

Research Article

**OBSERVATIONS ON *FISSIDENS CEYLONENSIS* DOZY & MOLK.
(FISSIDENTACEAE, BRYOPHYTA) GROWING AS CAVE MOSS AT
CHITRAKOOT IN CENTRAL INDIA**

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ABSTRACT

The specimens of *Fissidens ceylonensis* Dozy & Molk., collected from Gupt-Godavari cave in Chitrakoot in Central India exhibited some variations which made us think to treat the population as an 'ecad' of the species. The high degree of humidity inside the water-filled cave along with the paucity of light is likely to cause most of these variations. The distinguishing features of this 'ecad' includes (i) the presence of the slightly to deeply curvaceous costa which is always percurrent in the leaves; (ii) one, or occasionally two layered incomplete limbidium, which is never submarginal; (iii) a distinct larger apical cell in the acute leaf apex; (iv) a central zone of highly thin-walled medullary cells surrounded by thick-walled 2-3 layered cortical cells; and (v) the lithophytes traits like the presence of numerous brown-red coloured rhizoids arising along the stem and the sheared leaves which are frequently partly or fully hyaline. The ecological adaptations of this cave moss are also discussed.

Keywords: *Fissidens Ceylonensis*; Cave Moss; Environment; Chitrakoot; Central India

INTRODUCTION

During a plant collection-cum-study tour of undergraduate students on 22nd October 2012 to Chitrakoot Dham, an important religious place of Hindus located in Central India (Figure 1A), we came across some fascinating patches of a moss growing inside the Gupt-Godavari caves located somewhat eighteen km away from the Dham. The Gupt-Godavari caves (25° 6' N; 80° 45' E; Alt. 207 m) are, in fact, a pair of limestone-make caves in the main Chitrakoot Dham in Vindhya Range formations. Out of the two caves, one is high and wide with an entrance through which one can barely pass; while the other is much longer and narrower with a water stream running along its base and is artificially lighted for visitors and tourists. The ankle to knee-deep water maintains a high degree of humidity in this cave throughout the year (Figure 2). It was inside this cave that we noted the lax population of the moss which was interestingly growing closely appressed to the rock surface in patches. An examination of the specimen in the field exhibited it to be the moss genus, *Fissidens* Hedw.

A perusal of literature on Indian *Fissidens* (Norkett, 1969; Gangulee, 1971; Ellis, 1992; Nath *et al.*, 2011) revealed the nearest species with which the present specimens came close was *Fissidens ceylonensis* Dozy & Molk. a Southeast Asian species which is found across the different states in India (Gangulee, 1971; Dandotiya *et al.*, 2007; Ellis, 1992; Lal, 2005, 2007; Madhusoodnan *et al.*, 2007; Manju *et al.*, 2008; Nath *et al.*, 2005, 2011). However, a closure examination of the Chitrakoot specimens showed some noticeable differences from that of the typical *F. ceylonensis* Dozy & Molk. and its two existing varieties, namely, var. *simplex* (C. Muell.) Norkett (Gangulee, 1971) and var. *acutifolius* Dix. & P. Varde (Ellis, 1992). These variations include (i) the frequent occurrence of curvaceous costa which invariably falls short of reaching the tip; (ii) the 1-2 layered limbidium, the outer layer being complete and the inner layer remaining incomplete, and never submarginal; (iii) a distinctly large apical cell in the acute apex of the leaf; (iv) in cross section of the stem, a central zone of highly thin-walled medulla surrounded by thick-walled 2-3 layered cortical cells; and (v) the lithophytes traits like the presence of numerous brown-red coloured rhizoids arising along the stem and sheared leaves which are frequently partly or fully hyaline. However, looking at these traits and considering the wider range of adaptability of the species, these variations were thought of being broadly environmental in nature.

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The Chitrakoot ecad of *Fissidens ceylonensis* Dozy & Molk. is described as under.

