem consisted of single layered rectangular parenchymatous cells covered by thick cuticle and beared uniseriate trichomes. Epidermis was followed by one layered collenchymatous (c) hypodermis and cortex with four layers of loosely arranged parenchymatous (p) cells. Endodermis was not distinct. Alternating patches of sclerenchymatous (s) tissues and patches of thin walled cells could be observed above the vascular bundles. A large number of vascular bundles which were conjoint, collateral and open were arranged in a ring. Primary xylem (xy) could be seen in young stem. Central pith (pt) consisted of large thin walled parenchymatous cells with intercellular spaces. Periderm (pd) and secondary xylem (sxy) could be observed in mature stem (Figure: 3 A-D).

Transverse section of mature root showed secondary growth with periderm (pd) and a parenchymatous cortex with 8-12 layers. Below the cork tissue secondary xylem (sxy) could be observed (Figure: 3 E, F).

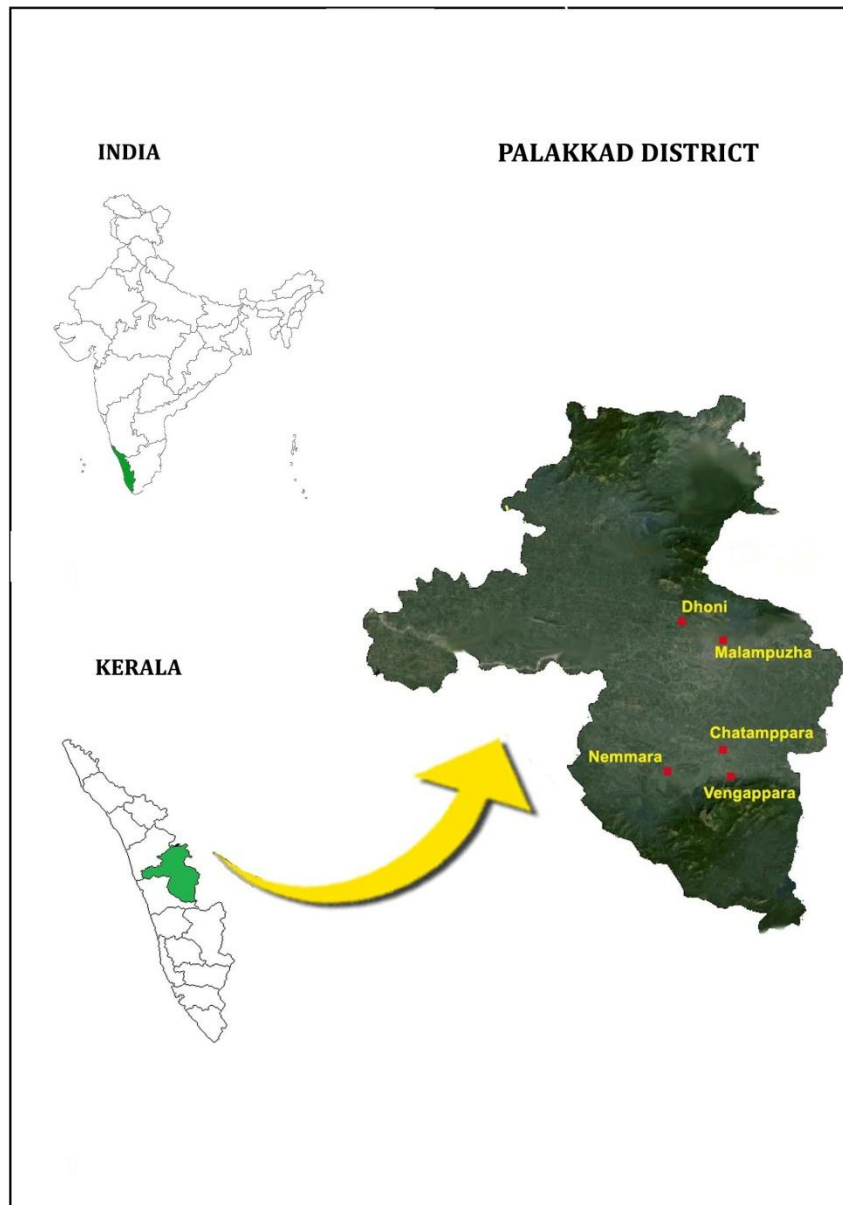
Margin of the leaf was seen reflexed in transverse section. The upper as well as lower epidermal layers were made of compactly arranged parenchymatous cells and both sides have unicellular trichomes. The mesophyll was differentiated into single layered palisade and spongy parenchyma cells. A single central vascular strand was observed in mid rib region (Figure: 4 A).

