

# *Conocephalum conicum* (L.) Dumort. (Snake Liverwort) Threatened in Bhaderwah (J & K) due to Environmental Shock

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## ABSTRACT

Paper includes information on population status of *Conocephalum conicum* collected from diverse habitats in Bhaderwah (J & K state). Taxon exhibits tremendous diversity in morphoanatomical details of various gametophytic characters. Isozyme analysis was performed to find out whether variability in the taxon is only environmental or has genetic basis as well.

**Keywords:** Bryophyta, Liverwort, Marchantiales, *Conocephalum*, Jammu & Kashmir

## 1. Introduction

Bryophytes constitute one of the largest groups of land plants among the plant kingdom. Himalayas rank first at national [1] and third at global level in bryo-diversity [2]. During the last few decades, however, Himalayas have suffered tremendously due to various tourism and urbanization related anthropogenic activities leading to the disappearance of many of their inhabitants including bryophytes. On basis of an observations [3] on occurrence of several hepatics in Western Himalaya (Nainital) over the years, 9 threatened taxa [*Athalamia pinguis*, *Dumortiera hirsuta*, *Cryptomitrium himalayensis*, *Reboulia hemispherica*, *Stephensoniella brevipedunculata*, *Weisnerella denudata*, *Fossombronina himalayensis*, *Sewardiella tuberifera* and *Conocephalum conicum*] which were had observed to grow luxuriantly in the yesteryears, but had disappeared or undergone extreme reduction in population size, from the area. The suggested specific reasons include anthropogenic activities like rapid urbanization, land clearance, road construction, deforestation, indiscriminate and wreck less collection etc., as factors which could have contributed to the habitat destruction and consequently, the disappearance of these taxa. She, therefore, voice was raised for their conservation.

Against this backdrop, work on intraspecific variability was initiated on three, *Reboulia hemispherica* [4],

*Dumortiera hirsuta* [5] and *Conocephalum conicum* [6] of the nine hepatic taxa enlisted by Pant [1] in Department of Botany, at University of Jammu, Jammu. Present communication deals with our observations on population status of *Conocephalum conicum* collected from Bhaderwah in Jammu region, one of the areas of the North-west Himalaya which used to host rich bryo-diversity in the yesteryears, because of the undisturbed, stable habitats due to the inaccessibility of the area.

Bhaderwah lies between 32°08' N - 35°52' N latitude and 75°48' E - 75°32' E longitude having an altitudinal range of 821 - 4341 m. The climate of Bhaderwah is temperate; temperature varies from minimum mean 17.3°C to maximum mean 29.9°C in summers and minimum mean -0.9°C to maximum mean 02.8°C in winters. It experiences severe cold during winters with snowy season between the months of December to March with temperature remaining subzero. The snow melts off by April and weather becomes pleasant and remains so up to May. In June and July, temperature increases upto the maximum 29.9°C. During August and September, the temperature subsides and it again becomes cold afterwards. The annual rainfall is up to 249.6 mm and maximum humidity is 84% [7].

In recent years, Bhaderwah has been subjected to tremendous developmental and tourism related pressures, like construction of bridges, highways, parks, roads,

tourism huts, deforestation, destruction of rocks by quarrying etc. Furthermore, a University Campus has recently been established at Bhaderwah over a vast area. These activities are likely to lead to habitat destruction and depletion/disappearance of many of the inhabitants of the area. Under such circumstances, only those organisms which have accumulated genetic variability are likely to survive, whereas genetically homogenous taxa are destined to be wiped out by the natural selection. *Conocephalum conicum*, a species reported to have disappeared elsewhere in Western Himalaya in response to similar reasons, was therefore selected for the present study.

## 2. Materials and Methods

*Conocephalum conicum* (L.) Dumort. is commonly called snake liverwort is the study material collected from Bhaderwah, Jammu & Kashmir, India.

