Ecological, Social and Commercial Role of Lichens in India with Special Reference to Garhwal Himalayas

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Preface

The Himalayas has been a perennial source of attraction, curiosity and challenge to human intellect throughout the ages. Amongst several assets the investigation provides and everlasting and interesting field of investigation. The diversity copiousness as well as uniqueness of the plant components in various habitats retained sound and aesthetic environment of the study area. However in the recent past a couple of decades excessive exploitation of vegetation, unplanned land use, natural disasters and several developmental processes, accelerated deterioration of biodiversity and harmonious ecosystem of the Himalaya.

Forest resources of the Himalayas are shrinking in size due to over-exploitation and there is increased interest to protect, manage and make them more protective. This requires essentially the knowledge of their population status, production behaviour and rate of utilization on unit area basis. The human influences on lichen diversity and other biodiversity and ecosystem functioning have largely taken form of rapid, large and frequent changes in land and resource use, increased frequency of biotic invasion, reduction of species number, creation of stresses and potential for changes in climate system.

This book is primarily based on the publication of various research papers and collection made by my previous work and references may be found in available literature. The specimens described in this volume were mostly collected during various excursions to Garhwal Himalaya.

This book is complied into eleven chapters. Chapter first (1) introduction deals with need of inventorying and monitoring of lichens of Garhwal Himalaya, historical background of lichens and detailed description about the Garhwal Himalayas. The chapter ends with the description of vegetation (forest) type of the Garhwal Himalayas. Chapter second (2) a review of literature work done at regional Himalayan and national level pertaining to various aspects of the present information. Chapter third (3) deals with the phytosociological analysis of trees, shrubs, herbs and grasses in the temperate belt of Garhwal Himalaya. Assessment of lichen species in the temperate region of of Garhwal has been discussed in the fourth chapter.

Description of macro-lichens cover and their distribution pattern on common phorophytes

of the area has been provided in chapter fifth. Chapter sixth throws light on estimation of dry mass of epiphytic lichens of the area.

Similarly chpater 7th, 8th and 9th have provided the detailed information about fallen lichen species. Tenth chapter discuss the lichen resource use pattern and its socioeconomic status in the temperate region of Garhwal Himalaya. The last chapter provides the information on lichen-moss harvesting practices and their marketing strategy in the state Uttarakhand.

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Background

Uttarakhand, one of the newly formed states of India, is endowed with a wide base of natural resources. The state has a total land area of 53,524 Km². with 64 percent forest cover and a population of 84,79,562 with a 72 percent literacy rate (2001 census report). Around 67 percent of the population is dependent on farming and 80 percent of the workforce in agriculture is woman (DSTO office, 2001). Tough terrain, high inaccessibility, limited market avenues, low industrialization, low employment opportunities for many years have led to a low standard of living of the people living in this hill state. Although majority of population is dependent on agriculture, only about 12% of the total geographic area of the state is under cultivation. Agriculture is mostly at subsistence level owing to factors such as land inaccessibility, environmental heterogeneity and ecological fragility.

The natural resources form the major livelihood base for the downtrodden communities in the remote villages of this hill state. Forests are the most important natural resource in Uttarakhand providing firewood, fodder, biomass and other major and minor forest produce. Ringal (dwarf bamboo) and natural fibre, medicinal & aromatic plants and lichens & moss are one among the potential resources available in different villages and adjoining forests in this state. A number of communities are involved in bamboo and natural fibre crafts work for their survival.

In the state Chamoli and Rudraprayag district of Garhwal has found rich in natural resources. The region covered by the district Chamoli forms part of the district of Pauri Garhwal of the Kumaun till 1960. It occupies the north-eastern corner of the Garhwal track and lies in the central or mid Himalayas in the very heart of the snowy range described in the ancient books as Bahirgiri, one of the three divisions of the Himalayan Mountains. Chamoli covered as a separate revenue district in 1960 out of the erstwhile Garhwal district, lies in the central Himalaya and constitutes a part of the celebrated “Kedar Kashetra”. The district Chamoli is surrounded by Uttarakashi in North-West, Pithoragarh in South-West, Almora in South-East, and Rudraprayag in South-West and Tehri Garhwal in West. The geographical area of the district is around 7520 Km².

Geology

The geology of the region shows that the Himalayas are the young mountains in the world. During early Mesozoic times, or the secondary geological period, the land mass now covered by

them was occupied by the great geosynclinals Tethys Sea. The probable date of the commencement of the elevation of the Himalayas is about the close of the Mesozoic period, but the unveiling of the story of their structure has only just their begin, and in many cases no dating of the rocks is yet possible, though they include ancient and relatively recent crystalline intrusive, rocks and sediments allied to the peninsular part of the India. The section of the range in the district is deeply cut into by the headwaters of the Alaknanda River, this trunk stream seeming to have reached a latter stage of development than its tributaries. This much, however is known that there has been intense metamorphosis. In some part uplift has been considerable since the mid Pleistocene period, in others there are great stretchers of high but subdued topography and elsewhere there are the deepest gorges. The direction of folding in these mountain masses is generally North-South. The geological features of the district from two major divisions which lies North and South of an imaginary line extending East-South-East between the villages of Helang in Joshimath and Loharkhet in the Adjoining district in Pithoragarh. The Northern division, which is occupied by higher range and snow covered peaks consist entirely of medium to high grade metamorphic rocks and is intruded by later volcanic rocks. The division of the South, occupied by ranges of lower altitude, consists essentially of sedimentary and low grade metamorphic rock also intruded by later volcanic rocks. Geologically very little is known of the first division which consists of rocks such as quartzite's, marbles and various types of micaceous schist's and gneisses which a few sporadic occurrences of garnet, graphite, iron, knit mica and vein quartz. The division of the South of the imaginary line is better known geologically and consists of rocks such as gneisses, limestone, phyllites, quartzite, Seri cite biotic chests and slates.

Soils in the region are the coarse soils, well drained and acidic with pH levels varying between 4 to 5.5 (Sundriyal 1992).

Climate

As the elevation of the district ranges from 800mts to 8000 mts above sea level the climate of the region very largely depend on altitude. The winter season is from about mid November to March. As most of the region is situated on the Southern slopes of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the monsoon form June to September.

Rainfall

Most of the rainfall occurs during the period June to September when 70 to 80 percent of

the annual precipitation is accounted for in the Southern half of the district and 55 to 65 present in the northern half of rains is, among others, related to low temperature which means less evapotranspiration and forest or vegetation cover. However, the effectiveness is neither uniform nor even positive in areas where either the vegetation cover is poor or/ has steep slope or the soils have been so denuded that their moisture absorption capacity has become marginal.

Rain gauging stations put up at seven locations by meteorological department of Govt. of India, represent the settled land mass of district Chamoli Garhwal.

Temperature

The detailed of temperature recorded at the meteorological observation in the region show that the highest temperature was 34ºC and lowest 0ºC. January is the coldest month after which the temperature begins to rise till June-July. Temperatures vary with elevation. During the winter cold waves in the wake of western disturbances may cause temperature to fall appreciably. Snow accumulation in valleys is considerable.

Humidity

The related humidity is high during monsoon season, generally exceeding 70% on the average. The driest part of the year is the pre monsoon period when the humidity may drop to 35 during the afternoon, during the winter months humidity increases towards the afternoon at certain high stations**.**

District Rudraprayag, the newly created district of Garhwal was part of three districts Chamoli, Pauri and Tehri. On 16th September 1997 Rudraprayag district was carved out from whole of Augustmini & Ukhimath block and part of Pokhri & Karnprayag block from Chamoli, Part of Jakholi and Kirtinagar block from Tehri district, part of Khirsu block from Pauri. Rudraprayag, carved as a separate revenue district in 1997. The geographical area of the district is around 2,328 Km².

Vegetation (forest) type

Based on the physiogamy (general appearance) the following categories of vegetation can be identified with in Garhwal Himalaya viz. a) Forest, b) Scrub vegetation, c) Temperate grasslands and forest banks, and d) Alpine meadows

The categories can be further divided into following ten distinct categories (equivalents to Champion and Seth's classes, 1968).

i. ***Temperate Chir-Pine forest:*** Dominated by Chir-Pine (*Pinus roxburghii*)

mostly on steeper south facing exposed slopes up to 2000m altitude.

ii. ***Temperate broad leaf (evergreen) forest:*** The forest consists of zones of oaks viz. white oak (*Quercus leucotrichophora*), green oak (*Q. floribunda*) and brown oak (*Q. semecarpifolia*) representing low altitude (1500-2200m), mid altitude (2200-2800m) and high altitude (2800-3500m) respectively constitute this category.

iii. ***Temperate broad leaf (moist deciduous) forest:*** This includes broad leaved forest communities such as *Aesculus-Acer-Juglans*, *Acer-Carpinus* and Alder (*Alnus*) patches along the drainage.

iv. ***Temperate broad leaf conifer (mixed) forest:*** This comprises extensive forest of Fir-Wild sandal (*Abies pindrow - Buxus wallichiana*) and brown oak- Fir, rich in forest floor.

v. ***Sub alpine forest:*** The sub alpine zone between altitudes of 3000-3500m is characterized by high altitude Raga/ Rai- Brich (*Pecia smithiana-Rhododendron arboreum*) communities.

vi. ***Temperate secondary scrub:*** The anthropogenic categories such as Ban oak scrub, dwarf bamboo (Ringal) under this category which is found close to human inhabitations within the eco development zone.

vii. ***Alpine scrub:*** The stunted forest for the moist alpine scrub adjacent to tree line is characterized by these vegetation types largely dominated by Brich (*Rhododendron*), deciduous scrub and reverine willow scrub.

viii. ***Temperate grasslands and thatches:*** Extensive grassy slopes on the south facing slopes at the result of frequent fires and exposure give rise to this vegetation types. The dominant fodder grasses on these slopes are species of *Themeda, Chrysopogon* and *Heteropogon*.

ix. ***Alpine meadows:*** The herbaceous meadows and grassy slopes above the alpine scrub zone and below high altitude steep slopes and barren rocks near tree line are rich in attractive herbs many of them are medicinally important. A large number of plant associations and special life forms have been reported from the alpine meadows. Alpine meadows have a high diversity of herbaceous species, many of which have medicinal or aromatic properties and are of great commercial value. Grasslands are also found below the tree line, and it is not clear whether they have been created and maintained by human activities such as pastoralism, specially the grasslands surrounded by natural forest. In general, the KWLS has very high floral diversity.

