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Lichen diversity assessment in Pindari Glacier Valley of Uttarakhand, India

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ABSTRACT

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Based on published literature, preserved lichen specimens at herbarium in National Botanical Research Institute, Lucknow (LWG), and recent collections made from the temperate and alpine areas, the lichen diversity of Pindari Glacier valley in Uttarakhand revealed the occurrence of 283 species belonging to 77 genera and 35 families. The area exhibits much diversity of all the growth forms of lichens and is represented by 117 foliose, 104 crustose and 50 fruticose taxa. The wide range of phorophytes supports rich diversity of bark inhabiting lichens represented by 131 species. Lichen family Parmeliaceae dominates the region and is commonly distributed among different sites of Pindari. *Caloplaca*, *Cladonia, Everniastrum* and *Phaeophyscia* are commonly distributed genera in the valley. The available information regarding lichen diversity provides baseline data which will be useful in conducting future biomonitoring studies and developing conservation strategies in the valley.

Key-words: Lichen diversity, Pindari Glacier, Bageshwar district, Kumaun Himalaya, Uttarakhand.

INTRODUCTION

Since the middle of the last century a considerable progress in taxonomic and floristic studies on Indian lichens was achieved that revealed the occurrence of more than 2300 species from India with high degree of endemism (Awasthi 2000, Singh et al. 2004, Singh & Sinha 2010). The diverse climate, broad array of vegetation, asymmetrical topography and unlimited substratum availability make India one of the lichen-rich countries, standing 5th in the world (Negi & Gadgil 1996). The Indian Himalaya is the centre of high levels of lichen diversity and represents a hot spot within India (Negi & Gadgil 1996). The Western Himalaya (including Central Himalaya) is placed third after Eastern Himalaya and Western Ghats in lichen species richness and exhibits 550 lichen species (Singh & Sinha 1997, Nayaka & Upreti 2005, Nayaka et al. 2009). Recently, Upreti and Joshi (2010) reevaluated the lichen wealth of Uttarakhand and mentioned an increase of 160 species that gives a total of more than 700 species currently inhabiting different localities of the state.

Awasthi (1975) provided the floristic account on lichens of Pindari Glacier catchment from Kapkote to Pindari Glacier and enumerated 122 species of lichens belonging to 38 genera and 18 families. Subsequently, Upreti and Chatterjee (2000) reported the occurrence of 64 epiphytic lichen species found growing on different trees enroute from Loharkhet to Dwali. Joshi et al. (2008) provided a comparative account on the effect of climate change on lichen flora of Pindari region in the last 30 years.

The present enumeration deals with the addition and changes in lichen species collected intensively by various workers during the last 30-35 years from the same area in different altitudes of Pindari Glacier valley.

Considering the necessity and values of glacier lichen flora, the present work is put forth to ensure the exact status of lichen diversity in the valley and to develop some measures regarding lichen conservation and sustainable utilization together with their use in long term environmental monitoring programmes.

MATERIAL AND METHOD

Survey and collection of lichens: A total of 800 specimens of lichens were collected during May, 2007 in the study area from lower to higher or vice-versa from Loharkhet to Pindari Glacier in the Bageshwar district of Uttarakhand. Pindari Glacier is placed at about 30°15.30" N and 79°13'–80°2" E. The British naturalist Strachey (1847) visited the valley for the first time and provided general description of the area. The roughly 'V' shaped Pindari Glacier valley is situated in Bageshwar district of Uttarakhand at an altitude that ranges from 1700 m to 3660 m. Loharkhet, Dhakuri, Khati, Dwali, Phurkia and Zero-point are the major localities enroute to Pindari Glacier surveyed for lichen collection (Text-figure 1, Plate 1). The vegetation of valley comprises of *Pinus*, *Acer*, *Juglans*, *Cupressus*, *Quercus* and *Rhododendron* in temperate to subalpine zone while area between Phurkia and Pindari Glacier is mostly devoid of trees and is occupied by alpine meadows. The macrolichen samples hanging on the trees or branches and from trunk were picked by hand while most of the crustose-foliose lichens tightly attached to bark and rock were collected with the help of chisel and hammer along with their ecological notes. The dried samples were packed on hard card sheets inside a lichen herbarium packet (17cm × 13cm) with details of the locality, date of collection and substratum and are preserved in the herbarium of the National Botanical Research Institute, Lucknow (LWG). The specimens collected earlier from the study area were also studied together with the fresh collection for preparation of the detailed inventory.

Identification: The morphological characters of the species were studied under dissecting binocular microscope. The anatomy of the thallus and apothecia was studied under compound microscope by cutting thin hand sections mounted in water or cotton blue. The literature provided by Awasthi (1988, 1991, 2000, 2007), Walker and James (1980) and Orange et al. (2001) were considered for the identification of specimens and lichen substances. The present enumeration is based on the recent classification of lichens followed by Singh and Sinha (2010).

RESULTS AND DISCUSSION

The route from Loharkhet to Pindari Glacier (approximately 45 km trek) exhibits occurrence of 283 species belonging to 77 genera and 35 families (Text-figure 2, Table 1), which constitutes more than 40% of the total lichen flora so far reported from Uttarakhand. The area shows much diversity of all the growth forms of lichens and is represented by the occurrence of 117 foliose followed by 104 crustose, 50 fruticose, 9 squamulose and 2 leprose taxa (Tables 2, 5). The probable reason for luxuriant growth of lichens in Pindari region may be the rich diversity of phorophytes and large moist, shady valleys that provide diverse habitats for many lichen genera to colonize.

The lichen family Parmeliaceae exhibits dominance in six localities followed by Cladoniaceae in two while Physciaceae and Pyrenulaceae dominate single locality (Table 3). Parmeliaceae and Physciaceae are spread over ten localities out of the total eleven surveyed sites. Cladoniaceae, Peltigeraceae, Ramalinaceae and Teloschistaceae show their presence in nine localities. While Collemataceae, Lecanoraceae and Stereocaulaceae are distributed in eight localities. Each of the families Acarosporaceae, Arthoniaceae, Coniocybaceae, Haematommataceae, Ichmadophilaceae, Lecideaceae, Pannariaceae, Rhizocarpaceae, Sphinctrinaceae and Trapeliaceae is restricted to single locality (Table 1).