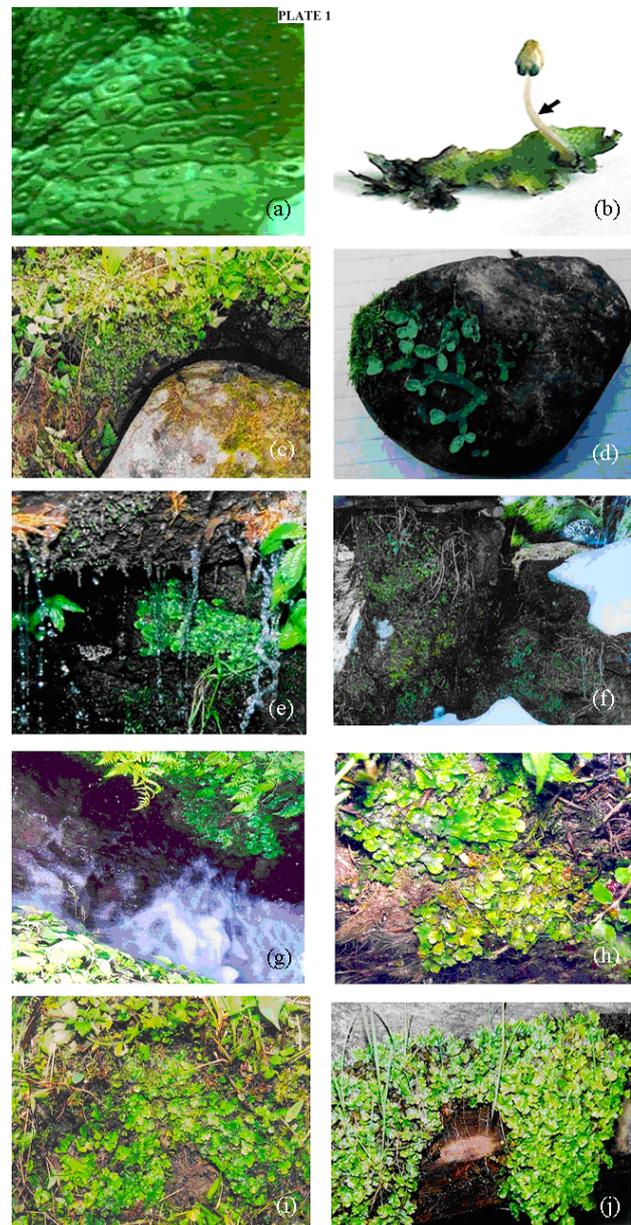
## 3. Results and Discussion

*Conocephalum conicum* is commonly called snake liverwort due to hexagonal areolae on its dorsal surface (**Figure 1(a)**). It is also called cone headed liverwort because of its conical archegoniophores (**Figure 1(b)**). It is worldwide in distribution, as it is known to be distributed in America, Algeria, Alaska, Azores, Bhutan, Caucasus, Canary, China, Europe, Florida, India, Ireland, Italy, Japan, Korea, Kuriles, Liukium Maderia, Nepal, Pakistan, Rubki-Neylong, Seghalim and Siberia [8]. From India, the taxon is reported from Eastern [9-11] and Western Himalaya [12-16].

In Jammu and Kashmir (North West Himalaya), it has so far been collected from Poonch [17], Udampur and Kathua as stated by [18] districts of Jammu region and Ladakh [19].