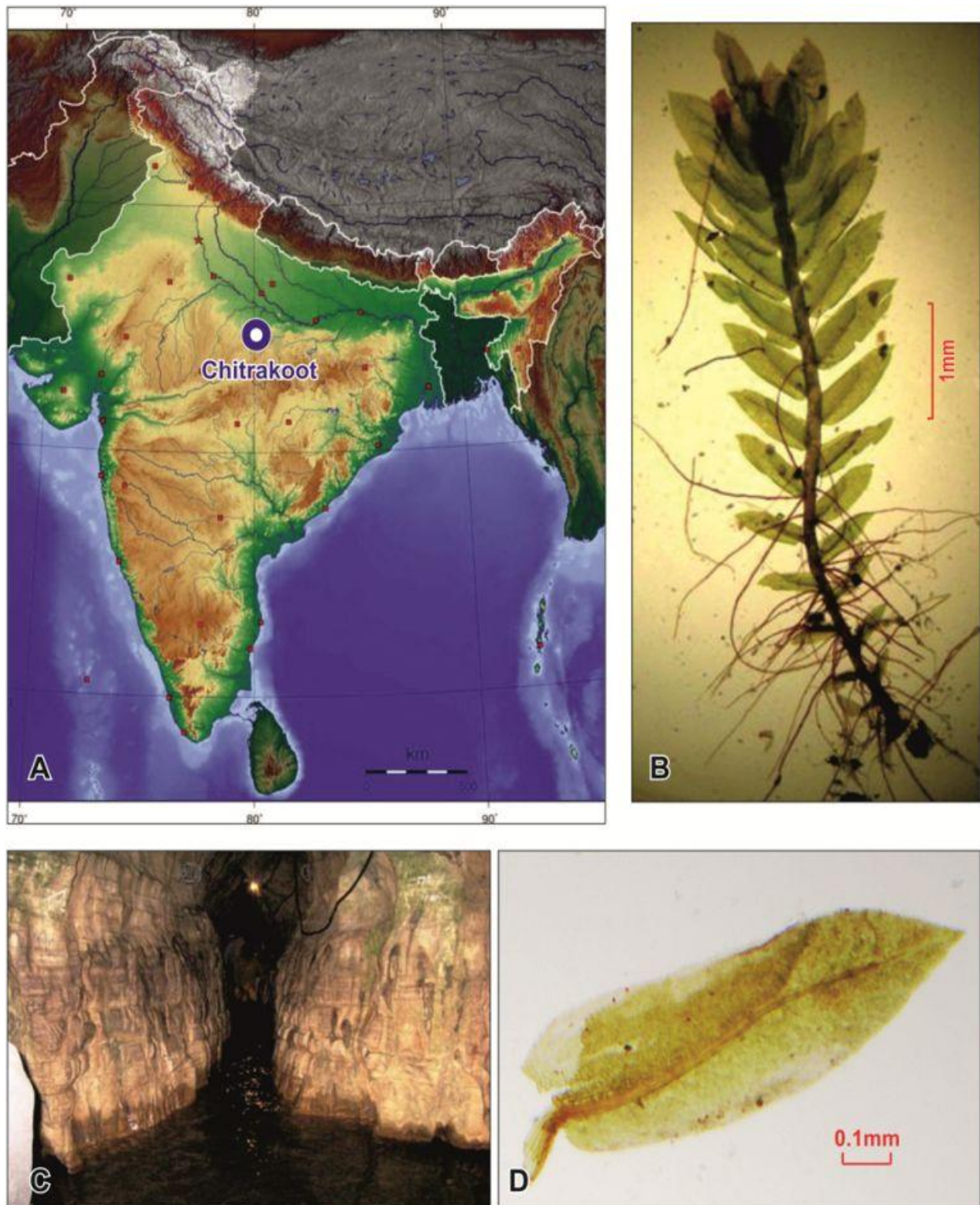


Plate 1: A. Map of India showing the place of collection, Chitrakoot; B. *Fissidens ceylonensis* Dozy & Molk. Chitrakoot ecad, the plant; C. The actual site of collection, Gupt-Godavari cave; and D. A leaf

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MATERIALS AND METHODS

The morphological studies of fresh specimens were made using Motic BA 210 Digital microscope. The slides of various parts of the plant including hand sections were mounted in glycerine jelly. The field photographs were taken by Olympus camera. All the specimens are deposited in Duthie Herbarium, Botany Department; University of Allahabad.

