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## Morphological variations in *Cyathodium aureonitens*(Griff.)Mitt.from Pithoragarh in Uttarakhand, India

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### Abstract

The paper reports for the first time populations of *C. aureonitens* (Griff.) Mitt. a species of the Marchantialian taxon *Cyathodium* Kunze from a new locality, Chaukori in the Pithoragarh district (Kumaon Region) of Uttarakhand. Morphological studies have revealed interesting strategies adopted by the populations for successful establishment in the new habitat.

**Key words:** Liverwort;Morpho-anatomy;*Cyathodium*.

### Introduction

The worldwide distributed Marchantialian member *Cyathodium*Kunze shows 13 valid species (Söderström et al., 2016) out of which 9species are known from the Indian sub-continent (Singh, 2016). The taxon is abundantly represented both in the plains and hills though a majority of them are reportedly endemic. The present article embodies morpho-anatomical variations observed in a species of the taxon *Cyathodium aureonitens* (Griff.) Mitt.,recorded from a new locality, Chaukori in the hills of Pithoragarh district in Uttarakhand. The species occurs in the rainy season,endures moderate winters and dies out on the onset of the summers.

Earlier populations of the species had been reported by Srivastava and Dixit (1996) from Mussoorie and Asthana et al., (2008) from Chakrata. Both the sites are located in the Garhwal region of Uttarakhand. This is the first report of the species from the Kumaon region of Uttarakhand.

### Materials and methods

Morpho-anatomical analysis of the population was pursued after selecting fresh and previously preserved plants in 70 % ethanol. External features of thalli were studied under stereo microscope Olympus SZ61. Hand sections of thalli were mounted on glass slides after staining in 50% safranin and observed under light microscope Olympus CH20i. All photographs and measurements were taken under Leica DM 2500 microscope with the help of its software.Scanning Electron Microscope (SEM) observations of spores was made with JEOL.

### Results and Discussion

*Cyathodium aureonitens*(Griff.)Mitt.

Dioecious. Thalli light green to green, thriving in irregular rosettes, densely overlapping, 5 – 10 mm x 4 – 10 mm, regularly branched, fan shaped having entire margins.Dorsal surface exhibiting outlines of air chambers and dorsal pore. Pores large, elliptical to rounded about 155 – 286 µm x 61 – 158 µm, encircled by 3 – 4 concentric rings of 4 – 5 cells each. Dorsal epidermis single layered, cell thin walled, polygonal, 50 – 90 µm x 40 – 63 µm, chlorophyllose, chloroplasts scattered.Cross section of thalli showing single rowed, empty air chambers 60 – 130µm high and 200 – 587 µm wide partitioned by 1 – 3 celled sometimes upto 5 celled high uniseriate partition walls.Ventral epidermis single layered, ventral pore absent, cells thin walled, polygonally elongated 85 – 203 µm x 46 – 66 µm, chlorophyllose, chloroplasts scattered.Rhizoids numerous hyaline,smooth walled, 14 – 17 µm wide, thick to thin walled, straight to undulate. Tuberculate rhizoids absent. Ventral scales frequently near involucre, filamentous, uni – biseriate, 4 – 6 celled long, apical cell without terminal mucilage papilla. Female thalli sparsely to profusely fertile with 3 – 5 or sometimes upto 12 involucre (in larger plants) arising anteriorly below the notch (sinus) between apical lobes of thalli. Involucre “vase” – shaped, hairy, deeply bilabiate, labium rim single