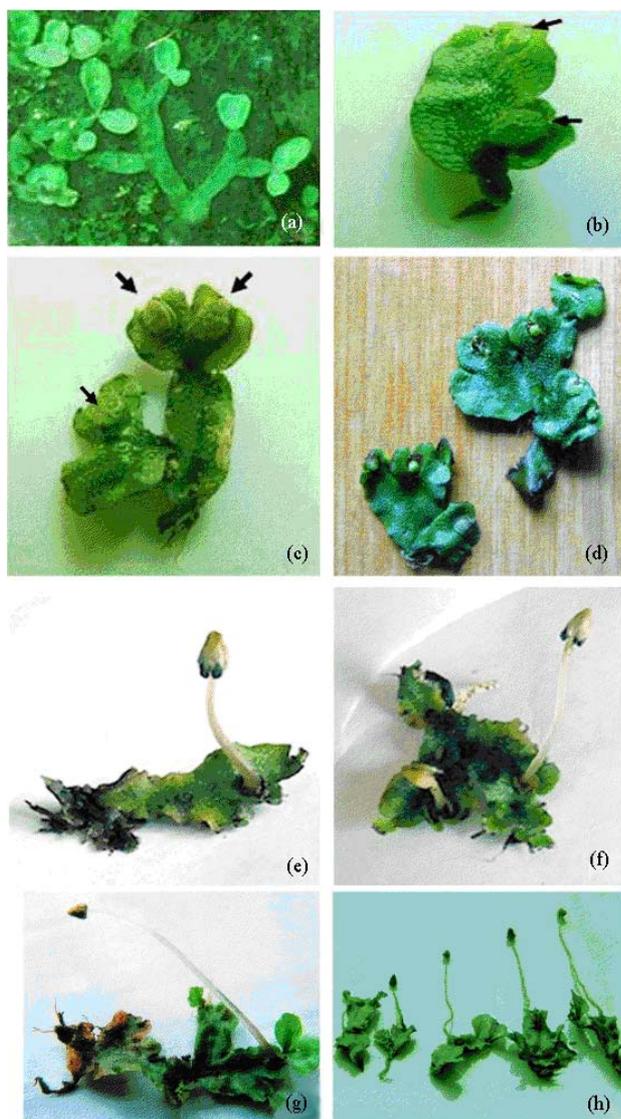
During present investigations, 46 accessions of *C. conicum* have been collected growing at different sites ranging in altitude from 1230 m - 2600 m. Populations were collected growing on substrates with pH ranging between 6.5 - 6.9. Plants have been collected from diverse habitats, such as epilithic (rock crevices, caves; **Figures 1(c) and (d)**), under dripping chilled water (**Figure 1(e)**), under snow cover (**Figure 1(f)**), stream banks (**Figure 1(g)**), submerged under water (**Figure 1(h)**), non-epilithic (cool and moist shady soil, loamy soil) (**Figure 1(i)**), and epiphytic on decaying log of *Cedrus deodara* (**Figure 1(j)**).

Thalli of various populations displayed variability in morpho-anatomy of almost every gametophytic character (thallus size, rhizoids, scales, air pores, vegetative anatomy etc.) studied, that has been communicated separately. In this paper focus is mainly on reproductive biology of the taxon.



**Figure 1.** (a) A part of Thallus showing hexagonal areolae on its dorsal surface. (b) Thallus of *C. conicum* showing conical archegoniophore. (c) & (d) Various habitats from where populations of *Conocephalum conicum* have been collected. (e) Under dripping chilled water. (f) Under snow cover. (g) Stream banks. Submerged under water. Non-epilithic. (h) Epiphytic. (i) On rotten log of *Cedrus deodara*.

*C. conicum* reproduces both, asexually as well as sexually; asexual reproduction occurs usually by regeneration from thallus fragments; thallus being light in weight, is easily transported by water; thallus produces ventral innovations, both apical and lateral (**Figure 2(a)**). During



**Figure 2.** (a) Thalli of *Conocephalum conicum* showing apical and lateral innovations. (b) & (c) Male plants with 2 - 3 receptacles. (d) Female thalli with young (Note upto 4 receptacles/thallus). (e) & (f) Mature receptacles (1 in Figure 2(e) and 2 in Figure 2(f)). (g) Female thallus with healthy receptacle and stalk. (h) Female thalli of Acc. MI 37 and MI 38 showing unhealthy/shriveled receptacles and stalk.

present investigation, only 15 accessions were recorded in fertile form, of which 12 comprised both male and female thalli growing together, while remaining three had only female plants. Dioecious; male receptacles sessile, green, disciform, disc slightly raised above main thallus, surrounded by thin growth of thallus; terminal or subterminal; receptacles oval or circular having conspicuous papillae on their upper surface; borne on main thallus as well as on apical innovations; number of re-