Fauna

The Kedarnath Wildlife Sanctuary (KWLS) in Rudraparayag and Nanda Devi Biosphere Reserve in district Chamoli are the protected areas for wildlife. The Palaearctic to the north and

oriental to the south. These two areas harbour a rich and unique biodiversity. It supports several endangered mammals and pheasants such as Musk Deer (*Moschus chrysogaster*), Himalayan Thar (*Hemitragus jemlanhicus*), Serow, Asiatic Brown Bear (*Ursus thebetanus*), Himalayan Black Bear (*Ursus arctus*) and Monal (*Lopophorsus imperjanus*).

Fig: Photographs of some forests sites

People and forest management

The primary occupation of the peoples is agriculture, but owing to the subsistence nature of hill agriculture, they are partially dependent on surrounding forest resources for their livelihood. Local people are dependent on the resources of different forests and alpine pastures mainly for grazing of sheep and goats and collection of timber and non-timber forest produces (Ringal, herbs, fungi, lichens and medicinal & aromatic plants). A substantial number of residents and migratory sheep and goat depend on the grazing resources of forest. The local people have been using these forests for generations and continue to exercise number of rights in the area.

Human population

Until recently, ten of big villages with between 80 and 150 families had the right of habitation in the KWLS, according to the rights of Makku Van Panchayat (Makku village) has been permanent rights but the other nine villages remain in habitat no permanent rights throughout the year. The area, villagers practice small-scale cultivation, herd livestock, and have other rights, including the right to various forest products.

Human population pressures

The grazing of sheep and goats in the protected areas and in high-altitude thatches (meadows), collection of medicinal, aromatic, edible herbs and plants for locally used, collection of fuel wood is degrading the habitat, extraction of timber is deforesting the area, disturbing the animals, and threatening many species with local extinction.

Livestock is one of the most important economic resources of the local people. Every household invariably keeps a few cows and many more sheep and goats. These animals are usually kept for wool, meat and manure. Sheep's wool is used by the villager for making blankets, sweaters**,** and shawls, while goat hair is used for making blankets only. The dung of these animals is of course, good manure for the fields.

Local people, as well as people from neighbouring areas, graze their livestock in the protected area like KWLS. Migrant grazing is seasonal from May- November. During those months, goats and sheep are herded to high-altitude pastures or thatches. Grazing of sheep and goats in what is now KWLS has been taking place for generations. For many local people it is more a way of life than an economic activity.

Flock size is variable, generally is varies from 300 to 500 animals each flock. The number of the grazers accompanying a 400-500 animals is generally five to six grazers. Each flock contains

sheep and goats belonging to several families from one or more villages. Grazers coming from beyond adjacent areas often pick up sheep and goats from the villages they pass through on their way to the KWLS. Such grazers often stay in local farmers fields. Their flock can manure the fields while the grazers are given food and shelter in exchange. The grazers also are paid by the villagers, often in kinds rather than cash, for taking their sheep and goats into the KWLS.

The impact of grazing on the KWLS areas is not fully known. However livestock's are known to transmit diseases to wild animals, encourage weeds growth, and prevent regeneration of trees in low-altitude patches. Studies of the impact of grazing on forests have shown that the grazing of livestock not only hinders regeneration of naturally dominant tree species, but it can also lead to significant changes in the structure and composition of different plant species on the forest floor.

Lichen exploitation

The lichens are collected exhaustively throughout Himalaya and are frequently used as ingredient of spices, Aurvedic medicines and other purposes. Every year about 10,000 tons of lichen is collected from the Central Himalayan region of India. But in the protected areas like KWLS, lichen exploitation is totally band. Commercially the lichens are sold in the name of "Charrila" or "Jhoola".

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Chapter-1

INTRODUCTION

History

The history of Lichenology dates us back to Theophrastus (370- 285 BC), who accredited as father of botany, used the term 'lichen', a word of Greek origin to denote the superficial growth on the bark of olive trees. Linnaeus grouped all lichen species under the genus Lichen and gives it to one of his last student Erik Acharis for further study. Erik Acharius (Acharius 1803, 1810 and 1814) a Swedish botanist and was born in the Swedish town of Gävle in 1757. At the age of 17 he came to Uppsala where he studied botany as one of Linnaeus' last students. Acharis, referred to as father of lichenology, coined several terms for the structures peculiar to lichens and described many new genera and numerous new species on the basis of external morphology in his monumental works Methodica Lichenum, Lichenographia Universalis, and Synopsis Methodica Lichenum.

What are lichens?

Lichens are fungi that live in intimate symbiotic association with green algae or cyanobacteria. Lichens comprise a unique group of plant that consists of two unrelated organism, a fungus and an alga, growing together in a close symbiotic association. The study of lichen remains quite neglected throughout the world, through they together with mosses form dominant organism in ecosystem covering over 10% of the earth terrestrial habitats, particularly at higher elevations (Nash and Egan 1988). Lichens with cynobacterial blue green symbionts, contribute significantly for forest nitrogen fixation (Slack 1988). Besides many other uses, lichens are also used as pollution monitors. They are the plants which occur in most adverse conditions of climate and substrate. Thus the importance of this group in an ecosystem is very high in its own way. Lichens are just like little sponges that take up everything that comes their way, including air pollution (Fleishner 1994).

Lichens form easily distinguishable coloured patches on tree barks, rocks and soil. They are universally distributed organisms occurring in varied climatic conditions ranging from the poles to the tropics in earth. They may look like crust, spreading rapidly over the surface (crustose lichens) or leafy and loosely attached to the surface (foliose lichens) and branched and shrubby, hanging from tree twigs or branches, with a single attachment (fruticose lichens).

Lichens have ability to resist extremes of climatic conditions ranging from low tide sea shores to the tops of the mountains and from arctic to tropical regions, dominating as much as 8% of the earth's surface (Ahmadjian 1993; 1995) and are amongst the most significant indicators of air pollution and ecosystem health (Richardson 1992) and, besides having many economic medicinal applications. They are very sensitive to microclimatic changes. Therefore any natural manmade disturbances are bound to affect lichen populations. Requisite moisture and light, unpolluted air and undisturbed substratum often favour optimum growth and abundance of lichens. Lichens arbitrarily classified into three to seven growth forms that do not reflect how the lichens are related to each other. Different species within a genus may have different growth forms viz 1. Crustose, 2. Foliose, 3. Fruticose and 4. Squamulose. Crustose lichens form crusts that are so tightly attached to the rocks, trees, side walls or soils they grow on that they cannot remove without damaging the substrate. Cracked crusts like the species of Acarospora that are separated into segments (areoles) are called areolate. Crustose lichens, that grows immersed in rocks only their fruiting bodies above the surface are called endolithic, and those that grow immersed in plant tissues are called endophloidic or endophlodal. Loose, powdery lichen crusts without a layered structure called leprose lichens. Foliose lichens are somewhat leaf-like, composed of lobes. They are relatively loosely attached to their substrates, usually by means rhizines. Their lobes have upper and lower sides and usually grow more or less parallel to the substrate viz. *Lobaria*. Fruticose lichens are usually round in cross section and most are branched. They can like little shrubs growing upward, or they can hang down in long strands viz. *Usnea longissima*.

Lichens in Indian Languages

In Indian context, the Sanskrit synonyms of lichens are 'Shailaya' and 'Shila Pushp' meaning Shila=rock Pushp=flower. Lichen species are commonly known 'Stone flower' in English, 'Pathar Ka Phul' in Hindi, 'Dagad Phul' in Marathi, 'Kalahu' in Kanada, 'Kalpasi' in Tamil, and 'Rihamkarmani' in Urdu. Locally in Garhwal it is known as 'Mukku', 'Shewal', 'Jhoola'; 'Chaarila' in Kumaun; 'Chaai' and 'Mendi' in Himanchal. In Hindi the lichens are also known as 'Shaik' (meaning Shai= Shewal and K= Kawak).

India ranks amongst one of the twelve-mega-biodiversity countries of the world. The innumerable life forms from unicellular to multicellular and microscopic to gigantic harboured in the forests, deserts, mountains, other land forms and air and water. They are source of food, fuel, clothing and various others our daily needs and raw material for industries.