rowed, cells narrow, rectangularly elongated, thick walled, non – pigmented. Remaining cells thin walled and polygonal. Hairs thick walled, upto 1mm long evenly distributed all over involucre surface. Posterior end of involucre showing few filamentous scales and rhizoids. Each involucre generally containing a single (rarely 2) sporogonium. Sporophyte consisting of a small rounded parenchymatous foot, a very short seta and an oval to sub – globose dark colored capsule 0.5 – 0.8 mm x 0.5 – 0.9 mm. Capsule wall single layered elsewhere but apically 2 tiered forming apical lid or operculum. Lid 75 – 92  $\mu\text{m}$  in diameter, outer tier of 4 pyramidal thin walled cells lacking thickening bands, inner tier plate – like of 21 thin walled cells. Upper  $\frac{1}{2}$  –  $\frac{1}{3}$  part of capsule wall brown colored, dehiscent, splitting into 8 almost equal sized valves. Cells tetragonal to polygonoid, thick walled, 26 – 46  $\mu\text{m}$  x 21 – 40  $\mu\text{m}$ , with annular to semi – annular thickening bands. Lower part of capsule wall non – dehiscent, cell thin walled, rectangular to isodiametric, chlorophyllose, 22 – 60  $\mu\text{m}$  x 19 – 32  $\mu\text{m}$ . Spores globose to sub – globose, isopolar, 43 – 51  $\mu\text{m}$  x 41 – 53  $\mu\text{m}$ , spinate, spines 4 – 6  $\mu\text{m}$  long x 2 – 3  $\mu\text{m}$  wide at base, straight to slightly bent apically. Under SEM the sporoderm showed a double sculptured pattern. Exine surface showed distinct minute reticulations interspersed with conspicuous spines with more or less mammillate bases. Spines basically triangular with acute, blunt or curved tips (Singh & Singh 2008). Elaters few, 9 – 14, dark brown, bi – trispiral, 450 – 656  $\mu\text{m}$  long x 15 – 18  $\mu\text{m}$  wide. Male thallus not found. (Figs. 1 & 2).

**Habitat and ecology of *C. aureonitens*:** Plants growing in small pocket on wet soil intermixed with mosses and some liverworts like *Plagiochasma appendiculatum*, *Asterella multiflora*, *Marchantia polymorpha* etc. at an altitude of 1946 m under the dense shades of pine and oak trees. The soil substrate showed a pH of 7.2 and 28.5 % moisture content.

**Specimens examined:** India: Western Himalaya: Uttarakhand – Pithoragarh: Chaukori, 1 km from Chaukori T.R.H, alt. ca. 1946m, 4525AUL/14, 4560AUL/15, Duthie Herb. All India Univ., leg. S. Sinha, det. N. Bhowmik.

**Distribution :** India: Eastern Himalaya – Assam, Darjeeling, Sikkim; Himachal Pradesh; Western Himalaya – Dehradun, Mussoorie, Chakrata; Gangetic Plains – Calcutta; South India – Bombay, Malabar hills, Panchgani, Pratabgarh, Khandala, Konkan, Maharadhapore; Tamil Nadu; Africa; Burma; Java; Vietnam.

#### Comparison with perviously reported populations

The species *C. aureonitensis* stated to be common in Eastern Himalayas and South India and reportedly rare in the West Himalayan territories (Srivastava and Dixit, 1996; Asthana et al., 2008). From the Western Himalayas the species has so far been recorded from only two sites viz., Mussoorie and Chakrata, both belonging to the Garhwal region of Uttarakhand. According to above author sparse populations of the species, mostly confined to small areas were found growing in patches along the road side (Asthana et al., 2008).

A comparison of morphological features of the presently described species with those of earlier described populations revealed significant variations. Thalli from the new site were not only relatively small but also showed larger dorsal and ventral epidermal cells. Even the number of cells encircling a pore is less (4-5) compared to material from Mussoorie where encircling cells are more in numbers (4-7).

Besides these, the Chaukori population also differs from those of Mussoorie and Chakrata in having filamentous ventral scales lacking terminal mucilage papilla, fewer numbers of deeply bi – labiate involucre per thallus, involucre being “vase” – shaped and generally containing a single (rarely two) sporophyte (1 – 5 sporophytes per involucre in Chakrata plants). Even capsules are comparatively large (0.5 – 0.8 mm x 0.5 – 0.9 mm) compared to capsules from Garhwal region material. And, exine on spinate spores are shorter in length and wider at base (4 – 6  $\mu\text{m}$  x 2 – 3  $\mu\text{m}$ ) compared to exine spines in spores of Mussoorie and Chakrata populations. Even the number and size of elaters within capsules from the two regions varied. While fewer elaters (9 – 14) of shorter length were recovered in capsules from Chaukori long elaters numbering 8 – 17 were reported in capsules earlier from studies. (see Table. 1).