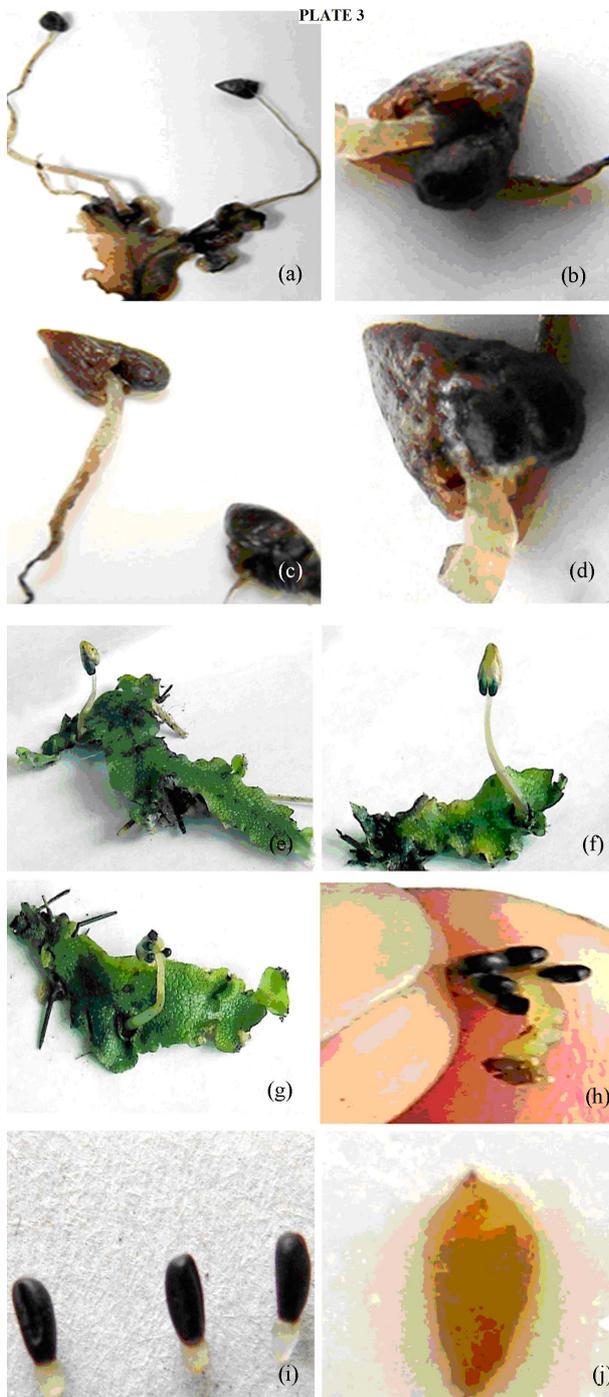
ceptacles per thallus varied from 2 - 3 (Figures 2(b) and (c)); initiation of male receptacles occurred in April, and they disappeared in July.

Although female thalli were recorded presently in 15 accessions, mature receptacles could be observed only from 3; in the remaining 12 accessions, receptacles were observed at young stages only, as they degenerated before reaching maturity. Female receptacle terminal or slightly sub-terminal, 1 to 4 per thallus, sunken when young in a cup formed by dorsal growth of the thallus (Figure 2(d)); receptacles appeared in first week of May; one flask shaped archegonium present per lobe with broad venter and long neck; post fertilization changes recorded after mid June, when neck of archegonium degenerated; receptacles started emerging out of sunken cup, stalk elongated slowly till it reached maximum of 11 cm (Figures 2(e)-(g)) in March next year. Mature receptacles conical; raised on long stalk.

Receptacles were symmetric, healthy and 5 - 8 lobed in single accession (Acc. MI 46; Figures 2(e)-(g)) and unhealthy and asymmetric up to 5 lobed in two (Acc. MI 37 and MI 38; Figures 2(h)-3(d)). Stalk stout and healthy in Acc. MI 46 (Figures 2(e)-(g)) but unhealthy and shriveled in Acc. MI 37 and MI 38 (Figures 2(h)-3(d)). Mature sporophytes were present only in 1 and/or 2 lobes per receptacle in Acc. MI 37 and MI 38; remaining lobes being extremely reduced, whereas in Acc. MI 46 mature sporophytes were recorded in a maximum of 5 lobes out of 8 (Figures 3(e)-(h)). One sporophyte per lobe, having foot, reduced seta and pyriform capsule (Figure 3(i)). Sporophytes excised from developed lobes of unhealthy receptacles exhibited reduced capsules (Figure 3(j)).