Among the different genera, *Cladonia* and *Lecanora* show dominance over three localities followed by *Leptogium* in two and *Anthracothecium* in a single locality (Table 3). The species of lichen genera *Caloplaca*, *Cladonia*, *Everniastrum* and *Phaeophyscia* are the commonly distributed in nine localities followed by *Heterodermia*, *Leptogium*, *Peltigera*, *Stereocaulon* and *Usnea* in eight localities. More than 20 genera have restricted distribution in a

Table 1. An enumeration of lichens from Pindari Glacier valley.

Name of taxa	1	2	3	4	5	6	7	8	9	10	11
ACAROSPORACEAE											
Acarospora veronensis Massal.										+	
Sarcogyne privigna (Ach.) Massal.										+	
ARTHONIACEAE											
Arthothelium chiodectoides (Nyl.) Zahlbr.								+			
CALICIACEAE											
Buellia aethalea (Ach.) Th. Fr.	+										
Calicium subquercinum Asah.				+							
Dirinaria confluens (Fr.) D. D. Awasthi								+			
CANDELARIACEAE											
Candelaria concolor (Dicks.) Stein	+				+						
Candelaria indica (Hue) Vain.								+			
Candelariella vitellina (Hoffm.) Müll. Arg.									+	+	
CHRYSOTHRICACEAE											
Chrysothrix candelaris (L.) Laundon				+		+					
CLADONIACEAE											
Cladonia cartilaginea Müll. Arg.	+						+			+	
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.			+						+	+	
Cladonia coccifera (L.) Willd.									+		
Cladonia coniocraea (Flörke) Spreng.								+			
Cladonia corniculata Ahti & Kashiw.		+				+					
Cladonia corymbescens Nyl. ex Leight.		+		+		+	+		+	+	
Cladonia delavayi Abbayes										+	
Cladonia didyma (Fée) Vain.				+							
Cladonia fenestralis Nuno								+		+	
Cladonia fimbriata (L.) Fr.		+									
Cladonia furcata (Huds.) Schrad.		+	+					+			
Cladonia macroptera Räs.										+	
Cladonia pocillum (Ach.) Grognot								+	+	+	
Cladonia pyxidata (L.) Hoffm.								+	+	+	
Cladonia scabriuscula (Del.) Leight.								+			
Cladonia singhii Ahti & Dixit						+					
Cladonia squamosa Hoffm.											
Cladonia subulata (L.) Web. ex Wigg.								+			
Cladonia verticillata (Hoffm.) Schaer.		+									
COCCOCARPIACEAE											
Coccocarpia erythroxyli (Spreng.) Swinsc. & Krog									+		
COLLEMATACEAE											
Collema auriculiforme (With.) Coppins & J. R. Laundon										+	
Collema coccophorum Tuck.	+										
Collema crispum (Huds.) G. H. Web.										+	
Collema pulcellum Ach. var. subnigrescens (Müll. Arg.) Degel.	+	+									
Collema subconveniens Nyl.		+									
Collema subnigrescens Degel.	+										
Leptogium asiaticum P. M. Jorg.		+	+	+							

Leptogium askotense D. D. Awasthi		+									
Leptogium burgessii (L.) Mont.						+					
Leptogium burnetiae Dodge	+	+	+	+		+		+		+	
Leptogium cyanescens (Rabenh.) Körb.	+						+				
Leptogium delavayi Hue	+		+	+							
Leptogium furfuraceum (Harm.) Sierk		+									
Leptogium javanicum Mont.		+									
Leptogium pedicellatum P. M. Jorg.		+	+	+		+				+	
Leptogium saturninum (Dicks.) Nyl.		+									
Leptogium trichophorum Müll. Arg.	+	+	+	+		+					
CONIOCYBACEAE											
Coniocybe coniophaea Norm.						+					
GRAPHIDACEAE											
Graphis chlorotica Massal & Kremp.								+			
Graphis scripta (L.) Ach.		+	+		+						
Graphis proserpens Vain.			+	+		+		+			
HAEMATOMMATACEAE											
Haematomma puniceum (Sw.) A. Massal.		+									
ICHMADOPHILACEAE											
Thamnolia vermicularis (Sw.) Schaer. var. *vermicularis*										+	
MEGASPORACEAE											
Aspicilia almorensis Räs.				+				+			
Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold			+					+	+	+	
Aspicilia calcarea (L.) Körb.	+					+				+	
Aspicilia cinerea (L.) Körb.				+							
Aspicilia dwaliensis Räs.								+	+	+	
Aspicilia griseocinerea Räs.	+					+					
Lobothallia alphoplaca (Wahlenb. in Ach.) Poelt & Leuckert										+	
Lobothallia praeradiosa (Nyl.) Hafellner										+	
LECANORACEAE											
Lecanora alba Lumbsch	+		+	+		+					
Lecanora campestris (Schaer.) Hue subsp. *campestris*					+						
Lecanora cenisia Ach.	+					+					
Lecanora cinereofusca var. *cinereofusca* H. Magn.	+			+	+	+					
Lecanora cinereofusca var. *himalayensis* Upreti	+				+	+					
Lecanora fimbriatula Stirt.		+		+	+	+					
Lecanora flavidofusca Müll. Arg.								+			
Lecanora formosula Lumbsch						+					
Lecanora garovaglii (Körb) Zahlbr.										+	
Lecanora henssenii Vänskä						+					
Lecanora impudens Degel.						+					
Lecanora imshaugii Brodo.		+									
Lecanora interjecta Müll. Arg.						+					
Lecanora japonica Müll. Arg.				+		+		+			
Lecanora meridionalis H. Magn.		+									
Lecanora muralis var. *dubyi* (Müll. Arg.) Poelt											+
Lecanora muralis var. *muralis* (Schreb.) Rabenh. *em.* Poelt										+	+