Mountains and hill hold a rich variety of ecological systems. Because of their vertical dimension, mountains create gradient of temperature, precipitation, and insulation. In Uttarakhand nine of the thirteen districts comprise the expansion of lesser Himalayas. But with the rapid modernization and increasing anthropogenic pressure coupled with natural disasters on vegetation in general and on the forests in particular, the Himalayan vegetation is rapidly deteriorating in its richness as well as diversity. However, in recent past there has been a deep concern and a realization for the conservation of the fragile Himalayan ecosystem.

Garhwal Himalaya exhibits sub-mountain to alpine climate with distinct physiography, altitudes, and aspects that harbours a variety of forest types. Owing to the varied topography and altitudes, diverse forest and alpine pasture communities may occur within a distance of 300-500 km (Singh, 1992). The distribution of different forest types is primarily governed by the altitude and secondarily by the factors such as geology, soils, orientation of the valleys and other biotic and abiotic stresses (Champion and Seth 1968). Forest account is nearly 45% of the total geographical area of the Garhwal Himalaya. A wide variety of forest types are found in this region of Uttarakhand hills. The vegetation is dominated by *Quercus leucotrichophora* (Banj oak), Q. floribunda (Tilonj oak) and *Q. semecarpifolia* (Kharsu oak) in altitudinal gradient. Some other main species found in the region are *Abies pindrow*, *Rhododendron* spp, *Lyonia ovalifolia, Acer spp, Asculus indica* and *Ilex*.

Vegetation within a forest type is greatly affected by differences in the microclimate and altitude (Pande et al 1996). The selection pressure, originating due to the difference in microclimate and interspecific competition, influence the vegetation of different tree species and also open the door for the invasion and acclimatization of new species in the forest ecosystem. The interactive influence of the biotic and abiotic factors of the environment affects the survival and growth of seedlings and sprouts (Sorenson and Forrel 1979 and Muller-Dombios et al 1980).

Topography and other mountain slopes, in combination with perennial streams and dark shady localities of the area have created micro-climatic conditions to provide diverse environmental conditions, encouraging luxuriant growth of several moisture loving lichens, orchids, herbs, shrubs and climbers, which have immense ecological as well as economical value.

Altitudinally defined climatic and soil factors are deemed to be primary determinants of change in species composition and community structure in undisturbed mountains (Whittaker and Marks, 1975). Economic change and population increase is threatening the ecology of the

Himalayas. In Garhwal Himalaya substantial increase in human and bovine population has taken place during last decades (Negi et al 1997 a & b). Simultaneously natural resources are depleting at an alarming rate (Negi 1991, Singh & Singh 1992, Chauhan et al 1999). The repercussion of these factors can be observed in lichen diversity of the area. Decline in crop yield and out migration of the rural people in search of livelihood has definite linkages to this situation.

Hence the protection, improvement and rehabilitation of mountain have a critical importance in achieving the developmental goal. In recent years the deforestation in the foothills and the Middle Himalaya and, overgrazing on the high pastures have led to soil erosion and other environmental problems. Deforestation is a particular concern in the western Himalaya, where increased demand for firewood, extensive tree trimming to feed livestock, and construction of roads in the border regions have increased the destruction rate of forests and the number of landslides. Forest resources of the Himalaya are shrinking in size due to over-exploitation and there is increased interest to protect, manage and make them more protective.

Competition, both within and among species, is one of the major forces determining the distribution and abundance of plant species and the biodiversity of plant communities (Tilman, 2000). Although most plants compete for the same resources (light, water and nutrients) and large number of species coexist in many plant communities (Silvertown and Charlesworth 2001). Intuitively, spatial heterogeneity of resources used by plants is probably one of the most powerful promoters of niche separation and coexistence between plants.

The area is quite rich in lichen diversity and needs to be explored and inventoried critically. Thus, the present book is an attempt to inventories and study the lichens mass on standing trees as well as lichen fall estimation, lichen cover on host tree species and its vertical distribution pattern in the Garhwal Himalayas. Some part of the study like vertical distribution and cover of the lichen species, lichen dry mass estimation on host tree and lichen fall estimation methods are first time developed and followed by the author.

There are three reasons why ecologists are interested in ecological diversity and its management. First, the well documented patterns of spatial and temporal variation in diversity which intrigued the early investigators of the natural world (Clements 1916; and Thoreau 1960) continue to stimulate the minds of ecologists today (Currie and Paquin 1987; May 1986). Second, measures of diversity are frequently seen as indicators of well being of ecological systems. Thirdly, considerable debate surrounds the measurement of diversity. Biodiversity indicators (popularly

known as bio-indicators) are useful for defining and presenting the data those decision-makers requires. Bio-indicators can be used in ecological evolution, especially for communities indicating areas of conservation interest.

Need of inventorying and monitoring lichens of Garhwal Himalayas

Formulating proper methodology for documenting floristic diversity with ecological correlates is a prerequisite for inventorying periodical monitoring and conservation of bio resource. The study will attempt to-

i. The pattern of relative abundance of lichens

ii. Document season of maximum lichen fall

iii. List of tree species and their part harbouring maximum lichen in a lichen rich area

iv. This information will be the first attempt to answer these basic queries and help in periodical monitoring, conservation and management of lichens

v. Inventorying and monitoring the lichen diversity will be provide fundamental and essential biological information used by basic scientific disciplines (viz. ecology, population biology, behaviours and other fields of comparative biology)

vi. Available information will provide a basis for the scientific research necessary to understanding the habitat in which rich lichen dry mass (from tree as well as fallen lichen mass) found (either on open or closed canopied site of the *Q. semecarpifolia* forest)

vii. Define the current and future option available for alternate livelihood from the lichens. It will be help to guide immediate and long term management, policy and decision making strategies

viii. Provide information necessary for sustainable management of natural resources (lichens). Help in identifying economically or commercially valuable lichens

ix. Define the impact of human activities on lichen diversity so as to reduce undesirable effect in the environment

x. Helps to understand the potential effects and impact of climate change and other forms of natural environment change

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Chapter-2

REVIEW OF LITERATURE

Lichenology in India

India has a rich diversity of lichens represented by more than 2,000 species (Awasthi 2000), which is about 10% of the total 20,000 species known from the world. The lichens are common to abundant in temperate and alpine regions of the Himalayas and hilly regions of the peninsular India. Through the maximum diversity of lichens in the country is recorded for South Indian regions and Eastern Himalayan region, but they are relatively common in occurrence in Western Himalaya (Awasthi 2000). The present number of lichens in the country appears a lower estimate as many more areas especially mountains and the forest canopies are yet to be explored (Negi and Gadgil 1996; Negi 1999; Negi and Upreti 2000).

The lichen studies were initiated little late in India as compared to the rest of the world. It was Quraishi (1928) and Kashyap whose collection was published by Smith (1931). Chopra (1934) published a comprehensive account of lichens of Himalayas. Dr. D. D. Awasthi in the late forties of the last century established a school of lichenology in India and a number of lichenological investigations related with monographic, revisionary and floristic studies were initiated in the country.

The first record of lichen community studies from India was provided by Dudgeon (1923) who studied succession of epiphytic lichens on *Quercus leucotrichophora* tree in Western Himalayas. Biswas and Awasthi (1948) provided an account of the distribution of Indian lichens; Bhatia (1957) made observation on the lichen communities of the western Himalayas.

The more extensive and intensive studied on the community ecology of Indian lichens have initiated recently when Upreti (1995) explained loss of diversity in Indian lichen flora; Upreti (1996) provided an enumeration of the lichens growing on *Shorea robusta* trees in Jharsuguda district, Orissa; Negi and Gadgil (1996) studied in the pattern of distribution of macrolichens in western part of Nanda Devi Biosphere Reserve; Upreti (1997) provided an account of diversity of Himalayan lichens; Upreti (1998) extensively discussed in detail the account of lichens occurring in tropical, temperate and alpine region of India and also categorized lichens according to forest type with six different vegetation zones of tropical lichens and detail description of endemic lichens and affinities of Indian lichen flora vis-à-vis world.

Community studies can be carried out at various spatial scales. Most of the investigations on lichen diversity have been descriptive and have concentrated on regional and global scales (Groombridge 1992; Heywood 1995; Gaston 1996; Galloway 1996). The current focus such studies is shifting from these higher scales to locally manageable landscapes as land use decisions and management policies are most often implemented at these latter scales (Ricklefs and Schluter 1993; Nagendra and Gadgil 1999; Negi 1999). Moreover, floristic inventories particularly of lower plants suffer from lack of uniform field methods. This has partly hindered progress on long term monitoring of biological diversity and its conservation (Negi and Gadgil 1997; Negi 1999). Formulating proper methodology for documenting floristic diversity with ecological correlates should therefore be a prerequisite for inventorying, periodical monitoring and conservation of bio resources.

Number of specie and any other higher ranks of taxonomic organization in a site (species richness or alpha diversity) and their compositional change across different habitat types (species turnover or beta diversity) within a landscape are important parameters of biodiversity that have wide applications such as environmental monitoring and conservation evaluation (Magurran 1988; Pressey et al 1994; Negi 1999).

