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Cover: Life and death in one night - wolf hunting the hare. Mixed media—gouache, acrylics, pen & colour pencils. © Dupati Poojitha.



Pinnatella limbata (Bryophyta: Neckeraceae): reassessment of conservation status based on recent findings

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Abstract: *Pinnatella limbata* Dixon (Neckeraceae), a rheophytic moss species with a bistratose leaf margin unique in the genus was reported from Sampkhand in Kanara district of Karnataka State in India. The species was subsequently collected from two additional localities of Kodagu (Coorg) District in Karnataka State and that *P. limbata* should be removed from the threatened category of the IUCN World Red List of bryophytes due to the new information of its distribution range. The present collection from Aralam Wildlife Sanctuary, in the Kannur District of Kerala is a range extension of this species in the Western Ghats and the first report from Kerala. An attempt is made to reassess the IUCN Red List status of *P. limbata*.

Keywords: Aralam Wildlife Sanctuary, IUCN Red List, Kannur District, Karnataka, Kerala, mosses, new record, taxonomy, Vulnerable, Western Ghats.

A world monograph of *Pinnatella* by Enroth (1994) gives a thorough and insightful re-examination, clarifying all the taxonomic complexities that existed in the genus and recognized 15 species. Recently, Manju et al. (2023) added a new species *P. enrothiana* Manju,

J. Muñoz, Sruthi, Mufeed & K.P. Rajesh, from the Western Ghats of India to the list. Among the *Pinnatella* species *P. minuta* (Mitt.) Broth. is the only representative in the Neotropics and continental Africa. The greater diversity for *Pinnatella* lies in southern and southeastern Asia (Enroth 1994).

During a field survey in the deep forest of the Aralam Wildlife Sanctuary in the Kannur District of the Peninsular Indian state of Kerala, an intriguing moss species was discovered. It was found attached to a large rock surface in a streamside and hanging down like a loose green curtain covering the entire rock surface. Through careful examination and detailed study, the species was identified as *P. limbata* of the family Neckeraceae. *P. limbata* can be distinguished from other *Pinnatella* species by its bistratose leaf margin which is a unique feature of the species. It was first described by Dixon (1921) from the Kanara district of Karnataka State based

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on the collection by Mr. L.J. Sedgwick during 1919. Later, Raghavan in 1960 collected the species from Agumbe of Karnataka and observed that it is a fairly common species on moist rocks in association with *Papillaria fuscescens* (Hook.) A.Jaeger (Raghavan & Wadhwa 1968). Subsequently, Schwarz (2013) based on the collections of Frahm, Schwarz, & Schumm in 2012 reported it from other two localities of Karnataka. The present collection proved to be the first report of the species from the state of Kerala and it implies a range extension of the species in the Western Ghats. The present collection showed variability in the stem length and texture of the plant as compared to previous reports. Usually, it has a shorter stem, maximum up to 15 cm. Here relatively larger species were found, reaching twice the length of those

reported earlier.

Pinnatella limbata was assessed as a 'Critically Endangered' species in the IUCN World Red List of bryophytes (id 39178; Bryophyte Specialist Group, 2000; <https://www.iucnredlist.org/species/39178/10167017>). Schwarz (2013) based on the new information gathered on its distribution suggested that *P. limbata* should be removed from the threat category of the IUCN Red List of bryophytes. The present collection from Kerala is a record of its further range extension in the Western Ghats. The IUCN Red List status of *P. limbata* Dixon is further reassessed here (Images 1,2).