Lecanora perplexa Brodo	+									
Lecanora phaedrophthalma Poelt										+
Lecanora subimmersa (Fée) Vain.	+			+		+				+
Lecanora subrugosa Nyl.		+		+		+				
Miriquidica mexicana Rambold, Sipman ex Hertel										+
Rhizoplaca chrysoleuca (Sm.) Zopf										+
LECIDEACEAE										
Lecidea paratropoides Müll. Arg.										+
LOBARIACEAE										
Lobaria isidiosa (Müll. Arg.) Vain.		+	+							
Lobaria kurokawae Yoshim.		+	+	+						+
Lobaria meridionalis Vain.						+				
Lobaria pseudopulmonaria Gyeln.										+
Lobaria retigera (Bory) Trev.	+	+	+	+		+		+		+
Sticta damaecornis (Sw.) Ach.				+				+		
Sticta nylanderiana Zahlbr.		+	+	+		+				
Sticta platyphylloides Nyl.		+								
Sticta praetextata (Räs.) D. D. Awasthi				+				+		
NEPHROMATACEAE										
Nephroma helveticum Ach.			+			+				
OCHROLECHIACEAE										
Ochrolechia pallescens (L.) Mass.			+							
Ochrolechia subpallescens Vers.			+							
Ochrolechia yasudae var. ***corallina*** Poelt		+								
PANNARIACEAE										
Fuscopannaria saltuensis P. M. Jørg.		+								
PARMELIACEAE										
Bryoria bicolor (Ehrh.) Brodo & D. Hawksw.			+							
Bryoria confusa (D. D. Awasthi) Brodo & D. Hawksw.		+					+			
Bryoria smithii (Du Rietz) Brodo & D. Hawksw.		+	+							
Bulbothrix isidiza (Nyl.) Hale		+								+
Bulbothrix meizospora (Nyl.) Hale		+	+			+		+		
Bulbothrix sensibilis (J. Steiner & Zahlbr.) Hale	+			+						
Bulbothrix setschwanensis (Zahlbr.) Hale		+				+				
Canoparmelia texana (Tuck.) Elix & Hale	+									
Cetraria islandica Ach.									+	+
Cetrelia braunsiana (Müll. Arg.) W. L. Culb. & C. F. Culb.		+	+	+		+			+	
Cetrelia cetrarioides (Del. ex Duby) W. Culb. & C. F. Culb.		+	+	+		+		+		
Cetrelia olivetorum (Nyl.) W. L. Culb. & C. F. Culb.				+		+		+		
Cetreliopsis rhytidocarpa (Mont. & v.d. Bosch) M. J. Lai subsp. ***rhytidocarpa***		+				+				
Everniastrum cirrhatum (Fr.) Hale ex Sipman		+	+	+	+	+		+		+
Everniastrum nepalense (Taylor) Hale	+	+	+	+			+	+		
Flavocetraria cucullata (Bell.) Kärnefelt & Thell									+	
Flavocetrariella leucostigma (Lév.) D. D. Awasthi										+
Flavocetrariella melaloma (Nyl.) D. D. Awasthi										+
Flavoparmelia caperata (L.) Hale				+		+				
Hypotrachyna adducta (Nyl.) Hale						+				

Hypotrachyna awasthii Hale & Patw. +
Hypotrachyna crenata (Kurok.) Hale +
Hypotrachyna infirma (Kurok.) Hale +
Hypotrachyna osseoalba (Vain.) Y. S. Park & Hale + +
Hypotrachyna physcioides (Nyl.) Hale +
Hypotrachyna pluriformis (Nyl.) Hale + +
Hypotrachyna radiculata (Kurok.) Elix +
Hypotrachyna scytophylla (Kurok.) Hale + + + +
Myelochroa aurulenta (Tuck.) Elix. & Hale + +
Myelochroa macrogalbinica Divakar, Upreti & Elix +
Myelochroa metarevoluta (Asah.) Elix & Hale
Myelochroa subaurulenta (Nyl.) Elix & Hale + + +
Myelochroa upretii Divakar & Elix +
Myelochroa xantholepis (Mont. & Bosch) Elix & Hale +
Nepromopsis nephromoides (Nyl.) Ahti & Randl. + +
Nephromopsis pallescens (Schaer.) Park + + + + +
Nephromopsis stracheyi (Bab.) Müll. Arg. + + +
Parmelaria subthomsonii D. D. Awasthi +
Parmelaria thomsonii (Stirt.) D. D. Awasthi + +
Parmelia marmariza Nyl. +
Parmelia meiophora Nyl.
Parmelinella wallichiana (Taylor) Elix & Hale + + + + + + +
Parmotrema direagens (Hale) Hale +
Parmotrema eunetum (Stirt.) Hale +
Parmotrema grayanum (Hue) Hale + +
Parmotrema indicum Hale +
Parmotrema nilgherrense (Nyl.) Hale + + + + +
Parmotrema praesorediosum (Nyl.) Hale + +
Parmotrema reticulatum (Taylor) Choisy + + +
Parmotrema sancti- angelii (Lynge) Hale +
Sulcaria sulcata (Lév) Bystr. ex Brodo & D. Hawksw. + +
Tuckneraria laureri (Kremp.) Randl. & Thell. +
Usnea compressa Taylor + + + + +
Usnea eumitrioides Mot. +
Usnea longissima Ach. + + + + + +
Usnea nepalensis G. Awasthi + +
Usnea orientalis Mot. + + +
Usnea pangiana Stirt. +
Usnea perplexans Stirt. + +
Usnea robusta Stirt. +
Usnea sordida Mot. + +
Usnea splendens Stirt. + + +
Usnea thomsonii Stirt. + +
Usnea undulata Stirt. +
PELTIGERACEAE
Peltigera canina (L.) Willd. + + + + +
Peltigera didactyla (With.) J. R. Laundon +