Singh and Bujarbarua (2002) presented note on the lichen diversity of Assam; Singh et al. (2004) provided a comprehensive account on the endemic lichens of India. Balaji and Hariharan (2004) studied the lichen diversity and its distribution pattern in tropical dry evergreen forest of Guindy National Park (GNP), Chennai. The quantitative ecological data shows the occurrence of 31 species of lichens of fewer than 26 genera of 19 families and 9 fungal orders. These quantitative ecological data were recorded from 219 individuals of phorophytes in a total 264 samples, out of which 235 samples were taken from trees, 27 from shrubs and 2 from lianas of ≥3 cm gbh. Strongest correlation emerged between tree density and host tree diversity of lichen distribution. Species like Arthopyrenia alboatra, Parmotrema saccatilobum, Strigula elegans, Tapellaria sp. and, Verrucaria species were found to be narrowly distributed in the park and specific to a single host.

Satya et al. (2005) reported that Shorea robusta tree is a suitable phorophyte for the luxuriant growth and development of crustose lichens. Out of the 64 lichen species recorded from Shorea robusta trees in various forest sites of India, 42 species fall under the crustose lichens.

Air pollution and climate changes are threats to maintaining ecological health of protected areas. Lichens provide a relevant, sensitive and measurable indicator of long term monitoring. The

International treaty, Agenda 21 emphasize regular monitoring through sampling and other techniques, the components of biodiversity especially paying particular attention to those requiring urgent conservation measures. Thus, biological diversity is now increasingly recognized as a vital parameter to asses global and local environmental changes and sustainability of developmental activities. The development of information on the lichen ecology is widely scattered often in many inaccessible literature sources. Seaward (1977) complied the knowledge on lichens in relation to physical and biological component of their environment.

Upreti and Chaterjee (1999a) studied the distribution of epiphytic lichens on *Quercus* and *Pinus* trees in Pithoragarh and Almora districts of Kumaun Himalayas. *Quercus semecarpifolia* exhibits the dominance of lichen species represented by 25 species while *Quercus leucotrichophora* and *Quercus floribunda* have 20 and 12 species respectively. All tree species have dominance of Parmelioid species. The cultivated tree of *Pinus roxburghii* show occurrence of 19 species of lichens. Upreti and Chaterjee (1999b) also studied the epiphytic lichen flora of *Quercus* and *Pinus* trees in three forest sites of Pithoragarh district, *Quercus leucotrichophora* at altitude between 2700-3000m has 24 species while *Quercus dilatata* at the same elevation has only 15 species of lichen. Both the tree species have dominance of Usenea and Ramalina species. *Quercus leucotrichophora* at lower elevation between 1600-1800m has 14 species of lichens. *Pinus roxburghii* between altitudes of 15001600m has 21 epiphytic species in the area. Both *Quercus* and *Pinus* trees at lower elevation exhibit dominance of Parmelioid lichens.

Nayaka and Upreti (2002) studied the lichen communities of Sharavati River Basin, Karnataka, while Srivastava (2006) studied the Great Himalaya National Park, Himanchal Pradesh.

Divakar and Upreti (2005) and Kumar (2008) proposed the Chopta-Tunganath, Saryu River Valley in Pindari Glacier (Bageshwar district), Nain Singh top en route Milam Glacier, Chaubatia to Ranikhet (Almora district) and Mussoorie Hills (Dehra Dun district) of Uttarakhand areas as the "Lichen Sanctuary" owing of their rich, unique and some endemic lichen taxa.

Negi (2000) studied total 3211 colonies of microlichens from twelve 50m X 1m plots distributed across four microhabitat (vegetation) types between 1500-3700m in Chopta-Tunganath landscape of Garhwal Himalaya. This study revealed occurrence of 85 species, 15 genera falling under 13 families. *Lobaria retigera* stood as a broad niche generalist species with moderate levels of abundance in all the three major microhabitats, viz. rock, soil and wood across 83% of all the plots sampled, whereas *Umblicaria indica* occurring on rock substrates. *Heterodermia incana* and

Leptogium javanicum appeared to be rare members of the community as they were encountered only once during the field survey. The macrohabitats, in middle altitude (2500-2800m) with *Quercus* forest was richest in species and genera followed by higher altitude (2900-3200m) of *Rhododendron* forest, higher altitude grasslands (3200-3700m) and the lower elevation (1500m) *Quercus* forest. Negi and Gadgil (1999b) suggested that taxonomic rank such as genera may be used as surrogates for species because it is cost and time effective method for periodic monitoring of the biodiversity.

Negi (2000a) analyzed spatial patterns of diversity, conservation problems and their prospects; worked on the community ecology on lichens and mosses of Nanda Devi Biosphere Reserve, Uttarakhand.

Negi and Gadgil (2002) carried out biodiversity survey in 13, 10m X 50 sq. meter plots located between 1400-3700m above mean sea level in a range of habitats in temperate mixed oak and coniferous forest through sub alpine to alpine grass lands in Chamoli district of Uttaranchal (now called Uttarakhand) state in the Garhwal Himalaya. Cross taxon congruence in biodiversity (α-diversity and β-diversity) across macrohabitats, mosses, liverworts, woody plants (shrubs and trees) and ants was investigated, so as to examine the extent to which those groups of organisms can function as surrogates for each other. Although woody plants provided a major substrate for macrolichens and mosses, there was no species specific association between them. Woody plant species richness was highly positively correlated with mosses (r^2=0.63, P<0.001), but the relationship was not particularly very strong with lichens and liverworts. While there was a significant correlation in the species turnover (β-diversity) of macrolichens with mosses (r^2=0.21, P<0.005), the relationship was relatively poor with woody plants. On the other hand, negative correlations among them were positive. Since diversity between taxonomic hierarchies within the group was consistently significantly positively correlated in all these taxa, the higher taxonomic categories such as genus and family may be employed as surrogates for rapid assessment and monitoring of species diversity.

Upreti et al. (2004) studied on lichen flora of Gangotri and Gomukh areas of Uttaranchal (now called Uttarakhand), India and reported 149 lichen species belonging to 50 genera and 21 families, all the species were collected from the chest height of the trunk and from other substrata at forest floor.

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Chapter-3

PHYTOSOCIOLOGICAL ANALYSIS IN BROWN OAK DOMINATED FOREST OF GARHWAL HIMALAYA, INDIA

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ABSTRACT: The present study was carried out in eight forest sites dominated by Quercus semecarpifolia (brown oak) to asses variations in floral biodiversity and community with changes in microclimatic conditions between 2500-3500m elevation in Chopta (Garhwal). Anthropogenic disturbances are changing the species richness and diversity, which influence the soil and environmental conditions. Thus, the conservation and management of these forests will be important for the sustainability of human and land in the region. A total of 14 species of trees, 8 species of shrubs and 20 species of herbs & grasses were encountered across the study area.

Key words: Tree species, study sites, Garhwal Himalaya

INTRODUCTION

India is among the important mega-biodiversity centres of the world, with a lot of contribution from the Himalayan ecosystem. Biodiversity is used variously for fodder, fuel wood, timber, and leaf litter for manuring crop fields, construction, industrial raw material and several non-timber forest produce. Biodiversity is the totality of genes, species, and ecosystem in a region. Vegetation in a mountain area is affected by several factors of which altitude, aspect, slope, soil, canopy cover and microclimate are predominant at the modify regimes of moisture and exposure to sun. Forest diversity is the main source of livelihood of the people living in Uttarakhand, Central Himalaya. Species composition of major forest types of central Himalaya have been described by Ralhan et al (1982), Saxena and Singh (1984), Singh and Singh (1987), Singh and Singh (1992) have summarized the information on the structure and function of the Himalayan forest ecosystem. The present study was conducted in eight forest sites of *Quercus semecarpifolia* (brown oak) located between 2500-3500m elevations in Chopta forest of Garhwal to asses the phytosociological

analysis of the vegetation. The impact of local people on vegetation, variation in floral biodiversity and community with changes in microclimatic conditions, and regeneration status were recorded during 2006.

MATERIALS AND METHODS

Chopta forest is located at 79º-79º30´E longitude and 30º30´-30º42´N latitude between 1500-4000m elevation in the Garhwal Himalaya. Altitudinally Chopta is located in temperate zone. For the detailed study of plant biodiversity and other vegetational parameters, the area was divided into eight forest sites. All the sites are located approximately within the same elevation range (2500-3500m).

The Chopta is characterized by its typical climate from temperate to alpine. About 60% of the area falls under alpine zone, which remains under snow during winter months. Broadly, three seasons can be recognized for the Chopta area, viz. summer (April-June), rainy (July-September) and winter (October-March). Winter experiences serve cold the main precipitations are received in the form of snow. Maximum snow depth occurs in the subalpine and alpine areas during February-March. With the rise the temperature in the month of April snow start malting in the lower altitudes by April it remains in scattered isolated patches below 2800m especially in shady localities. Snow melts only in April-May in the alpine zone. The main annual rain fall of the Central Himalaya is 2000mm (Singh and Singh, 1992). Rains are mostly confined to rainy season and heavy down pours in rainy season causes landslides and soil erosion.

Total 15 (10mX10m) for trees, saplings and seedlings, 40 (2mX2m) for shrubs, and 40 (50X50cm) quadrats for herbs in each site were placed randomly and studied. Regeneration in the forests was sampled at four levels namely mature tree, sapling and seedling. Mature tree comprised of plants with >31.5 cm (gbh) over the bark at breast height (1.37m), sapling included all individuals >10.5 cm and <31.5cm gbh and seedling class composed individuals of <10.5cm gbh (Chaturvedi, et al 2005). The vegetational data was calculated for density (Curtis and Mc Intosh, 1950), and species richness was determined following Whittaker (1972) by tabulating the number of species in each site.