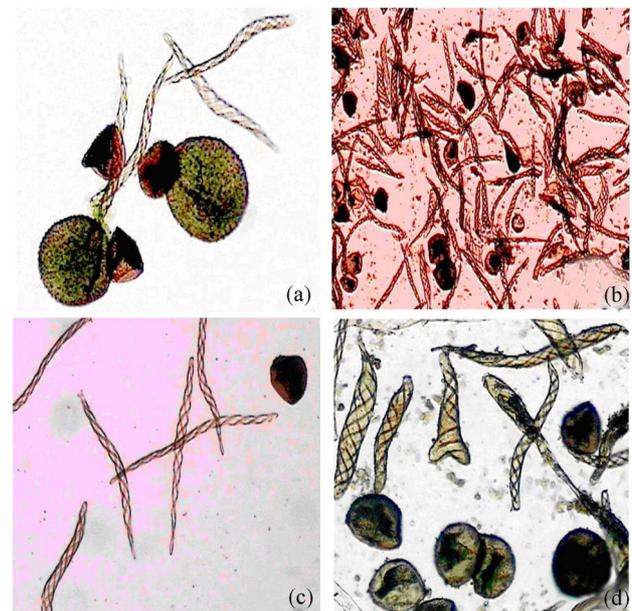
Mature spores observed only in Acc. MI 46 (Figure 4(a)); capsules of Acc. MI 37 and MI 38 possessed very few viable spores (Figure 4(b); Table 1). Capsules from even the fully mature receptacles of these unhealthy populations possessed developing sporocytes and elaters; ratio between the two being around 0.4:1. Capsules showed very low spore output as compared to that of elaters. Like the other two populations spore-elater ratio in the healthy population (Acc. no. MI 46) was around 0.4:1 (Table 3). Out of the spores formed in Acc. MI 46, another 10% were non viable. These were small ( $16\ \mu\text{m} - 20\ \mu\text{m}$ )  $\times$  ( $12\ \mu\text{m} - 16\ \mu\text{m}$ ), triangular and shriveled as compared to viable ones which were large ( $44.5\ \mu\text{m} - 102.3\ \mu\text{m}$ )  $\times$  ( $25\ \mu\text{m} - 55.4\ \mu\text{m}$ ), green and healthy (Table 2).

Elaters brown, healthy, bi- and tri- spiral, unbranched and bluntly fusiform in Acc. MI 46 (Figure 4(c); Table 2). Elaters of abnormal morphology (branched and blackish) were also present in capsules of Acc. MI 37



**Figure 3.** (a) A female thallus of Acc. no MI 37 showing asymmetric receptacles and stalk. (b-d) Female thallus of Acc. no MI 37 and MI 38 with unhealthy/shriveled stalk. (e-h) Female thalli of Acc. no MI 46 bearing receptacles with 1 (e), 2 (f), 4 (g) and 5 (h) sporophytes. (i) & (j) Healthy (i) and unhealthy (j) Sporophyte excised from receptacle lobes of MI 46 (i) and M 37 (j).

and MI 38 (**Figure 4(d)**; **Table 3**). Size of elaters var-



**Figures 4.** (a) A few viable and non-viable spores excised from mature capsule of healthy population. (b) Developing sporocytes and elaters, excised from capsule of unhealthy population (Note the abundance of elaters). (c) Whole mount of healthy elaters. (d) Whole mount of abnormal elaters.

ied between  $(50 \mu\text{m} - 150 \mu\text{m}) \times (15 \mu\text{m} - 70 \mu\text{m})$  (**Table 3**). Occurrence of elaters is a characteristic unique to the liverworts. In contrast, they are totally lacking in mosses. Archegonium throughout the class hepaticopsida is endothecial in origin and differentiates into sporocytes and elaterocytes; former undergo reductional division, each giving rise to 4 spores and the later differentiating into elaters. Since both, sporocytes and elaterocytes belong to the same generation, basic ratio between spores and elaters expected is 4:1. This ratio exists in a number of Marchantialean taxa like *Reboulia*, *Mannia*, *Targionia*, *Conocephalum* etc. During the course of evolution there has been a trend towards the increase in spore output and consequently, higher spore-elater ratios. *Marchantia polymorpha* displays highest ratio (128:1) among Marchantiales. *Schistochila* (Jungermanniales) exhibits still higher (200:1) spore-elater ratio (**Table 2**). Sporocytes of all such taxa where spore-elater ratio is higher than 4:1, undergo 1 or more mitotic divisions, prior to meiosis. Interestingly, these divisions have been accompanied by the reduction in spore size. Production of large number of small sized spores is an adaptation for wind dispersal of spores and subsequently, successful under terrestrial habitat. Although *Conocephalum*, *Reboulia*, *Mannia* and *Targionia* are theoretically expected to show 4:1 ratio, actual ratios are sometimes lower. Bischler (1998) re-