Peltigera dolichorrhiza (Nyl.) Nyl.		+		+							
Peltigera polydactylon (Neck.) Hoffm.		+		+		+					
Peltigera praetextata (Flörke) Zopf				+	+	+					
Peltigera rufescens (Weiss) Humb.			+	+	+	+			+		
Solorina simensis Hochst.						+		+	+		
PERTUSARIACEAE											
Pertusaria albescens var. ***albescens*** (Huds.) M. Choisy & Werner			+			+					
Pertusaria bryontha (Ach.) Nyl.						+					
Pertusaria coronata (Ach.) Th. Fr.	+		+	+							
Pertusaria kodaikanalensis Choisy						+					
Pertusaria leucosora Nyl.				+		+					
Pertusaria leucosorodes Nyl.	+	+									
Pertusaria multipuncta (Turn.) Nyl.				+		+					
Pertusaria quassiae (Fée) Nyl.	+	+									
PHYSCIACEAE											
Heterodermia albidiflava (Kurok.) D. D. Awasthi						+					
Heterodermia angustiloba (Müll. Arg.) D. D. Awasthi	+			+		+		+			
Heterodermia boryi (Fée) Kr. P. Singh & S. R. Singh		+	+	+							+
Heterodermia dactyliza (Nyl.) Swinsc. & Krog			+			+		+			
Heterodermia diademata (Taylor) D. D. Awasthi	+	+	+	+		+		+			
Heterodermia dissecta var. ***koyana*** (Kurok.) J.C. Wei	+					+					+
Heterodermia firmula (Nyl.) Trevis.		+									
Heterodermia hypocaesia (Yasuda) D. D. Awasthi				+		+	+	+			
Heterodermia incana (Stirt.) D. D. Awasthi			+	+							
Heterodermia japonica (Satô) Swinsc. & Krog						+					
Heterodermia leucomelos (L.) Poelt		+									
Heterodermia microphylla (Kurok.) Skorepa						+		+			
Heterodermia obscurata (Nyl.) Trevisan			+								
Heterodermia pseudospeciosa (Kurok.) W. Culb.						+					
Heterodermia rubescens (Räs.) D. D. Awasthi	+										
Heterodermia tremulans (Müll. Arg.) W. Culb.											+
Hyperphyscia syncolla (Tuck. ex Nyl.) Kalb						+					+
Phaeophyscia ciliata (Hoffm.) Moberg											+
Phaeophyscia endococcina (Körb.) Moberg	+						+		+		+
Phaeophyscia hispidula (Ach.) Moberg	+		+	+		+	+	+			
Phaeophyscia nepalensis (Poelt) D. D. Awasthi						+					
Phaeophyscia pyrrhophora (Poelt) D. D. Awasthi & M. Joshi		+	+								
Physcia caesia (Hoffm.)Fürnr											+
Physcia dilatata Nyl.				+	+						
Physcia phaea (Tuck.) Thoms.											+
Pyxine himalayensis D. D. Awasthi	+	+									
Pyxine minuta Vain.	+										
Pyxine sorediata (Ach.) Mont.	+	+		+							
Pyxine subcinerea Stirt.	+			+							
PORPIDIACEAE											
Porpidia albocoerulescens (Wulf.) Hertel & Knoph in Hertel						+		+			+
Porpidia macrocarpa (DC.) Hertel & Schwab.						+			+		

PYRENULACEAE									
Anthracothecium depressum Müll. Arg.				+	+				
Anthracothecium himalayense (Räs) D.D. Awasthi		+		+					
Anthracothecium himalayense var. ***pseudohimalayense*** (A. Singh) A. Singh		+			+				
Anthracothecium manipurense Müll. Arg.					+				
Anthracothecium platystomum Müll. Arg. var. ***platystomum***		+			+				
Anthracothecium platystomum var. ***papillatum*** A. Singh & Upreti		+		+	+				
Anthracothecium thwaitesii (Leight.) Müll. Arg.			+	+	+				
Lithothelium himalayense Upreti & Aptroot			+	+					
Pyrenula glabrescens Vain.			+						
Pyrenula globifera (Eschw.) Müll. Arg.				+					
Pyrenula immisa (Stirt.) Zahlbr.		+							
Pyrenula introducta (Stirt.) Zahlbr.		+	+						
Pyrenula neoculata Aptroot		+							
Pyrenula pinguis Fée		+							
Pyrenula subumbilicata (C. Knight) Aptroot		+	+		+				
RAMALINACEAE									
Bacidia alutacea (Kremp.) Zahlbr.					+				
Bacidia incongruens (Stirt.) Zahlbr.		+							
Bacidia laurocerasi (Del. ex Duby) Zahlbr.			+						
Bacidia millegrana (Taylor) Müll. Arg.							+		
Bacidia nigrofusca (Müll. Arg.) Zahlbr.			+		+				
Bacidia phaeolomoides (Müll. Arg.) Zahlbr.			+						
Bacidia rosella (Pers.) De Not.		+							
Bacidia rubella (Hoffm.) Massal.				+					
Phyllopsora catervisorediata G.K. Mishra, Upreti & Nayaka					+		+		
Phyllopsora corallina var. ***subglaucella*** G. K. Mishra, Upreti &Nayaka	+		+						
Phyllopsora parvifolia (Pers.) Müll. Arg.		+				+			+
Ramalina conduplicans Vain.		+	+		+		+		
Ramalina sinensis Jatta		+	+		+	+	+		
RHIZOCARPACEAE									
Rhizocarpon badioatrum (Flörke ex Spreng.) Th. Fr.									+
Rhizocarpon geographicum (L.) DC.									+
Rhizocarpon macrosporum Räs.									+
Rhizocarpon sublucidum Räs.									+
SPHINCTRINACEAE									
Sphinctrina tubaeformis Massal.					+				
STEREOCAULACEAE									
Lepraria lobificans Nyl.			+						
Lepraria vouauxii (Hue) R.C. Harris								+	
Stereocaulon foliolosum var. ***botryophorum*** (Müll. Arg.) I. M. Lamb		+					+		
Stereocaulon foliolosum var. ***strictum*** (Bab.) I. M. Lamb		+	+		+		+	+	+
Stereocaulon glareosum (Sav.) H. Magn.		+					+		+
Stereocaulon himalayense D. D. Awasthi & I. M. Lamb									+
Stereocaulon myriocarpum Th. Fr.			+		+				+
Stereocaulon paradoxum I. M. Lamb		+							
Stereocaulon piluliferum Th. Fr.		+	+	+					+

Stereocaulon pomiferum Duvign.		+				+				+	
TELOSCHISTACEAE											
Caloplaca approximata (Lynge) Magnusson		+	+	+	+					+	
Caloplaca cinnabarina (Ach.) Zahlbr.	+	+									
Caloplaca citrina (Hoffm.) Th. Fr.						+		+			
Caloplaca cupulifera (Vain.) Zahlbr.	+	+									
Caloplaca flavocitrina (Nyl.) H. Olivier						+					
Caloplaca flavorubescens (Huds.) Laundon				+		+					
Caloplaca flavovirescens (Wulf.) Dalla Torre & Sarnth.				+		+		+			
Caloplaca lithophila H. Magn.			+		+						
Caloplaca obliterans (Nyl.) Blomb. & Forss.						+		+	+		
Caloplaca ochroplaca Poelt & Hinter.				+	+	+				+	
Caloplaca pachychelia Poelt & Hinter.										+	
Caloplaca pyracea (Ach.) Th. Fr.					+						
Caloplaca saxicola (Hoffm.) Nordin									+	+	
Caloplaca subbassiae Y. Joshi & Upreti	+										
Caloplaca triloculans Zahlbr.				+							
Ioplaca pindarensis (Räs) Poelt & Hinter.		+	+	+	+	+					
Xanthoria elegans (Links.) Th. Fr.										+	
Xanthoria sorediata (Vain.) Poelt										+	
TEPHROMELACEAE											
Tephromela atra (Huds.) Hafellner in Kalb										+	
Tephromela khatiensis (Räs.) Lumbsch		+		+		+					
THELOTREMATACEAE											
Diploschistes awasthii Pant & Upreti									+		
Diploschistes diacapsis (Ach.) Lumbsch										+	
Diploschistes gypsaceus (Ach.) Zahlbr.									+		
Diploschistes scruposus (Schreb.) Norman	+					+		+		+	
TRAPELIACEAE											
Trapelia coarctata (Sm.) M. Choisy						+					
UMBILICARIACEAE											
Umbilicaria indica Frey			+			+				+	
VERRUCARIACEAE											
Dermatocarpon miniatum (L.) W. Mann var. *miniatum*				+		+		+	+		
Dermatocarpon vellereum Zschacke	+					+					
Endocarpon nigrozonatum A. Singh and Upreti (Verrucariaceae)				+							
Endocarpon subrosettum A. Singh & Upreti										+	
Verrucaria acrotella Ach.				+		+					
Total	**45**	**96**	**59**	**89**	**27**	**104**	**13**	**56**	**23**	**70**	**2**