Description

Plants terrestrial, growing as lithophytes, closely adhered to rock surface, yellowish green, small, in tuft, 3.0-5.5 mm long and 1.0 - 1.5 mm wide with leaves, having 12 to 16 pairs of leaves, gradually increasing in size from base towards the stem apex. Stem prostrate, dark brown, up to nearly one-third from the base and pale green in the remaining two-third, unbranched; in cross section 4-8 celled across, all cells with chloroplasts, cell walls brown, differentiated into outer cortical cells, the inner cortical cells and a central medullary conducting zone; the outer cortical cells 1 - 2 layered, 2 x 4 to 4 x 7 μ m and highly thick-walled, surrounding the comparatively less thick-walled, 1 layered, large inner cortical cells, 11 x 14 μ m, which in turn surround the thin walled central medullary cells. Rhizoides numerous; tough, dark brown, well-branched, developing singly or in groups along the stem from the base up to one-third region of the stem or more.

Leaves oblong-lingulate, 0.85 mm long and 0.32 mm wide, yellowish green, often partly or completely colourless, more commonly sheared, never curled when dry, mostly equally broad from base till three-fourth of their length; Dorsal lamina base narrower and rounded and vanishing at the point of attachment with stem; Costa brownish near the base becoming pale-green above, ending 2-3 cells below the apex, percurrent, often showing a curvature where it leaves the sheathing lamina, deeply curvaceous twice or once before reaching the tip; Sheathing lamina somewhat unequal (open), 0.55 mm long and 0.15 mm wide, pellucid B/L = \pm 30/100 and S/L = \pm 70/100; Limbidium confined to 1 or occasionally 2 layers, starting from the base, never submarginal; leaf margin crenulate due to projected marginal cells; leaf tip acuminate, the apical cell being prominent and pronounced, 18 x 7 μ m; leaf cells nearly uniform throughout the lamina ranging between 7-9 x 4 μ m, quadrate to somewhat hexagonal, multi-papillate, papillae rather indistinct, punctate and weak. Sporophytes not seen.

Ecology and Distribution

The species grows in pure stands on rocks inside the cave, which is rich in humidity throughout the year. The water temperature here ranges between 22⁰ and 26.5⁰C. Studies on the chemical analysis of the cave rock samples reveal that it has maximum concentrations of Calcium Oxide (CaO) and Magnesium Oxide (MgO); and an alkaline pH as 8.30 (Prasad, 2008). The plants were collected from the rock surface having a very thin layer of soil under diffused light conditions.

Specimens Examined

CIMPS 2005M/12 & CIMPS 2006M/12, inside Gupta Godavari cave, Chitrakoot, District Satna, Madhya Pradesh, Central India, 22 December 2012; leg. Dhiraj Pandey, Meena Rai & S.N. Srivastava; Deposited in Duthi herbarium, Department of Botany, University of Allahabad, Allahabad.

Type: Ceylon (Now, Sri Lanka) Nepal, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, Papua New Guinea, New Zealand, Australia and India.

In India, the species is known from different regions across the country including Western and Eastern Himalaya, Central India, Gangetic Plains and South India.

Discussion and Conclusion

Instituted by Frans Dozy & J.H. Molkenboer in 1844 from the 'type' locality, Ceylon (now, Sri Lanka), *Fissidens ceylonensis* (Section: Semilimbidium C. Muell.) is largely a South-East Asian species recorded from Nepal, Indonesia, Malaysia, Phillipines, Singapore, Thailand, Vietnam, Papua New Guinea, New Zealand, Australia and India.