**Table 1. Number of viable/non-viable spores in receptacles with different sporophytes.**

Acc. No.	Size (µm)			Number of Viable/Non-Viable Spores in Receptacles with Different Sporophytes							
	Oval		Circular	1	2	3	4	5	6	7	8
	L	B	diameter								
MI 37	42.5 - 115 (89.5)	22 - 52 (49.1)	22.5 - 52.5 (38.2)	2848 - 2861 (2672)	5344 - 5675 (5545)	—	—	—	—	—	—
MI 38	42 - 110 (93.3)	25.5 - 49 (37.4)	22 - 50 (37.4)	2789 - 2915 (2845)	5125 - 5478 (5344)	—	—	—	—	—	—

**Table 2. Variation recorded in spore characters.**

Acc. No.	Size (µm)			Number of Viable/Non-Viable Spores in Receptacles with Different Sporophytes							
	Oval		Circular	1	2	3	4	5	6	7	8
	L	B	diameter								
MI 37	42.5 - 115 (89.5)	22 - 52 (49.1)	22.5 - 52.5 (38.2)	2848 - 2861 (2672)	5344 - 5675 (5545)	—	—	—	—	—	—
MI 38	42 - 110 (93.3)	25.5 - 49 (37.4)	22 - 50 (37.4)	2789 - 2915 (2845)	5125 - 5478 (5344)	—	—	—	—	—	—
MI 46	44.5 - 120.3 (95.7)	25 - 25.4 (44.3)	23.2 - 55.3 (33.4)	2485 - 2725 (2560)	5000 - 5350 (5130)	7787 - 7985 (7785)	9704 - 10492 (10263)	12500 - 13505 (13126)	—	—	—
Viable	16 - 20 (18.3)	12 - 16 (14.5)	—	50 - 110 (85)	150 - 225 (180)	315 - 375 (350)	400 - 425 (415)	450 - 480 (465)	—	—	—
Non-viable	—	—	—	—	—	—	—	—	—	—	—

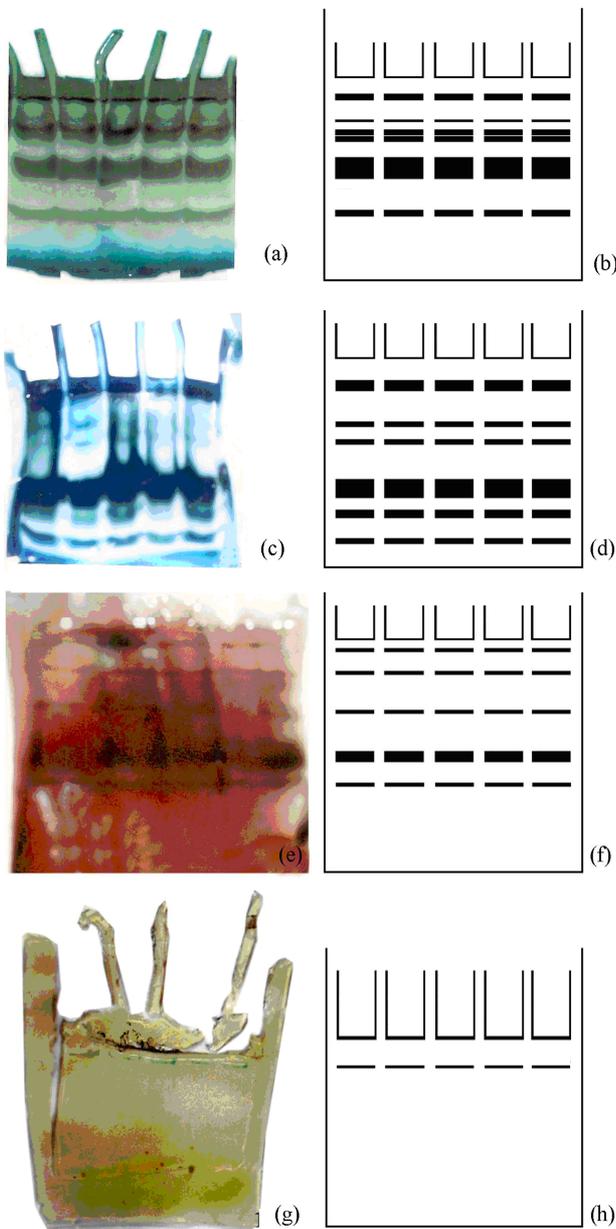
**Table 3. Variation recorded in elaters' output.**