Abbreviations: 1-Loharkhet, 2-Loharkhet to Dhakuri, 3-Dhakuri, 4-Dhakuri to Khati, 5-Khati, 6-Khati to Dwali, 7-Dwali, 8-Dwali to Phurkia, 9-Phurkia, 10-Phurkia to Pindari, 11-Pindari Glacier.

single locality (Table 1). Few lichen species were found growing luxuriantly and flourished well in some localities of temperate and alpine regions of Pindari irrespective of their distribution pattern (Plate 2).

The valley bears higher number of bark inhabiting lichens represented by 131 species growing exclusively on bark and tree trunk followed by 79 saxicolous and 21 terricolous lichens. A single taxon, *Sphinctrina tubaeformis* Massal., is known in parasitic mode of habitat (Table 4).

The rough bark of old *Quercus* and smooth barked young *Quercus*, *Juglans*, *Acer* and *Betula* trees provide varied niches to many lichens and integrate the epiphytic diversity of Pindari lichens. The presence of lichen genus *Anthracothecium* and *Pyrenula* clearly elucidates the thinned out forest canopy and exposed habitats with many young and smooth barked trees of the localities. Most of the members of lichen family Pyrenulaceae and Parmeliaceae are light loving and prefer to grow in exposed, sunlit surfaces. The fell-fields on the bank of Pindari river support many moisture loving saxicolous species of *Leptogium* and *Collema*.

Based on the altitude, the study area can be demarcated in two zones. The altitude above 3000 m belongs to the alpine regions while the localities from 1700 m to 3000 m fall under temperate areas. Phurkia, route from Phurkia to Pindari Glacier and Pindari Glacier come under alpine region while Loharkhet, route from Loharkhet to Dhakuri, Dhakuri, route from Dhakuri to Khati, Khati, route from Khati to Dwali, Dwali and route from Dwali to Phurkia belong to temperate- subalpine region. The trail from Phurkia to Pindari glacier exhibits maximum alpine lichen diversity represented by 70 species followed by Phurkia with 23 and Pindari Glacier with 2 species. However overall lichen diversity of alpine zone is represented by 82 species with dominance of saxicolous and terricolous lichens. Among temperate localities, the trail between Khati and Dwali has the maximum diversity of lichens

Table 2. Diversity of lichens in Pindari Glacier valley based on habit.

Growth form	Number of species
Crustose (Cr)	104
Foliose (F)	117
Fruticose (Fr)	50
Squamulose (Sq)	9
Leprose (Lep)	2
Unorganized thallus (UO)	1

represented by 104 species followed by Loharkhet to Dhakuri and Dhakuri to Khati with 96 and 89 species respectively. The total lichen diversity of temperate (including subalpine) region is represented by 201 species.

The localities in and around Khati, Dwali, Phurkia and Pindari Glacier reveal the poor lichen diversity represented by 27, 13, 23 and 2 species respectively (Tables 1, 5). The poor growth of lichens in Khati, Dwali and Phurkia may be attributed to the fact that these localities are situated near the village and Rest Houses and face heavy anthropogenic pressures due to villagers, tourists and trekkers who visit the glacier every year. The area adjacent to the Pindari Glacier snout is highly disturbed due to frequent landslide and recurrent snowfall. The unstable environment and ice covered rocks diminish the possible growth of lichens near the glacier snout and only species of lichen genus *Lecanora* are able to colonize in such habitats.

The exposed open alpine region in the vicinity of Pindari Glacier from Phurkia to Pindari exhibits is maximum number of 43 saxicolous lichens followed by 28 species enroute Khati to Dwali that represents the transition zone from temperate to alpine with mixed substrate composition of bark, rock and soil.

The distribution of crustose and foliose lichens in the forests between Khati and Dwali is maximum with 43 and 46 species followed by Dhakuri to Khati having 30 and 44 species respectively. Both the sites have a steep elevation gradient with abrupt change in climate

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Plate 1

1-6. Localities surveyed for lichen collection enroute to Pindari Glacier. 1. Loharkhet. 2. Dhakuri. 3. Khati. 4. Dwali. 5. Phurkia to Pindari route. 6. Pindari Glacier.