#### 3.7.1. Trichome and stomatal traits

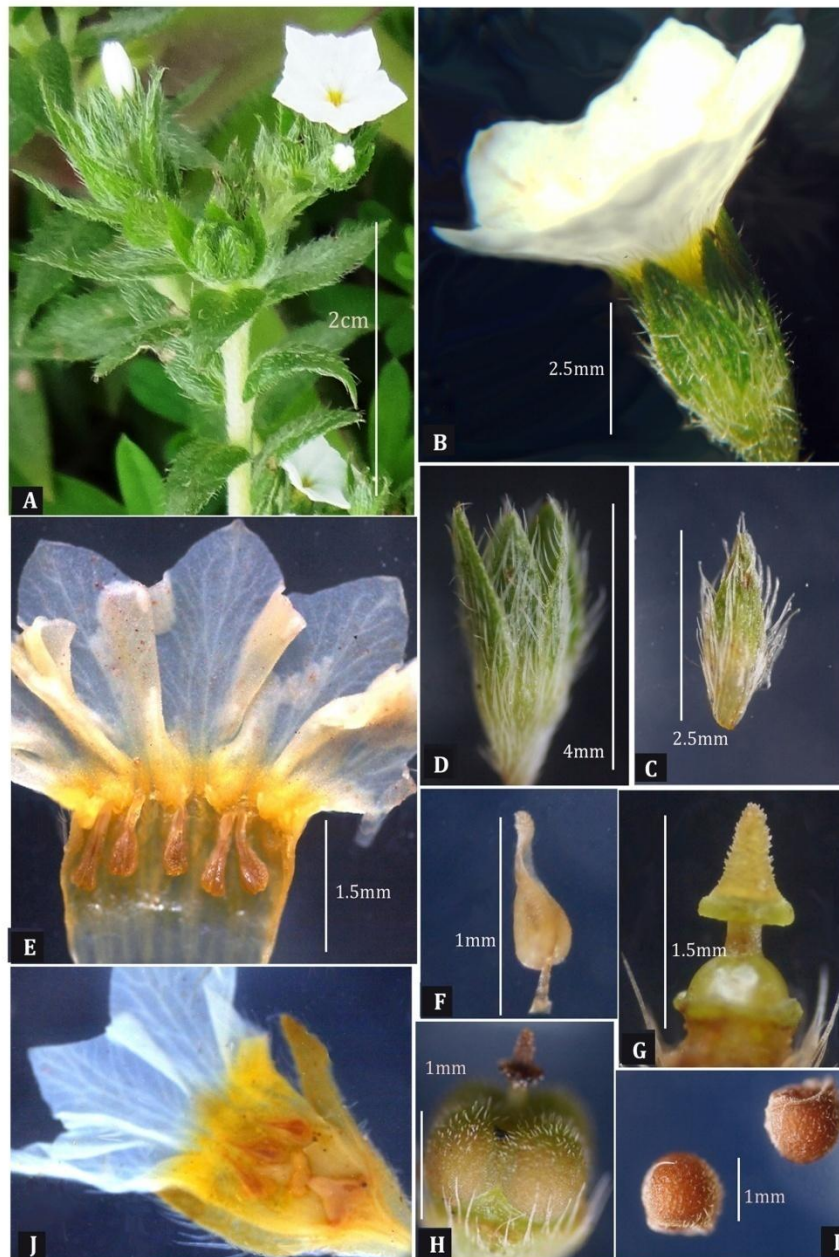
Unicellular trichomes of size ranging from 15 – 85  $\mu\text{m}$  length and 5 – 6  $\mu\text{m}$  width was present in stem as well as leaves. Bulbous bases of each uniseriate trichome were surrounded by 5 – 8 epidermal cells. Stomata were distributed on adaxial as well as abaxial surfaces. Stoma was of anomocytic type, each surrounded by 3 - 5 subsidiary cells which were indistinguishable from other epidermal cells. Stomatal index was found to range between 155 -168. Stomatal density ranged from 15.0 - 16.6 per square centimetre (Figure: 4 B-D)