RESULTS: Quantitative analysis of trees, saplings, seedlings, shrubs and herbs at different study sites are given in Table 1-3. A total of 14 species of trees, 8 species of shrubs and 20 species of herbs & grasses were recorded from the study area. Except three sites (site 4th, 5th and 8th) broadly *Rhododendron arboreum* have similar major tree species. *Quercus semecarpifolia* and/or *Rhododendron arboreum* are the major tree species in all the eight sites. Only five sites are well canopied having 50-58% canopy cover. Tree layer: Among the different sites, the maximum total tree density 2488 ind ha^{-1} recorded in the site 4th. However the minimum total tree density 379 ind ha^{-1} was recorded at site 8th. The maximum density was of *Quercus semecarpifolia* (546 ind ha^{-1}) followed by (390 ind ha^{-1}). *Acer sp, Taxus baccata, Lyonia ovalifolia,* and *Sourbus cuspdata* showed the minimum tree density 6 ind ha^{-1} (Table 1). Sapling layer: The total sapling density was recorded between 6-645 ind ha^{-1} at different sites. The Quercus semecarpifolia was found in sapling stages at only four sites except site 1st, 2nd, 5th, and 8th and its density ranged from 6-133 ind ha^{-1} (Table 1). Seedling layer: The seedling density of Quercus semecarpifolia was recorded to maximum 406 ind ha^{-1} at site 7th and minimum (6 ind ha^{-1}) at site 2nd and site 8th respectively. Among the species maximum seedling density was recorded 692 ind ha^{-1} for site 7th and the minimum density also recorded 32 ind ha^{-1} at site 2nd (Table 1). Shrub layer: The shrub density was recorded to be maximum 29675 ind ha^{-1} at site 1st and minimum 425 ind ha^{-1} at site 5th. Among the species maximum density was recorded for 33100 ind ha^{-1} was recorded for site 1st and the minimum density also recorded 2875 ind ha^{-1} at site 5th (Table 2). Green layer: The herbaceous (ground vegetation) density was recorded to be maximum 526000 ind ha^{-1} at site 6th and minimum density was 425 ind ha^{-1} at site 5th. Among the species maximum density was recorded 1699600 ind ha^{-1} at site 4th and the minimum density also recorded 422025 ind ha^{-1} at site 5th.

Distribution pattern: There was no regular distribution pattern of the different strata was observed in the study area as maximum species (88.01%) displayed their random distribution pattern at different sites and 11.98% species displayed contagious distribution pattern at different site of the study area (Kumar, 2008).

Table 1: Density (ind ha^{-1}) for trees, saplings and seedlings

Site	Species	Tree	Sapling	Seedling
1	*Quercus semecarpifolia*	193	-	210
	Rhododendron arboreum	213	53	-
	Abies pindrow	106	-	-
	Taxus baccata	20	-	26
	Ilex dipyrena	40	-	-
	Acer sp	6	-	-
		578	**53**	**236**
2	*Quercus semecarpifolia*	372	-	6
	Rhododendron arboreum	80	-	13
	Ilex dipyrena	33	-	13
	Acer sp	13	-	-
	Abies pindrow	13	-	-
	Taxus baccata	6	-	-
		517	**0**	**32**
3	*Quercus semecarpifolia*	153	6	53
	Abies pindrow	25	-	-
	Ilex dipyrena	40	-	-
	Rhododendron arboreum	53	-	60
	Lyonia ovalifolia	6	-	26
	Machilus gamblei	33	-	-
	Quercus floribunda	13	-	-
		323	**6**	**139**
4	*Quercus semecarpifolia*	546	6	-
	Rhododendron arboreum	390	20	-
	Acer sp	220	20	-
	Aesculus indica	666	-	-
	Taxus baccata	666	-	-
		2488	**46**	**0**
5	*Quercus semecarpifolia*	293	-	73
	Rhododendron arboreum	380	73	16
	Abies pindrow	13	-	-
	Taxus baccata	13	6	6
	Acer sp	13	-	-
		712	**79**	**95**
6	*Quercus semecarpifolia*	220	10	40
	Rhododendron arboreum	120	40	40
	Acer sp	113	40	-
	Taxus baccata	26	-	6
	Sourbus cuspdata	6	-	-
	Syzgium cumini	13	-	-
	Abies pindrow	13	-	-
		511	**90**	**86**
7	*Quercus semecarpifolia*	293	133	406

	Rhododendron arboreum	220	46	-
	Rhododendron anthopogon	160	426	286
	Taxus baccata	80	40	-
	Abies pindrow	13	-	-
	Syzgium cumini	33	-	-
		799	**645**	**692**
8	*Quercus semecarpifolia*	146	-	6
	Rhododendron arboreum	20	-	60
	Acer sp	13	-	-
	Rhododendron arboretum	20	-	-
	Picea simithiana	180	-	-
		379	**0**	**66**

Table 2: Density (ind ha^{-1}) for shrubs

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Daphne cannabina	29675	14000	5625	-	3425	-		-
Vibrunum cylindricum	1675	4675	800	2125	425	2875	675	6875
Berbaris petiolaris	1750	2000	925	3250	-	-	1550	
Daphne papyracea	-	600	-	-	-	-	-	-
Thamnoclamus jonsarensis (Ringal)	-	-	-	39100	-	-	-	-
Cotonneaster microphyllus	-	-	-	-	3425	-	-	1800
Skimmia anquetilia	-	-	-	-	-	-	22675	2425
Cotoneaster acuminatus	-	-	-	-	-	-	4050	-
Rosa sericea	-	-	-	-	-	-	1925	-

Table 3: Density (ind ha^{-1}) for herbs

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Lycopodium sp	42800	-	-	-	-	-	-	190400
Fragaria Sp	388800	418800	484000	366800	42800	-	118000	-
Heteropogon contortus	232800	-	232000	-	202000	-	40800	-
Impatins thomsonii	28000	-	-	-	-	-	-	-
Gentiana peldicellata	38000	340800	266000	-	84000	104000	-	238800
Ocimum americanum	184000	68000	-	10000	32000	52000	-	-
Pusiyaghass*	104800	-	-	416000	-	526000	28800	230800
Dryopteris sp	40000	254000	-	112800	-	44000	46800	96000
Bistorata macrophylla	-	106000	252000	104800	30000	168000	122000	-
Daphniphyllum himalense	-	58000	-	160800	-	38800	-	-

Potentilla fulgens	-	92000	54000	-	425	-	-	114000
Sellaginella sp	-	-	172800	-	-	-	-	-
*Lentana*sp	-	-	100800	-	-	-	100800	18400
Saxifraga andersonii	-	-	-	16800	30800	-	-	-
Potentilla fulgens	-	-	-	32800	-	-	-	-
Valeriana jatamansi	-	-	-	100800	-	-	16000	44800
Impatins thomsonii	-	-	-	378000	-	68800	-	-
Pteris cretica	-	-	-	-	-	-	104000	60000
Gaultheria nummylariodes	-	-	-	-	-	-	-	290800
Nardostachys jatamansi	-	-	-	-	-	-	-	74800

- ***Locally identified***

DISCUSSION

The present study area is located in the altitudinal range of 2500-3500m and divisible of 8 different study sites on the basis of various disturbances such as grazing, browsing, litter removal and lopping. *Quercus semecarpifolia* and *Rhododendron arboreum* are the dominant tree species in all study sites. Giri, et al (2008) reported, the total tree density ranged from 320 to 1560 ind ha^{-1} in *Quercus leucotrichophora* forest and 320 to 1960 ind ha^{-1} in *Quercus floribunda* forest, but it was not recorded in *Quercus semecarpifolia* forest. The total tree density ranged from 323-2488 ind ha^{-1}, total sapling density from 0-645 ind ha^{-1} and seedling density from 0-692 ind ha^{-1} were recorded in present study sites. The tree density was comparatively high than the value of other oak reported by Giri, et al (2008). Anthropogenic disturbances change the vegetation structure and regeneration status of a particular forest. The anthropogenic pressure on *Quercus semecarpifolia* forest for firewood, fodder and timber, play an important role in declination of forest together with lichen moss collection. Various levels of disturbances cause the increase in community species richness. This is because disturbances prevents dominance by a few competitive species and allows opportunistic species to invade.

In the present years the awareness regarding to conservation of flora and fauna among the local community and in people residing in the forest has helped in a large extend in protecting the forest in this area. The tendency of the people have changed as they are earning their livelihood regularly from forest by some alternative (selling milk, firewood by utilizing the forest foliage) instead of destroying trees.

Appropriate Technology India (ATI) is non-profit organization registered under the India societies act 1860, was established in August 1994 and developed as centre for ecological studies, which provides short term training and conduct program regarding conservation of nature and flora in school and college together with local peoples.

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Chapter-4

ASSESSMENT OF LICHEN SPECIES IN A TEMPERATE REGION OF GARHWAL HIMALAYA, INDIA

ABSTRACT: An enumeration of 106 lichen species belonging to 47 genera and 28 families from Baniyakund-Chopta areas of Garhwal is provided. The area is dominated by macrolichens (foliose to fruticose form). The area exhibit the luxuriant growth of corticolous lichens represented by the occurrence of 64% of corticolous (bark inhabiting) lichens followed by 30% of saxicolous (rock inhabiting) and 4% of terricolous (soil inhabiting) lichens. A single species growing on leaves (foliicolous) is also recorded from the area. If we compare the lichen diversity of the study area vis-à-vis other regions, it is about 30% of the Garhwal Himalayas, 20% of the Uttarakhand and 10% of the Himalayas and less than 0.5% of Indian lichen diversity.