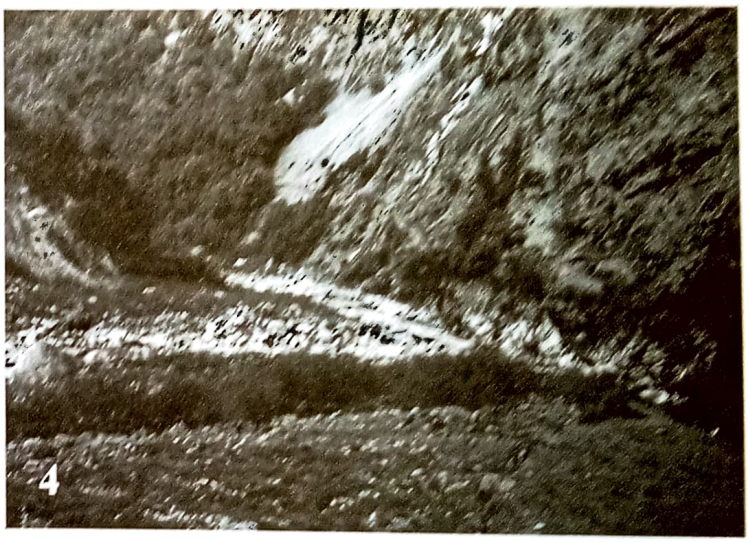
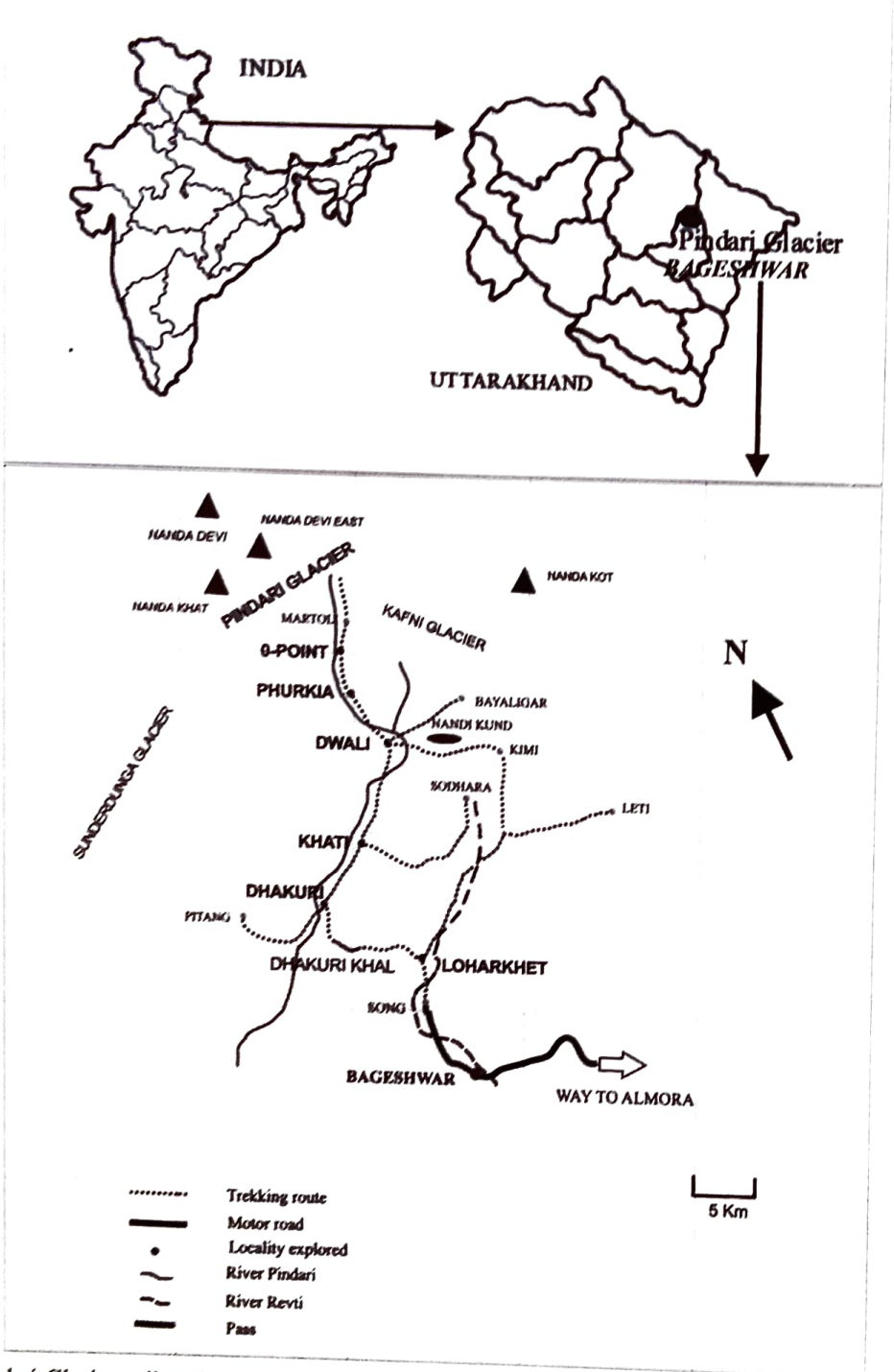