MATERIALS AND METHODS

The present collection was made from the Aralam

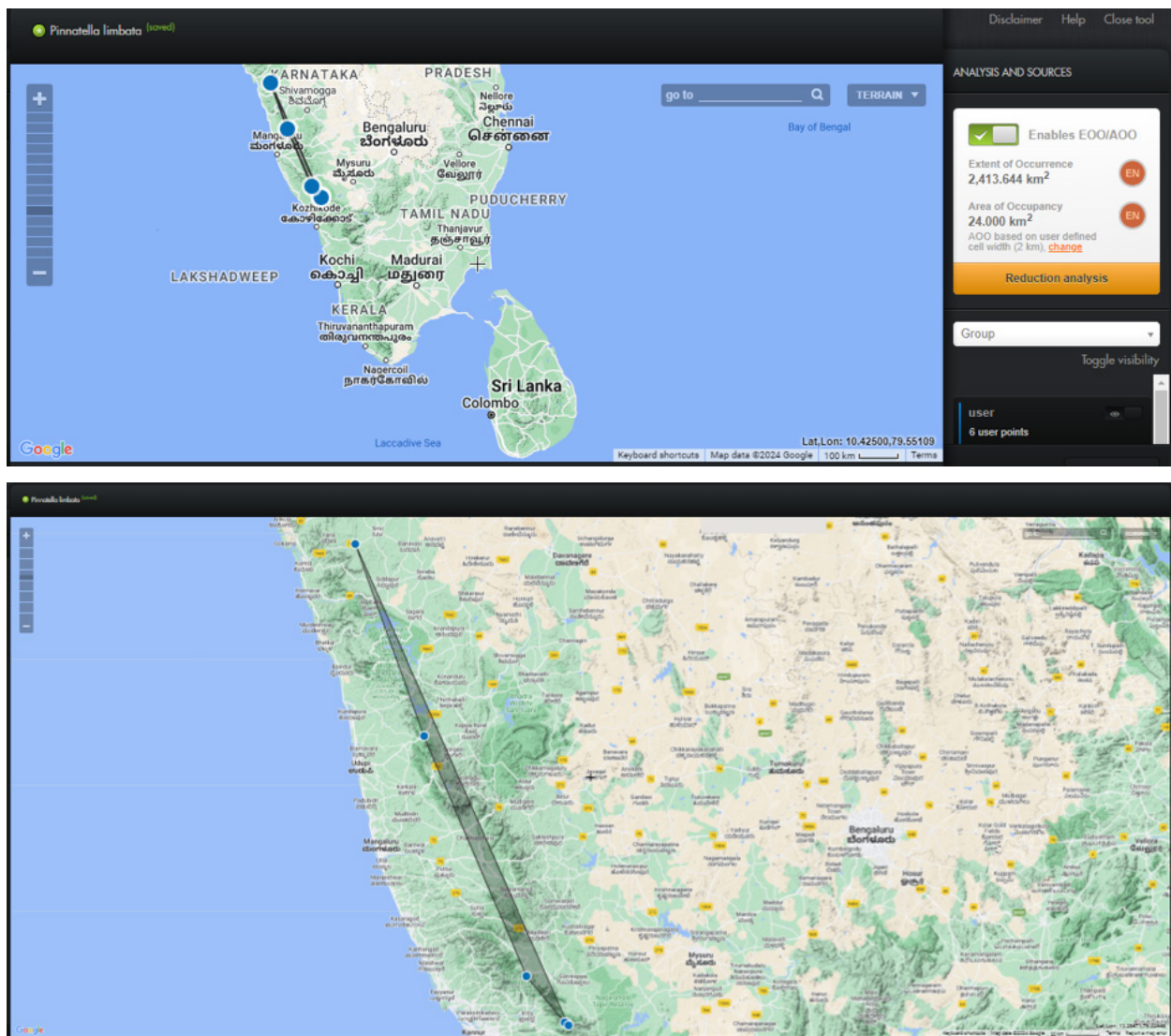


Image 1. Distribution and assessment of extent of occurrence and area of occupancy of *Pinnatella limbata* Dixon. (<https://geocat.iucnredlist.org/editor>).

Wildlife Sanctuary, a protected evergreen forest in the Western Ghats of Kannur District in Kerala in peninsular India. The collections were made in two different seasons from different localities. A combination of microscopes was used to study the characteristics of the specimen, a Leica Sapo Stereo Microscope was used for morphological observations, and an Olympus CX21liLED microscope for anatomical examinations. Magnus Analytics MagVision software (version: x64, 4.8.15674.20191008) was used to measure the plant parts and cells. An updated description of the species was prepared based on the present collections. The collected specimens were processed and the herbarium packets of standard size are deposited in the Calicut University Herbarium (CALI) and Central National Herbarium (CAL).

The distribution data of this species has been tabulated based on previous records as well as the present observations. The area of occupancy (AOO) and extent of occurrence (EOO) were assessed using GeoCat (Bachman et al. 2011; <https://geocat.iucnredlist.org/editor>). The threat status was assessed according to the IUCN Red List criteria (Version 3.1).

RESULTS

Taxonomic treatment

Pinnatella limbata Dixon, J. Indian Bot. 2: 184. 1921. – Type: India, Karnataka, Leonard John Sedgwick, #6437 1919 (BM).