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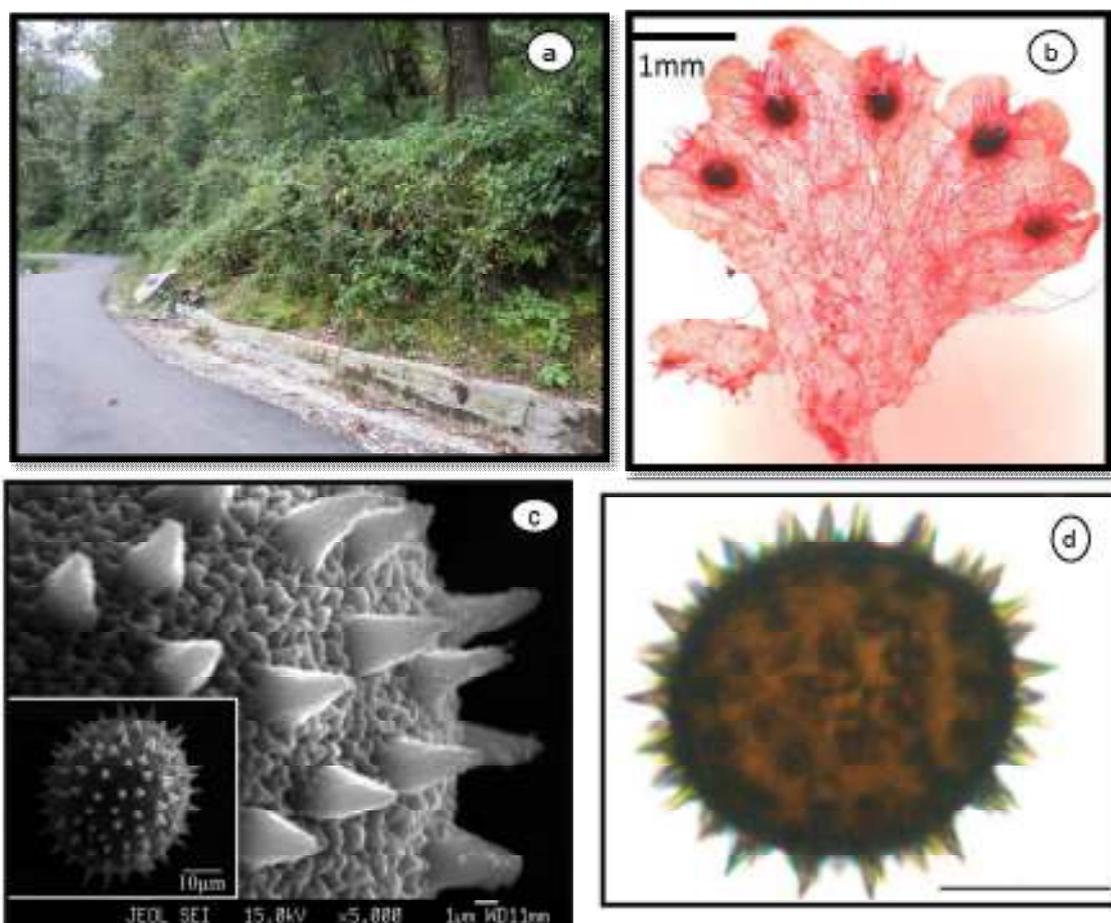
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**Table 1:** Comparison of characters of *Cyathodium aureonitens* described herein with those described earlier by Srivastava & Dixit (1996), Asthana et al. (2008) and Singh & Kumar (2013).