### 3.8. Pollen morphology

Pollen grains were monads, isomorphic and circular. The shape of the pollen was prolate spheroidal ( $P/E \times 100 = 108$ ), with the polar diameter (P) 34 – 40 $\mu\text{m}$  and the equatorial diameter (E) 31-37 $\mu\text{m}$ . The grains were brevipentacolporate with five colpi having prominent operculum alternating with five pseudocolpi. Pseudocolpium in the mesocolpium region was marked by horizontal ridges and elongated depressions. The colpus margin was crustate. The exine ornamentation was micropunctate (Figure: 5 A, B)



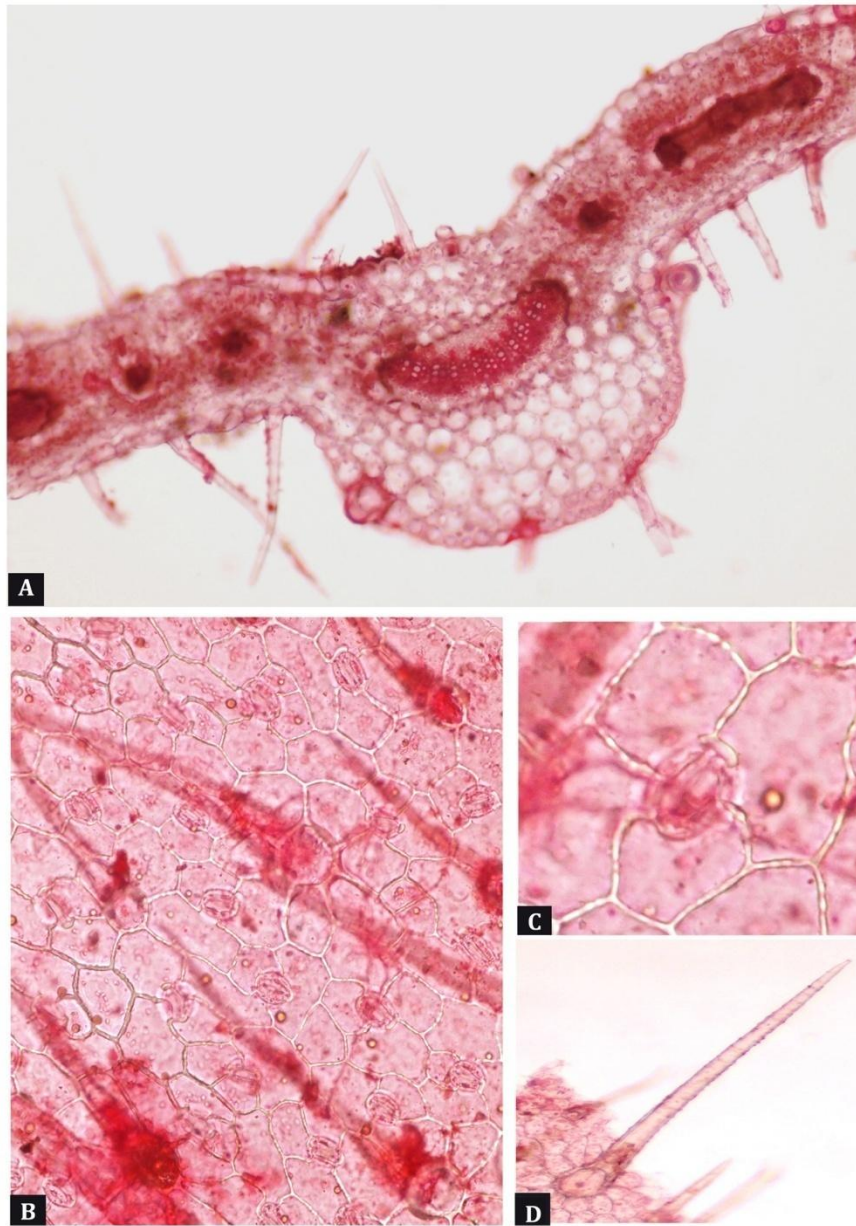
**Figure 1:** Distribution map showing sampling locations of *Heliotropium rotleri* Lehm.