Plants gregarious, pendent, up to 30 cm long, irregularly pinnately branched, older parts dark green to brownish green, younger parts and branches pale green, flagelliform branches present; stolons in cross-section oval-round, cortical cells small, in 2–3 layers, thick-walled, inner medullary cells in several layers, comparatively larger, thin-walled. Stolon leaves small, closely appressed, loosely imbricate, 0.7–0.9 x 0.4–0.5 mm, triangular in shape, gradually ending to an acute tip, margin serrulate except at extreme base; costa reaching above half of the leaf. Stipe short, 1–2 cm long, 0.4 mm diameter in cross-section, with 6–9 layers of cortical cells surrounding several layers of rounded to hexagonal medullary cells, central strand absent; stem pale yellow, up to 27 cm long, with 6–7 layers of small, thick-walled cortical cells in cross-section, medullary cells thin-walled, larger than cortical cells, rounded to hexagonal, central strand absent. Stem leaves comparatively larger than stolon leaf, ovate-lanceolate, 1.7–2.3 x 0.9–1.2 mm, loosely imbricate, twisted when dry, nearly symmetrical, leaf apex sub-acute–obtuse, sometimes mucronate, margin entire below, serrulate at apex, leaf cross-section adaxially flat, abaxially convex,

bistratose margin ends near extreme tip, leaf tip cells rhomboidal, 8–14 x 3–7 µm, median laminal cells slightly elongated than tip cells, 11–27 x 3–5 µm, basal cells elongated vermicular, 19–50 x 3–6 µm, extreme basal juxta costal cells porose; costa ending below apex. Stem leaf base wider than branch leaf, 1.7–2.1 x 0.8–0.9 µm, leaf apex obtuse, sometimes mucronate, margin entire below, serrulate apex, bistratose margin vanishing near tip. Cells at leaf tip rhomboidal, 8–13 x 3–8 µm, median laminal cells slightly elongated than apex cells, 13–27 x 2–4 µm, basal cells elongated vermicular, 25–46 x 3–4 µm, extreme basal cells porose near the costa. Sporophyte not observed (Image 3).

Specimens examined: India, Kerala, Kannur District, Aralam Wildlife Sanctuary, Meenmutty waterfalls (400 m), 11.947N, 75.882E, on a large rock near stream, 28 September 2022, Sruthi O.M. 14898 (CALI); Chavachi waterfalls (280 m), 11.929N, 75.901E, on a large rock surface near stream, 11 January 2023, Sruthi O.M. 14262 (CALI); Meenmutty thodu (664 m), 11.950N, 75.890E, on a rock near streamside, 12 January 2023, Sruthi O.M. 14303 (CALI).

Distribution: Karnataka, Kanara District, Sampkhand (Dixon 1921; Enroth 1994), Shimoga District, Agumbe (Raghavan & Wadhwa 1968); Kodagu (Coorg) District, Kabbinakad, the area around Kabbe Holiday Homestay and the area around Honey Valley Homestay (Schwarz 2013); Kerala (present study).

Habitat: This species grows as a mat or curtain on moist large rocks near stream sides which is not inundated by overflowing waterfalls but is always wet due to the flow of water. The type specimen was also reported from a similar habitat.

IUCN Red List reassessment: *Pinnatella limbata* is known only from a small area in the Brahmagiri region of the Western Ghats, with an EOO of 2,413.644 km² and an AOO of about 24 km². As per the major criteria (B1 and B2) of the IUCN Red List (ver. 3.1) it thus qualifies for consideration as Endangered (EN). It also meets sub-criteria B1a and B2a, as it is known from less than 10 locations. Since the area is protected and located in interior forest there are no other direct threats to the species. Observations on other sub-criteria such as trends of population decline are not available at present. Although restricted in EOO and AOO, it does not qualify for Endangered (EN) due to more than five locations that are not severely fragmented. However, it does not qualify for Vulnerable (VU) either due to no known threats which are impacting the area, extent, quality, locations, or mature individuals. The species is categorized as Near Threatened as it misses the criteria



Image 2. Locations of *Pinnatella limbata* Dixon in the Western Ghats of India.

for VU narrowly.

DISCUSSION

In the genus *Pinnatella*, *P. limbata* is unique in having the bistratose leaf margin. The species is known to grow on moist rocks in the streams and streamlets of evergreen forests in a small area in the Brahmagiri region of the Western Ghats of Karnataka and Kerala. The bistratose margins may be an adaptation for the rheophytic

habitat, as it makes the leaves stronger (Enroth 1999). Thulasi *et al.* (2024) based on Ecological Niche Modelling (ENM) analysis of *Elaphoglossum beddomei*, a Southern Indian endemic fern, predicted sharp decline of evergreen habitats in the Western Ghats of India. This trend of loss of quality of habitats will also affect other Southern Indian endemics, especially those adapted to the moist habitats. *P. limbata* was assessed as Critically Endangered (Bryophyte Specialist Group 2000), as it was