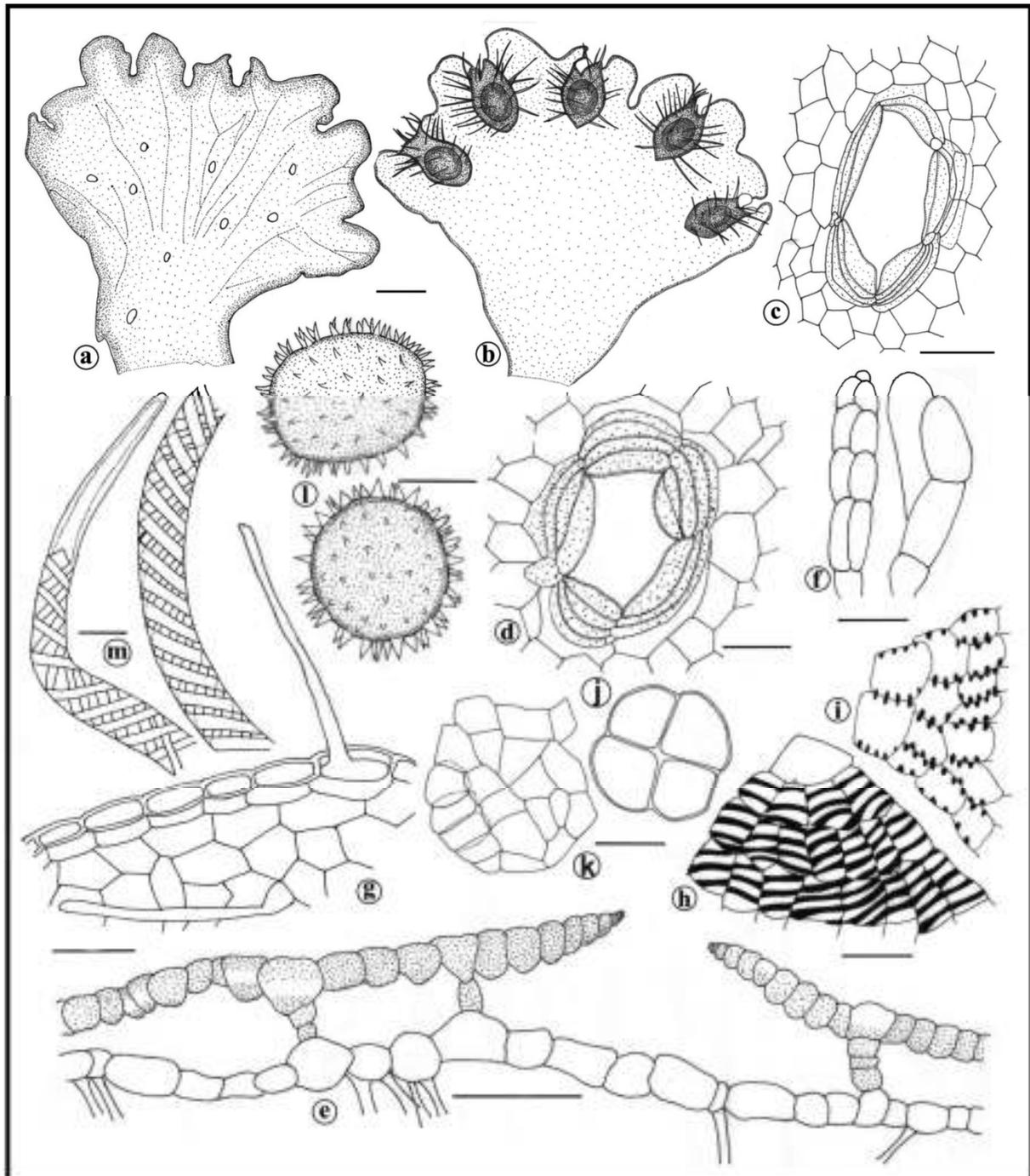
Characters	Srivastava & Dixit (1996)	Asthana et al. (2008)	Singh & Kumar (2013)	Present material
<b>Thallus (Dioecious)</b>	Light green to brownish green, densely overlapping, in irregular rosettes or small mats. <b>Sterile Plants:</b> Linear, 4 – 6.8 mm long x 2.4 – 3.2 mm wide. <b>Female Plants:</b> Larger, broad, 8 – 18 mm long x 11 – 26 mm wide. <b>Male Plants:</b> Small, usually unbranched, 2 – 4.4mm long x 1.2 – 2.4mm wide.	--  -- Fan shaped, spongy, 10 – 15 mm long x 6 – 8 mm wide.  --	Light green-deep green, delicate, overlapping in irregular rosette or small mats.  -- Irregularly branched, lobes linear, strap – shaped, delicate, 6-25 mm long x 3-7mm wide.  --	Light green to green, densely overlapping in irregular rosettes.  -- Regularly branched, fan – shaped, 5 – 10 mm long x 4 – 10 mm wide.  --
<b>Dorsal epidermis</b>	Single layered cells, thin walled, polygonal to sub quadrate, 32-40 x 60-76 µm, chlorophyllose.	--	Single layered, cells thin walled, sub quadrate – polygonal, 32.5-75 x 25 -52.5 µm, chlorophyllose.	Single layered cells, thin walled, polygonal, 50 – 90 x 40 – 63 µm, chlorophyllose, chloroplasts scattered.
<b>Air pore</b>	Surrounded by 2 – 4 concentric rings of 4 – 7 cells each.	--	Large, 3 – 5 concentric rings of 4 – 6 cells.	Large, elliptical to rounded, 155 – 286 x 61 – 158 µm encircled by 3 – 4 concentric rings of 4 – 5 cells each.
<b>Air chambers</b>	Single layered, partition wall 2-5 cells high, uniseriate, at ends 1-2 wide.	--	Single layered, rarely 2, partition walls 3-5 cells high.	Single layered, 200 – 587 µm wide x 60 – 130 µm high, partition walls 1 – 3, sometimes upto 5 cells high, uniseriate.
<b>Ventral epidermis</b>	Single layered, cells 40-56 x 64-88 µm	--	Single layered, cells larger than dorsal epidermal cells.	Single layered, cells thin walled, polygonally elongated, 85 – 203 x 46 – 66 µm, chlorophyllose, chloroplasts fewer than dorsal epidermis cells.
<b>Scales</b>	Uni – biseriate, 4-7 cells long, chlorophyllose with terminal rounded mucilage papillae.	--	Biseriate, 4-7 cells long, chlorophyllose with terminal rounded mucilage papillae.	Uni – biseriate, 4 – 6 cells long, without terminal mucilage papillae.
<b>Tubers</b>	Present	--	Absent	Absent