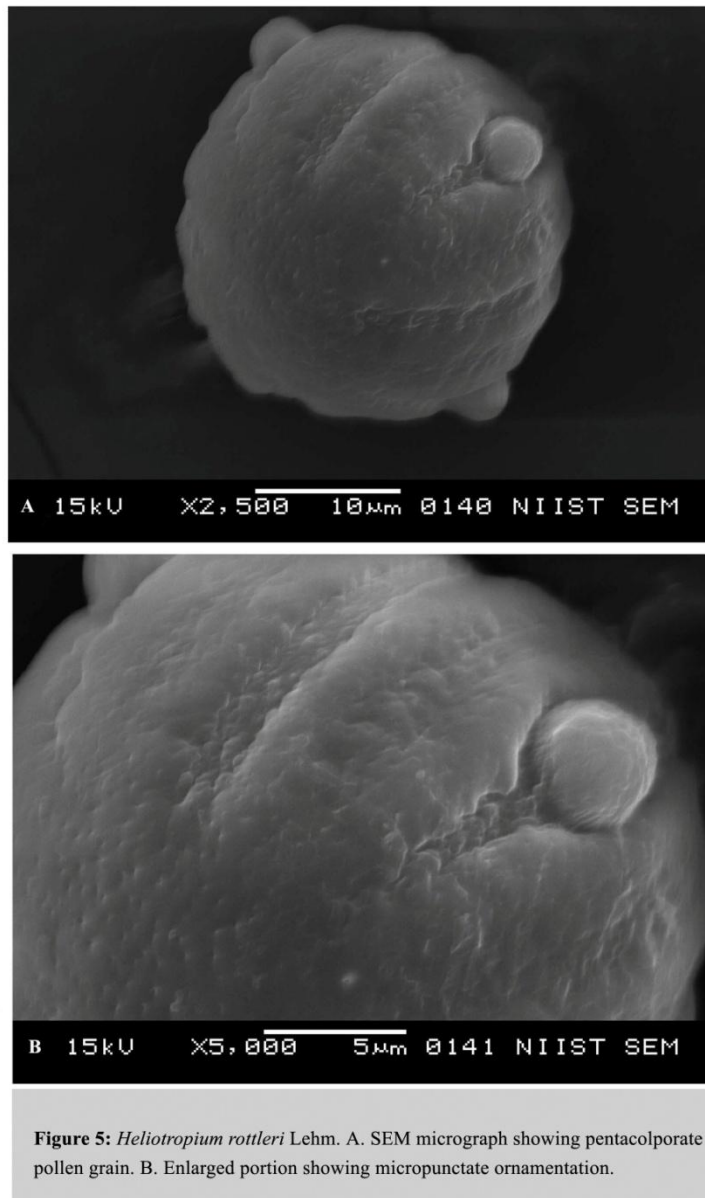
**Figure 2:** *Heliotropium rotleri* Lehm. A. Flowering twig; B. Single flower; C. Bract; D. Calyx; E. Corolla tube opened; F. Stamen; G. Gynoecium; H. Fruit; I. Seed; J. Flower LS.