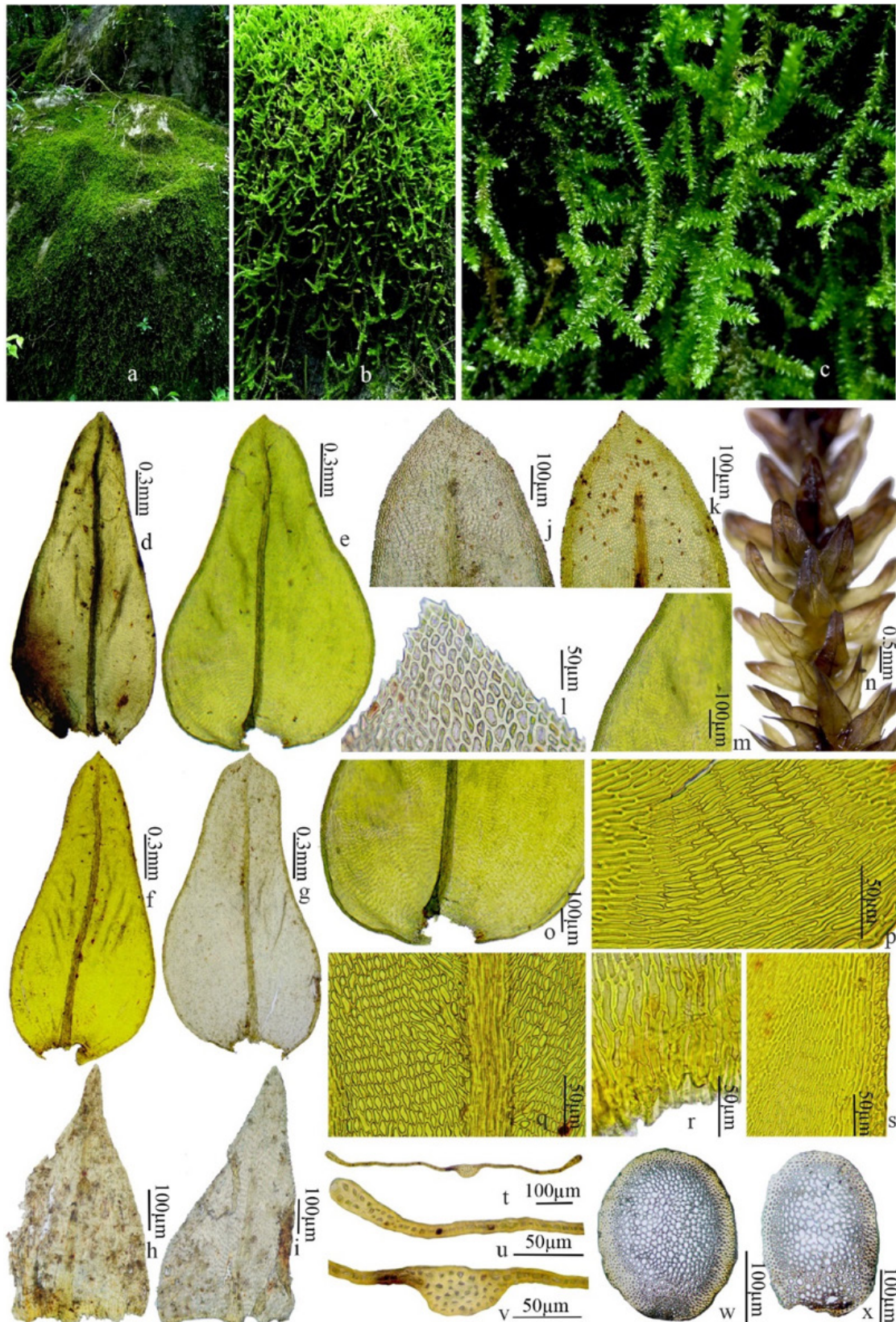


Image 3. *Pinnatella limbata* Dixon: a–c—habit | d,e—stem leaves | f,g—branch leaves | h—stolon leaf | i—stipe leaf | j—leaf tip of stem leaf | k—leaf tip of branch leaf | l—leaf tip cells | m—margin of stem leaf | n—a portion of primary stem showing leaf arrangement | o—stem leaf base | p—laminal cells of stem leaves | q—cells near costa | r—basal porose cells | s—bistratose leaf margin | t–v—cross section of leaf | w—cross-section of primary stem | x—cross-section of stolon. © O.M. Sruthi.

known only from the type collection from the Western Ghats of Karnataka. In the present re-assessment, based on updated distribution data from Karnataka (Dixon 1921; Raghavan & Wadhwa 1968; Schwarz 2013) and Kerala (present observations) the current status of the species has been categorized as Near Threatened due to its no known threats which are impacting the area, extent, quality, locations, or mature individuals.

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