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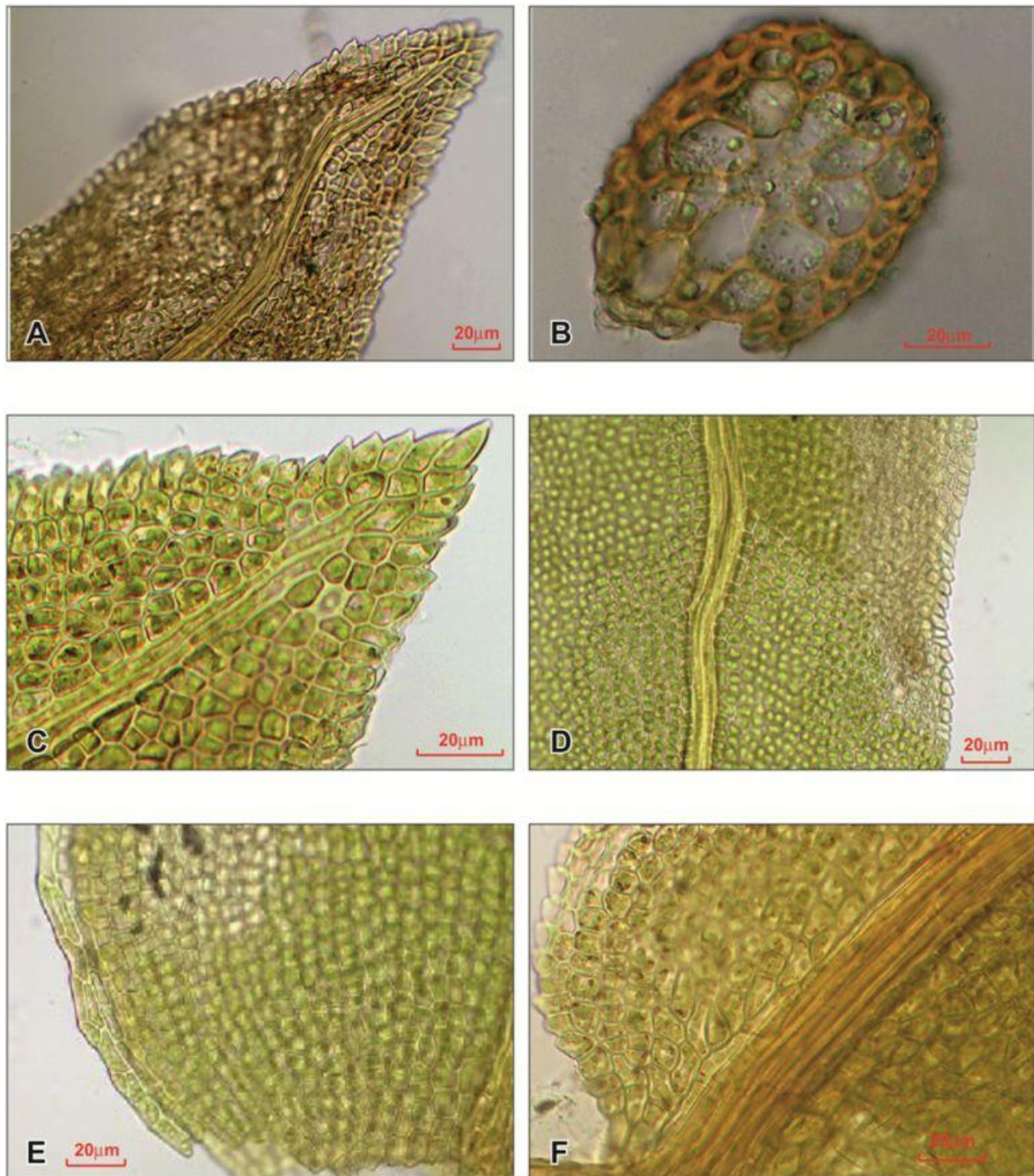


Plate 2: *Fissidens ceylonensis* Dozy & Mol. Chitrakoot ecad. A. Leaf tip with Curvaceous costa; B. Stem, t.s.; C. Leaf tip showing apical cell; D. Median cells of leaf; E. Limbidium in leaf; and F. Dorsal lobe of leaf