Acc.no.	Size (µm)		Number of elaters in receptacle with different sporophytes					No. of spirals				Spore/Elater ratio							
	L	B	1	2	3	4	5	6	7	8	2	3	4	1	2	3	4	5	
MI 37	45 - 105 (91.5)	15 - 75 (35.3)	6106 - 6504 (6305.2)	12212 - 12895 (12710.3)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MI 38	43 - 350 (320.5)	12 - 65 (25.5)	5895 - 5990 (5935.1)	12427 - 12895 (12610.1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MI 46	50 - 350 (250.5)	15 - 70 (45.5)	6335 - 6660 (6410.1)	12317 - 12910 (12730.4)	18318 - 18602 (18415.3)	24920 - 25689 (25220.1)	30982 - 31670 (31525.5)	—	—	—	—	—	—	—	—	—	—	—	—

corded a similar situation in *C. conicum* and *Pellia sp.*, and attributed it to endosporic, precocious spore germination in the species. Although in these species ratio was lower than 4:1 yet the number of spores was far more than elaters. Data obtained presently are in total contrast to the expected numbers. Here, elaters were more abundant than spores, leading to the ratio between spores and elaters as low as 0.4:1 (Table 2). This is attributable to the fact that a large number of sporocytes do not undergo reduction division and therefore, the number of spores does not multiply. This clearly indicates that although apparently, *C. conicum* seems to be well established under various habitats in the study area, all the populations are asexually propagated only. Although female receptacles were formed in 15 accessions, they reached maturity only in 3 and out of these too, a few viable spores are formed only in one.

**4. Population Status**

It can be inferred from the data obtained for various reproductive characters (female gametangia, sporocytes and spore-elater ratios) that there is minimal (if any) contribution of sexual reproduction to the variability recorded among various populations. In order to further assess the nature of variability, five populations of *C. conicum* collected from diverse habitats *i.e.*, epilithic (under dripping chilled water, under snow cover), non epilithic (moist shady soil, sandy soil) and epiphytic (*Cedrus deodara*) were subjected to Polyacrylamide gel electrophoresis for three enzyme systems (peroxidases, estrases and phosphatases). The zymograms, thus obtained revealed homogeneity in the occurrence of bands. A total of 6 bands were obtained for phosphatases (Figures 5(a)-(d)), 5 for esterases (Figures 5(e)-(f)), one



**Figures 5. Pictures of gels subjected to PAGE and explanatory figures thereof; Peroxidases (a-d), esterases (e,f) and phosphatase (g,h).**

for peroxidases (Figures 5(g) and (h)) in all the populations analyzed. Results thus obtained confirm our presumption that the variability recorded in the species is environmental and lacks any genetic basis.

Geissler *et al.* [20] laid down following five criteria to be fulfilled by a taxon before being termed threatened. a) It should be threatened worldwide, b) should be confined to a threatened habitat, c) should have a narrow range, d) should not be overlooked and/or over collected and e)

should have a unique morphology/biology or occupy a special evolutionary position.

## 5. Conclusions

Although *C. conicum* does not seem to satisfy criteria 1 - 4, populations studied exhibit unique reproductive biology. It can, therefore, be concluded that the species is threatened in Bhaderwah, as it has earlier been reported for Kumaon Himalaya.

## 6. Acknowledgements

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