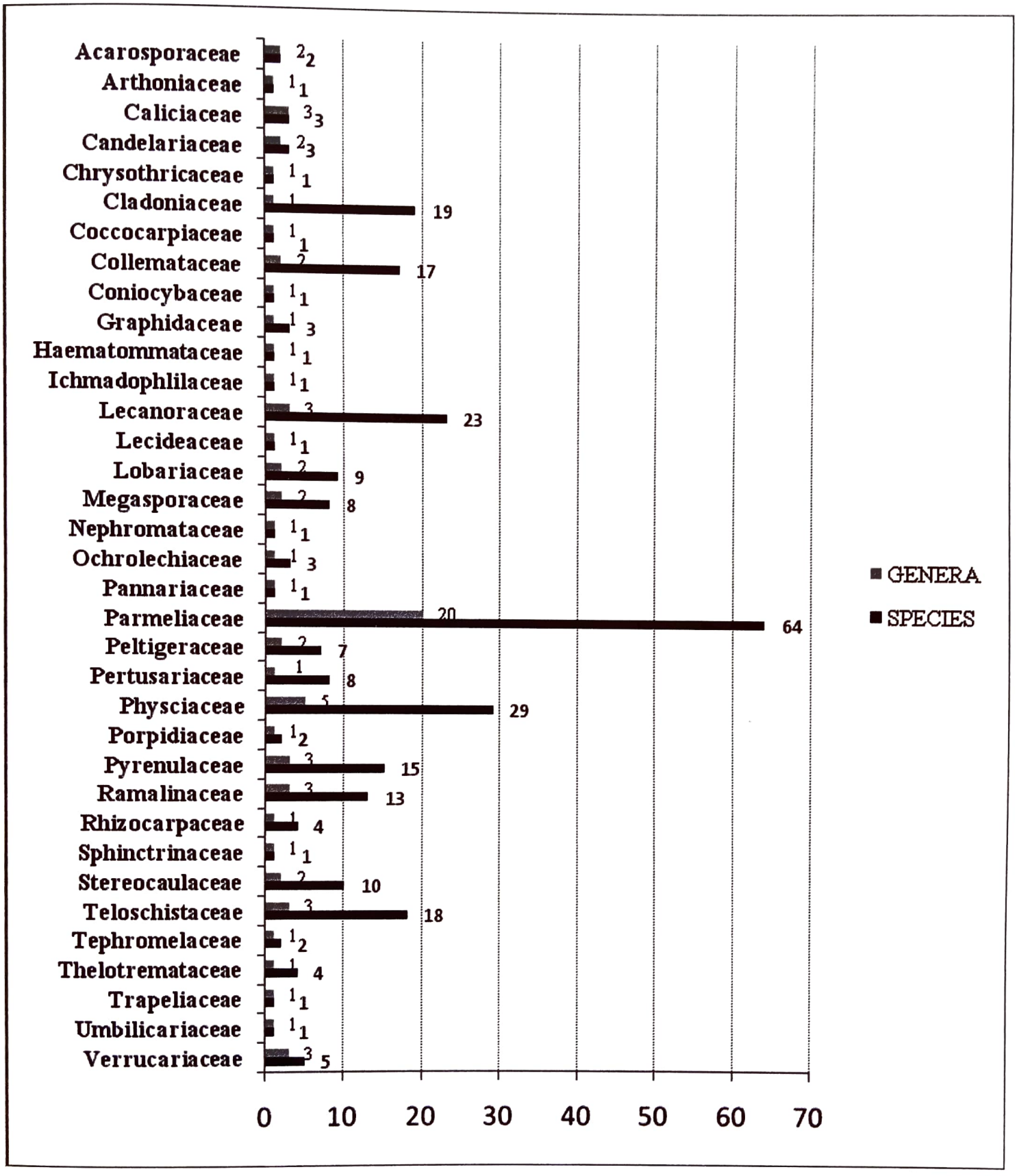
Plate 1



Text-figure 1. Map of Pindari Glacier valley showing collection sites.

and forest composition that supports luxuriant growth of lichens. On way to Dhakuri from Loharkhet, the dense canopy forests, crevices, and undersides of large boulders along the trekking sides provide wet and moist conditions for many soil loving dimorphic species of *Cladonia* and *Stereocaulon*. Dimorphic taxa together with light loving pendulous species of *Bryoria* and *Usnea* constitute the maximum number of 49 fruticose lichens in the site. The dense forest canopy and understorey vegetation of the area support 53 bark inhabiting lichens followed by 49 in Khati to Dwali and 46 in Dhakuri to Khati.

The observation based on the survey of Pindari sites stated that local people in the region are largely dependent on the forest resources for their daily needs and this induces some activities such as lopping and pruning of twigs, bark and wood for fodder and kitchen fuel. Besides these activities, the villagers also indulge



Text-figure 2. Generic and species composition of lichens per family in Pindari Glacier valley.

Table 3. Dominant lichen genera and families of Pindari Glacier valley.

Localities	Dominant genera	Dominant families
Loharkhet	*Lecanora* (6), *Heterodermia* (4), *Leptogium* (4), *Pyxine* (4)	Physciaceae (10), Collemataceae (7), Parmeliaceae (7)
Loharkhet to Dhakuri	*Leptogium* (8), *Parmotrema* (6), *Stereocaulon* (6), *Usnea* (6), *Cladonia* (5), *Pyrenula* (5)	Parmeliaceae (33), Collemataceae (10), Pyrenulaceae (9), Physciaceae (7), Stereocaulaceae (6)
Dhakuri	*Heterodermia* (5), *Leptogium* (5), *Usnea* (5)	Parmeliaceae (22), Physciaceae (7), Collemataceae (5)
Dhakuri to Khati	*Lecanora* (6), *Usnea* (6), *Caloplaca* (5), *Heterodermia* (5), *Leptogium* (5), *Peltigera* (5)	Parmeliaceae (25), Physciaceae (9), Lecanoraceae (6), Ramalinaceae (6), Teloschistaceae (6), Collemataceae (5), Lobriaceae (5), Peltigeraceae(5), Pyrenulaceae (5)
Khati	*Anthracothecium* (4), *Caloplaca* (4), *Lecanora* (4)	Pyrenulaceae (6), Teloschistaceae (5), Lecanoraceae (4), Parmeliaceae (4)
Khati to Dwali	*Lecanora* (12), *Heterodermia* (9), *Anthracothecium* (6), *Caloplaca* (6)	Parmeliaceae (22), Lecanoraceae (12), Physciaceae (12), Pyrenulaceae (7), Teloschistaceae(7)
Dwali	-	Parmeliaceae(4), Physciaceae (3)
Dwali to Phurkia	*Cladonia* (7), *Heterodermia* (5), *Usnea* (4)	Parmeliaceae(14), Cladoniaceae (7), Physciaceae (6)
Phurkia	*Cladonia* (5)	Cladoniaceae (5), Parmeliaceae (4)
Phurkia to Pindari glacier	*Cladonia* (8), *Stereocaulon* (6), *Caloplaca* (4), *Rhizocarpon* (4)	Cladoniaceae (8), Physciaceae (8), Lecanoraceae (6), Parmeliaceae (6), ,Stereocaulaceae (6), Teloschistaceae (6), Megasporaceae(5)
Pindari glacier	-	-

in collection of medicinal herbs and shrubs along with lichens which are sold to markets in the foothill areas of Kumaun Himalaya for their commercial exploitation (Upreti et al. 1995, Kumar 2009). However, the overall causative factors which directly or indirectly affect the loss of lichen biodiversity of Pindari valley are: negligence of lichen taxonomy, shortage of lichen taxonomist in India, deforestation for better access to modern means of livelihood (construction of buildings, dams and roads, agriculture, urbanization, mineral extraction, hydroelectrical projects, shifting cultivation), lack of awareness and inadequate technical understanding of the importance of biodiversity, outmigration of educated mass in the hills, forest fire, grazing, trading, natural disasters (landslides and cloud bursts), ambiguity in the exact status of lichen diversity due to lack of inventories, floras, database and periodic monitoring, insufficient funding for making inventory of lower plant groups, forest disturbance due to tourists interference, celebration of rituals and ceremonies in sacred grooves, and unplanned strategies for forest conservation with no link to the socioeconomic development of local communities depending on forest resources for their livelihood.

Table 4. Diversity of lichens in Pindari Glacier valley based on habitat.