**Figure 3:** *Heliotropium rotterli* Lehm. A. Young stem TS; B. A portion enlarged; C. Mature stem TS showing secondary growth; D. A portion enlarged; E. Root TS showing secondary growth; F. A portion enlarged.



**Figure 4:** *Heliotropium rotleri* Lehm. A. TS of leaf; B. Epidermal peeling distribution of trichomes and stomata; C. Stomata enlarged view; D. Trichome with basal cells.



#### 4. Discussion and conclusion

*Heliotropium rottleri* Lehm., inhabit small hillock areas and rocky plateaus that critically depend on monsoonal hydrologic regimes and the correlated edaphic conditions. The associated taxa in different sampling locations in the narrow geographical range showed that these areas differ from surrounding system in both microclimatic and floristic compositions. *Heliotropium marifolium* Retz., the closely related taxa show a wider range of distribution from Peninsular India to Sri Lanka and has been recorded from almost all districts of the state of Kerala (Sasidharan, 2010). But the morphometric analysis revealed that the population of *H. rottleri*, which share a narrow range of distribution at the gap areas has undergone lesser diversification with more or less similar features

that has been evolved at similar eco climatic regimes prevailed in the ecosystem. Hence any hindrances in the habitats by way of climate change and anthropogenic interferences will cause extinction of this endemic taxon.

Critical evaluation of anatomical and pollen traits also showed unique features for this taxon in comparison with other species of the genus *Heliotropium*. The upper and lower surface of leaf consisted of single layered palisade parenchyma in *H. rotleri* a feature similar to the condition in Iranian taxa *H. brevilimb*, *H. ellipticum* and *H. lasiocarpum* (Abbasi et al., 2011). Large intercellular spaces are absent among the spongy parenchyma in *H. rotleri* in contrast to the observations in the four species viz. *H. indicum*, *H. curassavicum*, *H. peruvianum* and *H. ovalifolium*, while the anomocytic stomata is a shared trait among these species (Pal, 1963). Leaf trichomes were with unicellular base in *H. rotleri* compared to multicellular base in *H. peruvianum* and *H. indicum* (Pal, 1963).

The pollen morphology of different species of *Heliotropium* has been undertaken by many authors (Fritzsche, 1834; Singh, 1931; Sahay, 1973). Dimorphic grains are reported in the three species: *H. supinum*, *H. noeanum* and *H. suaveolens*, while all other recorded taxa of *Heliotropium* are isomorphic (Sahay, 1973). Tricolpate grains with pseudocolpi have already been recorded in many species viz. *H. europeum* (Semia et al, 2005) and also in 12 other species viz., *H. arbainense*, *H. curassavicum*, *H. digynum*, *H. eichwaldi*, *H. indicum*, *H. myosotoides*, *H. noeanum*, *H. ovalifolium*, *H. stezogosund*, *H. suaveolens*, *H. subulatum*, *H. supinum* and *H. zeylanicum* while in *H. indicum* the grains are tricolporate (Sahay, 1973). Scheel et al., (1996) recorded heterocolpate grains with psilate ornamentation in six species of *Heliotropium*. The present study showed that in contrast to all other recorded taxa of *Heliotropium*, the pollen of *H. rotleri* possess brevipentacolporate grain with alternating pseudocolpi and micropunctate exine ornamentation. This is an indication that the taxon has developed unique genetic traits to thrive the narrow ecological regime and may be the reason for its narrow range of distribution and constricted ecological amplitude.

The anthropogenic interferences by way of mining and habitat modification has resulted in the marked reduction in *Heliotropium rotleri* populations and associated plants in the sampling sites. Distribution of taxa and their community composition may change as a corollary of climate change and many ecologically important but lesser known taxa like *Heliotropium rotleri*, which depend on critical amounts and timing of moisture in vulnerable precarious habitats needs careful focus in the long term conservation of biodiversity.

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