In India, the species is widely distributed and is known to exist in different bryogeographical regions across the country including Western Himalaya, Central India, Gangetic Plains and South India (Gangulee, 1971; Ellis, 1992; Lal, 2005, 2007; Madhusoodanan *et al.*, 2007; Manju *et al.*, 2008; Nath *et al.*, 2011). A species having such a wide range of distribution suggests its adaptability potential. Besides

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the type variety, *ceylonensis*, two other varieties of the species, namely, *simplex* (M.Fleisch) Nork. and *acutifolius* Dixon & P. Varde are known. While var. *simplex* is recorded from Nepal, Andman Islands, Java and Ceylon, the var. *acutifolius* is largely confined to South India.

A comparison of the Chitrakoot specimens with the images and descriptions of the ‘types’ of all the three varieties was made. The present specimens differed from var. *simplex* in having wider leaves ($B/L = \pm 30/100$ as against $\pm 20/100$) and an incomplete limbidium than the completely bordering limbidium in the latter variety. Similarly, it differed from var. *acutifolius* in neither having slender leaves nor a broad multilayered limbidium covering the sheathing lamina. On the other hand, the Chitrakoot specimens largely agreed with the type var. *ceylonensis* in leaf shape, the incompleteness of the limbidium, crenulose leaf margin, presence of papillae in leaf cells and the rounded dorsal margin.

However, the Chitrakoot populations have some of their own features including the varying degree of curvaceous costa in the upper part of the leaf; the presence of medulla having highly thin-walled cells surrounded by very thick-walled 1-3 layered cortical cells in stem; the presence of a 1-2 layered limbidium in which the outer layer is extending from base to apex and never sub-marginate but the inner layer is incompletely lying in the middle of the sheathing lamina; an invariably percurrent costa falling short of 3-4 cells from the apex; a distinctly large apical cell at leaf apex; green to hyaline and their varied combinations of the leaves; and, the abundance of dark brown, stout rhizoides arising up to 1/3 or more on the stem. It is important to note the habitat of these plants which were growing inside the water-rich cave having the higher degree of humidity and the poor light conditions. The growing habit of the plants was such that they were prostrate and closely adhered to the bare rocks having a very thin layer of soil. In a way, the plants were growing as lithophytes. As such, these plants had very stout brown coloured rhizoids meant primarily for strong anchorage; the leaves being entirely yellow green or hyaline or showing a combination of green and hyaline areas of various degrees because of the low light intensity; and, the tearing or splitting of leaves in a majority of plants we observed. The leaves were also distantly apart. In a moss, *Fissidens taxifolius* Hedw., growing in low light in the cavern in Virginia, Conard (1932) has observed that the plants showed leaves being distant apart than those of typical ones.

A feature of special interest has been the course of the costa in the leaf after it deviates from the sheathing lamina. We observed all kinds of situations, from a nearly straight costa to slightly or deeply curved costa in different leaves. The colourless leaves had more pronounced zigzag costae with two or occasionally one turn whereas in green leaves the curves were hardly noticeable. The possible explanation for such a variation might be in the water requirement of the two kinds of leaves; the costae get probably collapsed in colourless leaves since these are dead ones as against the functional living green leaves having greater degree of metabolism. In this way, the change in the shape and course of the costa is also seemingly guided by the environmental factor, namely, the need of water of the particular kind of leaf. Another significant feature is the presence of highly thin walled medullary cells in the stem representing the zone meant more for the storage of water than its conduction. The distribution of chloroplasts in all the stem cells, whether cortical or medullary, is again suggestive of the fact that this cave moss was growing under greater paucity of light. The acute apical cell and the strongly crenulate margins of leaves along with papillose cells show its xeric nature. As such, the Chitrakoot populations, though they belong to *Fissidens ceylonensis* Dozy & Molk., have such interesting deviations from the ‘type’ that one is tempted to create a separate variety. However, because of their changeability due to varying environmental factors inside the cave and also in the absence of supportive evidences for clear involvement of genetic elements, these populations are being treated as an ‘ecad’.

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