Habitat	Total no.
Corticolous taxa (C)	131
Saxicolous taxa (S)	79
Terricolous taxa (T)	21
Cort.,saxi. (CS)	20
Corti., terri. (CT)	6
Saxi., terri. (ST)	7
Corti., saxi., corti., terri. (CST)	11
Corti., saxi., terri., musci. (CSTM)	3
Corti., terri., musci. (CTM)	1
Terri., musci. (TM)	1
Ligni, terri. (TL)	1
Parasitic (P)	1
Muscicolous (M)	1
Total	**283**

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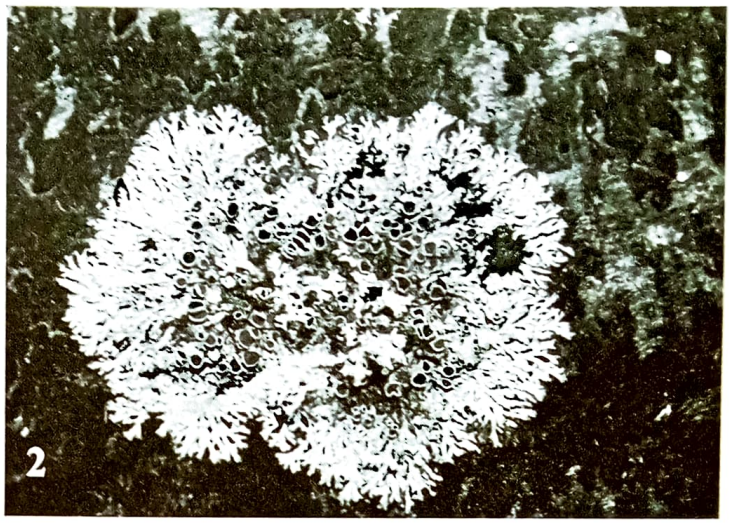
Plate 2

1-6. Lichens of Pindari Glacier valley. 1. *Bulbothrix meizospora* (Nyl.) Hale. 2. *Heterodermia diademata* (Taylor) D. D. Awasthi. 3. *Lecanora muralis* var. *muralis* (Schreb.) Rabenh. em. Poelt. 4. *Lobothallia praeradiosa* (Nyl.) Hafellner. 5. *Sticta nylanderiana* Zahlbr. 6. *Rhizocarpon geographicum* (L.) DC.



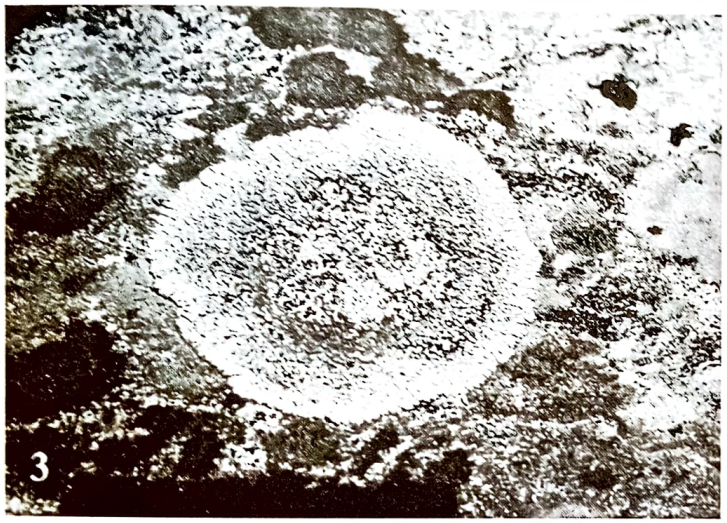


Plate 2

Table 5. Distribution of lichens in different localities of Pindari Glacier valley.

PINDARI VALLEY	Altitude in /m	GF	GF	GF	GF	GF	GF	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB	HAB
Localities		Cr	F	Fr	Sq	Lep	UO	C	S	T	CS	CT	ST	CST	CSTM	M	CTM	TL	TM	P
Loharkhet	1760	16	27	1	1	-	-	15	15	1	8	-	-	4	1	-	1	-	-	-
Loharkhet-Dhakuri	1760-2683	25	21	49	1	-	-	53	14	5	9	4	3	6	1	-	1	-	-	-
Dhakuri	2683	11	32	15	1	-	-	32	10	1	3	2	3	5	2	-	1	-	-	-
Dhakuri-Khati	2683-2210	30	44	12	2	1	-	46	16	2	9	4	1	8	2	-	1	-	-	-
Khati	2210	17	8	2	-	-	-	13	10	-	1	-	-	3	-	-	-	-	-	-
Khati-Dwali	2210-2734	43	46	13	1	-	1	49	28	2	9	2	4	7	1	-	1	-	-	1
Dwali	2734	-	8	4	1	-	-	6	1	1	2	1	-	2	-	-	-	-	-	-
Dwali-Phurkia	2734-3210	14	26	15	1	-	-	26	10	6	4	1	3	4	1	-	-	1	-	-
Phurkia	3210	8	6	8	-	1	-	2	9	5	-	2	2	2	-	1	-	-	-	-
Phurkia-Pindari glacier	3210-3660	23	23	19	5	-	-	4	43	8	1	3	3	4	2	-	-	1	1	-
Pindari glacier	3660	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-

CONCLUSION

Pindari Glacier valley provides ideal conditions for the growth of different plant groups, including lichens, in their specific ecological amplitudes. It has always been of great concern and purpose to document and enumerate the lichen flora in the area with high altitudinal gradient where the particular species have the limited environmental range. A slight change in the immediate environment may lead lichens either to extinction or shift their place or habitat. The long term periodic monitoring of lichens in a particular region depicts the effect of changing environmental conditions on restoration or deterioration of target species. Enumeration of lichens in Pindari Glacier valley is helpful to find out the exact status of lichens in the valley along with the present condition of forests. Creation of new strategies for lichen biodiversity assessment, other than the traditional species richness evaluation which is slow and time taking process, will further hasten the diversity assessment process of the valley. The current scenario of climate change makes it essential to prepare database and maintain records of floras in the areas sensitive to environmental changes. Glacier valleys are among the most sensitive indicators of climate change. Therefore the preliminary assessment of lichens in the Pindari Glacier valley provides baseline information regarding species composition and distribution pattern of lichens which will be helpful for conducting future biomonitoring studies in the area to measure the effect of global warming on plant components in the valley.

Dhar et al. (2001) and Upreti and Nayaka (2008) mentioned some themes and plans regarding biodiversity conservation that can also be effective in context of lichen conservation strategies and planning in Pindari Glacier valley like constitution of task force to facilitate the inventorization of floras, ex-situ conservation (lichen gardens, sanctuaries and national parks), conservation planning accompanied by social concern, creation of database, biological screening of RET species, collaboration of leading institutes, universities, colleges and unanimous political, financial, technical, social and cultural support.

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