Key words: Lichen diversity, phorophytes, substratum, growth forms

INTRODUCTION

Lichens comprise a unique group of plant that consists of two unrelated organism, a fungus and an alga, growing together in a close symbiotic association. The study of lichen remains quite neglected throughout the world, through they together with mosses form dominant organisms in ecosystem covering over 10% of the earth terrestrial habitats, particularly at higher elevations (Nash and Egan 1988). Lichens with cynobacterial blue green symbionts, contribute significantly for forest nitrogen fixation (Slack 1988). Besides many other uses, lichens are also used as pollution monitors. They are the plants that occur in most adverse conditions of climate and substrate. Thus the importance of this group in an ecosystem is very heigh in its own way. Lichens are just like little sponges that take up everything that comes their way, including air pollution (Fleishner 1994).

Lichens are universally distributed organisms occurring in varied climatic conditions ranging from the poles to the tropics in earth. They may look like crust, spreading rapidly over the surface (crustose lichens) or leafy and loosely attached to the surface (foliose lichens) and branched

and shrubby, hanging from tree twigs or branches, with a single attachment (fruticose lichens). The collections were made along the way from Dalkuri to Bhujgali (Chopta) via Chpota and at different localities of the region. Negi (2000) recorded the occurrence of 85 macrolichens in the area. The micro lichens from the area were not listed so far.

MATERIALS AND METHODS

Site Description

The study site Baniyakund-Chopta is situated between 2500m to 3500m (asl) in the Rudraprayag district of Uttarakhand along with Akashkamini valley at 79^0-79^0 30'E and 30^0 30' – 30^0 42' N. The local human population settled in the low land fringe areas comprises semi pastoralists with livestock grazing and agriculture as their dominant land use activities. While low elevation woodlands such as Quercus forests are open for fodder and fuel wood collection throughout the year, grazing in the higher elevation forests and grasslands starts in early June, reaching a maximum in July, August and stop in early October. The maximum monthly temperature in the area varies from around 19ºC to 37ºC from the higher altitude grasslands to the lower elevation Quercus forests respectively during the snow free months of May to October, while the minimum temperature drops as low as -15ºC in the alpine grasslands during the months of December to February.

In general the climate of the Chopta region is less severe summer, more or less higher precipitation and colder or more prolonged winter. The climatic factors i.e. precipitation, temperature, relative humidity and wind, in association with elevation (valley or mountain ranges from foot hills to mountain zones), proximity to Great Himalaya, slope aspect and vegetation type etc, cause variation in climates at local or even micro levels (Gaur 1999). Major output of precipitation is in the form of rainfall besides occasional occurrence of due hailstorms, fog, frost, snow fall etc. The south east monsoon commences towards the end of June and bursts until the mid of September.

Methodology

The lichen specimens were collected with the help of Chisel and Hammer along with their ecological notes. The type of forest vegetation, host tree type, location of the lichens thallus (on trunk, branch, twigs or leaves, soil and rock substratum); together with altitudes and other ecological notes were recorded. The collected specimens were investigated morphologically, anatomically and chemically at Lichenology laboratory of the National Botanical Research

Institute, Lucknow. The collected samples were packed on hard card sheets inside a lichen herbarium packet (17cmX10mm) with details of the locality and are preserved at museum Center for Ecological Studies, Appropriate Technology India Ukhimath (Rudraprayag), Uttarakhand and also preserved at Botany Department, Hemwati Nandan Bahuguna Garhwal University Sirinagar (Garhwal) Uttarakhand. A voucher specimen of each species was also preserved at Herbarium of National Botanical Research Institue, Lucknow (LWG).

Identification of lichen species

The external morphology was studied under dissecting binocular microscope. The anatomy of the thallus and apothecia were studied under compound microscope. The external morphology was examined generally in dry condition but dark brown to bluish specimens of Leptogium were studied in wet condition. The anatomical structures were studied after cutting the section of dry material by microtome and with the help of safety razor blade. The thin dry sections of the thallus and ascocarp were immersed in 90% ethyl alcohol to drive off the intercellular or inter-hyphal air bubbles and the sections were mounted in water or in cotton blue in lactophenol. The colour of medulla, epithecium, hypohtecium, and ascus were recorded. The shape and size of the asci, ascospores and conidia were measured in the sections mounted in water. The measurements of the thallus, medulla, epithecium, and hymenium were generally taken in the sections mounted in cotton blue. The thallus size was measured in centimeter, lobe size and ascocarps in millimeter and thallus medulla, epithecium, hymenium thickness, asci and ascospores size in milimicron. Chemistry of the specimens was included colour spot tests and Thin Layer Chromatography (TLC).

Colour Tests: Colour test has been preferred by chemical reagents by applying it on thallus and medulla resulting change in color. A positive change is denoted by a positive (+) symbol, followed by the colour produced and no change in colour is denoted by negative (-) symbol. The chemical reagents used are as follows:

a) K test: 10-25% aqueous solution of potassium hydro oxide, applied to cortex, medulla and part of apothecium.

b) C test: A freshly prepared aqueous solution of calcium hypochlorite or bleaching powder or modern commercial bleaching fluid containing active chlorine. It is prepared by dissolvingcalcium hypochlorite in the distilled water in 2% ratio.

c) KC test: At a particular spot of thallus, K is applied first and immediately followed by C.

d) PD test: Solution of paraphenylenediamine is prepared in ethanol or alcohol in a smallquantity for the use of a day. It is unstable and can not be used for the next day. A more stable solution called Steiner's PD is prepared by dissolving 1.0gm of paraphenylenediamine and 10gm of sodium sulphite in 100ml of distilled water with 1.0ml of a liquid detergent.This reagent keeps well for about a month.

e) I test: 2-5gm of iodine is dissolved in water with 0.5gm of potassium iodide. The reagent keeps well for several days and is to be renewed when fade colour.

Other colour tests: A dilute aqueous solution of nitric acid and aqueous solution of ferric chloride are sometime used for identification of Buellia species. The spot tests can be done on any part of the thallus but younger parts give better results. Colour test is done to a small fragment of the desired lichen thallus part or thallus or ascocarp. A definite colour comes showing the presence of any lichenic acid.

Micro-crystallography: Micro crystallography was introduced by Asahina (1936). The method does not need elaborate equipment. A small fragment of lichen to be investigated is placed on the middle part of a microscopic glass slide and one-two drops of acetone or any other organic solvent are dripped on to the fragment by means of dropper or pipette. Lichen substances if present gets dissolved in the solvent and extracted on the slide as residue in a ring form around the fragment as soon as the solvent evaporates. The thallus fragment is blown off. A micro-cover glass is placed over the residue and a drop of one of the crystallized fluids (detailed below) is placed at the edge of the cover glass. The fluid gradually seeps in. The slide is then heated gently over a sprit lamp. The residue dissolved in the fluid and lichen substances gradually crystallize into their characteristic of shapes on cooling. These crystals are observed under low power microscope and identified by comparison with the photographs or line diagram published by Asahina (1950, 1952), Hale (1967), Thomson (1967), Krog (1951) and others. Identification of depsides, depsidones and dibenzo-furans is usually confirmed by this method. The crystallizing fluids used are as:

a) G.E.- Glycerol: acetic acid, 1:3

b) G.A.W.- Glycerol: ethanol: water 1:1:1

c) G.A. Ot- Glycerol: ethanol: ortho-toludine 2:2:1

d) G.A. An- Glycerol: ethanol: aniline 2:2:1

e) G.A.Q. - Glycerol: ethanol: quinoline 2:2:1

Chromatography: Earlier in chromatography, paper was used for spotting the lichen substances.

Use of paper has been substituted by thin layer chromatographic plates. Glass sheets are either used in the laboratory by coating with silica gel or precoated Aluminum plates are prepared in the laboratory by taking ordinary smooth glass plates of 20cm square size. They are thoroughly cleaned by keeping them in glass tank, dried in a low temperature in (ca. 30-35ºc) oven. About 30gm of Merck or silica gel 'G' is made into a plate in 80ml of distilled water in a conical flask and stirred vigorously. This amount is sufficient for coating 10 plates. About 9-10ml of the silica gel paste is spread over glass plates are dried at 35ºc and can be left at that temperature till they are needed for chromatographic purposes. Generally Parmelinella wallichiana is used as a control for atranorin and salazinic acid (Rf class 2) and Usnea baileyi or Pyxine phillipina for norstictic acid (Rf class 4) have been used when the silica gel plate fully spotted with the desired number of extracts. It is placed in a jar, internally lined by filter paper and containing a specific solvent, level of which is about 1.0cm below the spotting places of the lichen extracts. The solvent gradually rises up in the silica gel coating and is allowed to rise up to 14cm mark. The plate is taken out dried in air and observed under ultra violet lamp; any fluorescence observed is marked or noted. For spotting the different fatty acids, distilled water is sprayed on the plates and spots are marked with pencil. A 10% aqueous solution of Sulphuric acid is finally sprayed over the coated surface of the plate which is then placed in an oven at a temperature of 110ºc for about 5-15 minutes or until the differently coloured spots at different levels become clear. The plate is then taken out, allowed to cool. The colour of the spots their position for each extract are noted, and again observed under ultra violet light and finally Rf value are calculated. Identification is made of lichen substances on the basis of the position and color of the spots by comparison with the charts published by Culberson (1972), Walker and James (1980) and White & James (1985).

$$\text{Rf Value} = \frac{\text{Distance traveled by lichen substance (indicated by spot)}}{\text{Distance traveled by solvent (Solvent front)}}$$

The following three solvent systems usually used for the chromatography are-

Solvent A or BDA- Benzene: 1, 4 dioxane: acetic acid: 90ml: 25ml: 4ml.