♂ <b>Receptacle</b>	Usually sessile, discoid or 2 – 4(11) lobed, occasionally star shaped.	--	Not seen	Not seen	
♀ <b>Involucre</b>	<b>No. per thallus.</b>	5 – 18, globose, shallowly bilabiate, hairy, hairs stiff 0.3-0.4mm long. Colorless elongated cells.	Many (7 – 10).	4-8, shallowly bilabiate.	3 – 5, rarely 12, vase – shaped (deeply bilabiate), hairs stiff, upto 1mm long.
	<b>Rim.</b>	1 – 2	--	Colorless elongated cells.	Narrow, elongated, thick – walled, non – pigmented cells.
	<b>No. of Sporogonia</b>		1 – 5	1	1 – 2
<b>Capsule</b>	Spherical – sub spherical, blackish brown, 0.4-0.6mm in diam. 2 tiered, outer of 4 thick walled cells, inner	--	Globose-subglobose, blackish brown, 595-856.8 µm in diam.	Oval - sub-globose, dark brown, 0.5 – 0.8 x 0.5 – 0.9 mm.	
<b>Operculum / apical lid</b>	tier of 12 – 14 thin walled.	--	2 tiered, 112.5-125 µm in diam., outer 4(-5) celled with or without thickening, inner of 12-14 thin walled cells.	75 – 92 µm in diam., 2 tiered, outer of 4 thin walled pyramidal cells, inner plate like of about 21 thin – walled cells.	
<b>Spores</b>	Oval – spherical, blackish brown, isopolar, 50 – 55 µm in diam., spinate, spines 5 – 7 µm long x 0.5 – 1.5 µm wide.	37 – 53 µm in diam, spinate, spines 5 – 7.5 µm, acute tip, blunt or curved.	Globose-sub globose, blackish brown, 45 – 62.5 µm in diam., sometimes oval 45 – 65 x 42.5 – 55 µm, spinate, spines 5 – 7.5 µm long.	Globose to sub – globose, dark brown, isopolar, 43 – 51 x 41 – 53 µm, spinate, spines 4 – 6 long x 2 – 3 µm wide at base, straight to slightly curved apically.	
<b>Elaters</b>	Brownish black, usually 8 – 17 per capsule, large, 452 – 747 µm long x 16 – 18 µm wide, bi-trispiral,	Elongated, 665 – 707 µm long x 16 µm wide, bi-trispiral.	Blackish brown, 384 – 556.8 µm long x 10 – 20 µm wide, bi-trispiral.	Dark brown, 9 – 14 per capsule, 450 – 656 µm long x 15 – 18 µm wide, bi – trispiral.	



**Figure 1.** (a) Site of collected plant, (b) Thallus of *C. aureonitens*, (c) SEM of spore, (d) LM of spore.

Scale bar: (a) = 1mm, (c) = 10µm, (d) = 20µm.



**Figure 2.** Illustrations of *Cyathodium aureonitens* (Griff.) Mitt.: (a, b) Dorsal and ventral views of a female thallus. (c, d) Magnified views of dorsal pores. (e) a portion of cross-section of thallus. (f) Ventral scales. (g) Portion of labium rim of hairy involucre. (h, i) Portions of capsule wall showing outer and inner views of cells respectively. (j, k) Outer tier and inner tiers of operculum in capsule wall respectively. (l) Spinate spores. (m) Magnified view of portions of elaters.

Scale bar: a, b = 1mm; c, g = 100 $\mu$ m; d, f, h – k = 50 $\mu$ m; l, m = 20 $\mu$ m.