Solvent B or HEF- Hexane: di-ethyl-ether: Formic acid: 130ml: 100ml: 20ml.

Solvent C or TA- Toluene: acetic acid: 85ml: 15ml.

The most common solvent system used for chromatography is-

T.O.A- Toluene 180ml, dioxane 60ml: 8- acetic acid.

Three dimensional TLC has also been used to find out and determine lichen substances which are not detected by one directional T L C. Further sophistication has been achieved by the use of high performance chromatography (HPLC) and spectrometry. These techniques are much expensive and usually beyond the reach of an average lichenologist and therefore not detailed here.

Key to the lichen genera of Chopta

1	Thallus leprose-crustose……	Group I
1a	Thallus otherwise……	2
2	Thallus foliose……	GroupII
2a	Thallus fruticose or dimorphic…….....	Group III

Group I

1a	Thallus leprose……	2
1b	Thrallus crustose……	3
2a	Thallus byssaceous or crustose leprose, yellow to yellowish green……	Chrysothrix
2b	Thallus leprose, bluish-white……	*Lepraria*
3a	Thallus K + purple……..	4
3b	Thallus K -……..	5
4a	Thallus orange above, brown black below……	*Ioplaca*
4b	Thallus yellow to orange to red above, not brown black below…	*Caloplaca*
5a	Ascocarps perithecioid……..	6
5b	Ascocarps apothecioid……	7
6a	Spores simple, paraphyses gelatinized……	*Verrucaria*
6b	Spores transversely septate, paraphyses simple…….	*Pyrenula*
7a	Apothecia periphecioid, disc opening by pore, apothecia immeresed in thalline verrucae……...	*Pertusaria*
7b	Apothecial disc wide open apotheciod to elongate lirellate……	8

8a	Ascocarps resembling apothecia but ascolocular in nature, round to lirellate……	*Opegrapha*
8b	Ascocarp true apothecia……..	9
9a	Apothecia elongated - lirellate……..	*Graphis*
9b	Apothecia disc shaped……..	10
10a	Asci multi (64-100 or more) - spored, spores hyaline, small, thallus saxicolous……	*Acarospora*
10b	Asci 1-8 spored (rarely 12, 16, 32-spored)……	11
11a	Spores brown, typically 1 septate, thick celled……	*Buellia*
11b	Spores hyaline, simple……	12
12a	Spores large & distinctly thick celled, apothecia adnate sessile…	*Ochrolechia*
12b	Spore small, thin or thick celled……...	13
13a	Apothecia lecanorine……	14
13b	Apothecia lecideine……	15
14a	Apothecia initially innate, later plane emergent…….	*Aspicilia*
14b	Apothecia emergent & sessile from the beginning…….	*Lecanora*
15a	Thallus corticate, paraphyses branched & anotomosing……	*Porpidia*
15b	Thallus ecorticate, paraphyses simple to purcate……	*Lecidea*

Group II

1a	Perithecia immersed within the thallus……..	*Dermatocarpon*
1b	Apothecia ± superficial, laminal or marginal…….	*Umbilicaria*

Group III

1a	Thallus paronelioid or physcioid……	7
1b	Thallus……	2
2a	Photobiont blue green…….	3
2b	Photobiont green……	6
3a	Photobiont not strtified, thallus homoiomerous……	*Leptogium*

3b	Photobiont stratified, thallus eteromerous……	4
4a	Thallus corticated on both surfaces……	5
4b	Thallus corticated in upper surfaces only……..	6
5a	Thallus cyphellate, cyphellae in lower surface……...	*Sticta*
5b	Thallus lacking cephellae……	*Lobaria*
6a	Apothecia marginal to submarginal, lower surface with veins & pascicalate rhizines……..	*Peltigera*
6b	Apothecia laminal, lower surface lacking veins……	*Parmelinella*
7a	Apothecia nephromoid on lobe ends, thallus cetrarioid…….	8
7b	Apothecia laminal or marginal, not nephromoid, thallus parmelioid or physcioid……	11
8a	Upper cortex containing usnic acid……	9
8b	Upper cortex lacking usnic acid……	10
9a	Apothecia mainly laminal, conidia bacillariform……	*Cetrariopsis*
9b	Apothecia mainly marginal & submarginal, conidia filiform…..	*Allocetraria*
10a	Thallus erect, fruticose or sub fruticose, lobes canaliculate, lower surface without rhizomes, terricolous, conidia oblong citriform…	*Cetrelia*
10b	Thallus adnate, foliose, lobes not canaliculate, lower surface normally with rhizomes, corticolous, lobe margins ciliate……	*Cetrelia*
11a	Thallus parmelioid……	12
11b	Thallus physioid……	22
12a	Thallus pseudocyphellate……	13
12b	Thallus lacking pseudocyphellate……	14
13a	Thallus enaculate, pseudocyphellae punctiform, rhizines on lower surface reaching up to edge of lobes, medulla K+ red……	*Parmelia*
13b	Thallus enaculate, pseudocyphellae punctiform, rhizines on lower surface not reaching up to edge of lobes, medulla K-……	*Punctelia*
14a	Thallus ciliate……..	15
14b	Thallus lacking cilia……	21

15a	Thallus with bulbate cilia along margins……	*Bulbothrix*
15b	Thallus with simple cilia along margin……..	16
16a	Rhizines dichotomously branched……	*Hypotrachyna*
16b	Rhizines simple or squarrosely branched……	17
17a	Rhizines restricted in the central part of lower surface……	18
17b	Rhizines present throughout the lower surface……	19
18a	Upper surface emaculate, or if maculate, maculae neither forming effigurate nor forming reticulate cracks……	*Parmotrema*
18b	Upper surface white maculate, maculae forming reticulate cracks……..	*Rimelia*
19a	Thallus lobes narrow, linearly elongate, canaliculate, dichotomous.....	*Everniastrum*
19b	Thallus lobes otherwise……	20
20a	Upper surface with effigurate maculae, cilia robust, Markedly tapered, commonly furcate, conidia pliform……	*Canomachlina*
20b	Upper surface emaculate or with spotted maculae, cilia slender, not markedly tapered, simple, conidial cylindrical or bifusiform	*Myelochora*
21a	Rhizomes simple to squarrosely branched, leaving a narrow bare marginal zone less than 2mm wide…….	*Canoparmelia*
21b	Rhizomes dichotomously branched up to margin……	*Hypotrachyna*
22a	Upper cortex composed of longitudinally disposed compact hyphae, as seen in VLS of thallus……	*Heterodermia*
22b	Upper cortex vertically disposed, conglutinate hyphae, cellular (paraplectinchymatous) in cross section in any direction……	23
23a	Hypothecium brown to dark brown……	*Pyxine*
23b	Hypothecium hyaline to yellow……	24
24a	Thallus grey brown, K- (atranorin absent)……	*Phaeophyscia*
24b	Thallus glaucous grey to grey, K+ Yyellow (atranorin present)…	*Physcia*

Group IV

1a	Thallus podetiate or pseudopodiate……	2
1b	Thallus not podetiate, inflated……	*Ramalina*
2a	Thallus podotia, pseudopotidia solid……	3
2b	Thallus podetia or pseudopodia hollow, lacking central chondroid axis, poditia with squamules……..……	*Cladonia*
3a	Thallus with a central chondroid axis within medulla……	*Usnea*
3b	Thallus lacking central chondroid axis…….……	4
4a	Thallus on rock, non-acidic soil or decaying debris……	5
4b	Thallus on rock or wood, rarely on non-acidic soils, with sucate pseudocyphellae…….	*Sulcaria*
5a	Thallus sterile, with distichous dendroid branches (pseudopodetia) and granular phyllocladia, cephalodia absent…	*Leprocaulon*
5b	Thallus fertile, pseudopodetia with brown to black terminal or lateral apothecia, cephalodia usually present……	*Stereocaulon*

Key to lichen species of Chopta

1	Thallus yellow, greenish yellow, yellow orange……	2
1a	Thallus whitish or greenish grey, thin with calycin……	*Chryothrix* sp
2	Thallus thin yellow without slight orange or greenish tinge or greenish yellow, granules minute 0.01-0.1 (0.2) mm diam, thallus K-, KC- or KC orange red P- or P+ orange……..	*C. candelaris*
2a	Thallus thick, vivid primary yellow, granules 0.1-0.2 mm diam, forming pulverulent mass, thallus K- or K+ fainting orange, C-, KC-, or KC+ red.....	*C. chlorine*
3	Scypni centrally proliferated……	*Cladonia* sp
3a	Podetia with interior of scyphi open, axils olso open…….	*C. squamosa*
4	P+ red, primary squamules, 3X1.5 mm, persistent, podetia1oX70 (-130) mm tall, 1-2 mm in diam dichotomously or irregularly branched, cupless, apically attenuated, squamulles on podetia……	*C. furcata*
4a	Podetia taller 20mm and above……	5
5	Podetia 30-45mm tall, P+red, apices Subcorymbose……..	*C. corymbescens*

6	Thallus with tomentum of multicellular hyphal hairs, spore muriform……..	7
7	Thallus isidiate…….	8
7a	Thallus lacking isidia……	9
8	Thallus surafe distinctly wrinkled, bluish, lobes 3-9mm wide, isidia globular to clavate apothecia usually absent …….	*Leptogium papillosum*
9	Whitish stiff trichomes present on thalline exciple…….	10
9a	Trichomes absent on thalline exciple……	11
10	Apothecia sessile to constricted at base, upto 2mm diam trichomes robust and dense on exciple, thallus grey-brown to brown-black, lobes 8-12mm wide, spores 20-35X10-13µm…….	*L. trichophorum*
11	Apothecia sessile to substipitate, up to 5 mm diam exciple thick, wrinkled with short trichomes, thick dark-brown to grey-black, lobes 3-20mm wide spores 25-34X8-12µm…….	*L. askotense*
11a	Apothecia stalk short, constricted, not lobular disc upto 4.5mm diam, thallus bluish-rgey to dark grey lobes 5-10 (-20) mm wide, smooth, spores 28-37X12-17µ…….	*L. pedicelatum*
12	Exciple complete (closed), variable in colour, totally black, lobia of exciple 4-12 sulcate at upper edge, sulcai black, nacked, not covered by hyphal tissue, lirellae emergent to dichotomously branched, spores 8-10 celled, 24-45X6-8µm……	*Graphis sikkimensis*
12a	Exciple domidiate (deficient at base), black…….	13
13	Spores 8-16 celled, 25-50X4-9µm……...	*G. scripta*
14	Thallus leprose, granular, apothecia absent…….....	15
14a	Thallus leprose, granular, apothecia always present..	*Lecanora* sp1
15	Thallus K-, C-, PD……	16
16	Thallus having zeorin, greenish, granular without projecting hyphae ……...	*Lecanora* sp2
16a	Thallus lacking zeorin, but having lecanoric like spot, which grey, with dense projecting hyphae……..	
17	Epihymenium of chlarotera type, zeorin absent……..	18
18	Thallus containing 2-0-methyl perlatoric acid apothecial disc pale	*L. achroa*

	orange brown, epihymenium yellowish brown……	
19	Lower surface black to brown, lobes sinuate……...	20
19a	Apothecia numerous, 3-10mm in diam, atranorin and salazinic acid present……..	*Bulbothrix meizospora*
20	Apothecia rare, adnate, 2-3mm in diam, atranorin only……	*B. bulbochaeta*
21	Spores 1-3 septate or sorediate…….	*Opegrapha leptoterodes*
22	Thallus isidiate or sorediate…….	23
22a	Thallus lacking isidia and soredia……	24
23	Thallus isidiate, isidia coralloid, soredia absent, lobes up to 15mm wide, upper surface grayish-white to brownish-tan, lower surface brown-black, medulla c-, KC+ pink or red alectoronic acid and alpha collatolic acid present…….	*Cetrelia braunsiana*
24	Medulla C+ pink or red (olivetoric acid present) lobes up to 15mm wide, upper surface grey, grey-white to light- brown, smooth to cracked, pseudocyphellae distinct……...	*C. pseudolivetorum*
25	Medulla C-, KC+ pinkish or KC-, lobes up to 15mm wide, tan or pale, lower surface jet black……	*C. cetrarioides*
26	Lower surface of thallus erhizinate or rhizinies only near margins.	*Everniastrum cirrhatum*
26a	Lower surface with uniform rhizines, and marginal cilia of varying length, once or twice furcated ……	*E. nepalense*
27	Thallus lacking isidea, barbatic acid present or absent……	28
28	Medulla K+yellow, atranorin and norstictic acid present……	*Hypotrachyna crenata*
29	Thallus closely to loosely adnate to the substratum, 4-10 across, lobes sublinear, subimbricate, 2-4mm wide……	*Myelochora irrugans*
29a	Thallus adnate to the substratum, 5-10cm across lobes sublinear to subirregular, imbricate, 2-5mm wide, 100-115 µm thick……	*M. aurulenta*
30	Thallus isidiate, pycnidia absent, lobes subdichotomously to irregularly branched and sinuate……	*Parmelinella wallichiana*
31	Thallus lobe margin lacking cilia…….	*Parmotrema mesotropum*

31a	Thallus KC+red……	*P. nilgherrense*
32	Spores, straight to curved, transversely 5-9 septate 34-96X3.5-5µm……..	*Peltigera polydactyla*
32a	Spores acircular, transversely 5-7 septate, 47-75X3-6µm……	*P. rufescens*
33	Thallus sorediate……...	34
34	Apothecia unknown & thallus corticolous……...	*Pertusaria leucosorodes*
35	Thallus K+yellow, P+orange, norstictic stitic and constictic acid present…….	*P. quassiae*
36	Spores transversely septate…….	*Buellia leptochina*
36a	Thallus saxicolous, continuous to cracked, areolate, hypothallus present, apothecia 0.2-0.6 (0.8) mm wide, spore 9-15X4-7µm.....	*B. stigmea*
37	Thallus ribbon like or rosulate, attached to substratum by basal or central part, lower cortex absent……	38
38	Thallus ribbon licke, with black rhizinae along margin, lower surface K+yellow-red, PD+yellow-orange, salazinic acid present...	*Heterodermia leucomela*
38a	Thallus rosulate, lobes suberect, lower surface (medulla) K+yellow-red, PD- or PD+ pale yellow, salazinic acid absent……	*H. incana*
39	Thallus lacking lower cortex, rhizinae absent on lower surface, but presence along with the margin, spore with or without polyblastidia…….	40
40	Lower surface of laciniae white, lacking pigment, black to purple-black in other parts……...	*H. japonica*
41	Thallus isidiate and/or sorediate……...	42
42	Medulla K+yellow turning reddish, PD+ deep yellow (norstictic and salazinic acid present), apothecia up to 8mm diam spores 26-32X12-18µm……	*H. speciosa*
43	Soralia capitate on short lateral branches, lacunae up to 1.5mm wide, apothecia up to 3mm diam, marginally sorediate, spores 26-32X12-18µm…….....	*H. psuedospaciosa*
43a	Medulla white…….	44
44	Medulla K-, PD-, thallus often large, much variable, laciniae 2-2.5mm wide, with or without lateral lobes, apothecia up to 7mm	*H. diademata*

	diam, margin crenulate to lacinulate, spores 23-35X10-15µm……	
45	Thallus sorediate, medulla, non-pigmented……..	*Pheophyscia hispidula*
46	Thallus UV+yellow…….	47
47	Medulla yellow, deep yellow, hypothecium K+red-violet……..	*Pyxine berteriana* var *himalayensis*
48	Thallus pseudocephallate, ascocarps always more than 0.5mm in diam, immersed, ostiole indistinct or umblicate…….	*Pyrenula immerse*
49	Thallus sorediate, dichotomous to irregularly divide……..	*Ramalina roesleri*
49a	Thallus lacking soredia…….	50
50	Thallus canaliculate, ribbon-like……..	*Ramalina canduplicans*
50a	Thallus not canaliculated……..	51
51	Thallus palmately lobed or dissected, pseudocyphellae alternating with corticated ridges.....	*Ramalina sinensis*
51a	Thallus strap- shaped to irregular with more than 1mm wide, pseudocyphellae raised on tubercles, prominent white……..	*Ramalina* sp
52a	A central axis solid, cortex of filamentose branches partially cracked to areolate and sometimes evanescent, thallus up to 30 cm long, main branch 0.5mm in diam, lateral branchlets dense, stictic acid complex present……..	*Usnea pectinata*
52b	Central axis brown or brownish……	53
53	Lateral branchlets sparse, rigid, filamentous branches with annular to irregular cracks, pseudocyphellae on palillae , cortex semi-prosoplectenchymatous, stictic acid complex present …….	*Usnea indica*
53a	Cortex evanescent through the filamentose branches. Lateral branchlets variable in length usually quite along, sometimes verrucose, isidiate, spore 8 X 6 µm….. ……	*Usnea longissima*
53b	Cortex present on filamentose branches or sometimes cortex evanescent …….	*Usnea pectinata*
54	Thallus lacking pseuedocephellai……	55
55	Thallus lacking isidia and soredia, apothecia present, cortex single layred, thallus surface papillate, normal branches present……	*Usnea orientalis*

55a	Thallus isidiate lacking soredia……..	56
56	Thallus decumbent to pendulous, upto 3cm long, branches convergent, lateral branchlets absent stictic acid complex persent	*Usnea aciculifera*
56a	Thallus erect, 6(-8) cm tall, branches divergent, lateral branches sparse to dense, stictic acid complex present……	*Usnea eumitrioides*
57	Young branches initially sorediate, soredia later isidiate, thallus 3-9cm tall, branches divergent, strains of norstitic, salazinic, squamatic and thamnolic acid present……..	*Usnea subfloridana*
58	Lower surface rhizinate, thallus up to 12cm diam……...	*Dermatocarpon vellereum*
59	Thallus with lichen substance……...	60
60	Thallus with norstictic, stictic and constictic acid, with fragile margin sometimes with distinct lobes……..	*Lepraria lobificans*

RESULTS

A total of 106 species of lichen specimens from the study area Chopta forest (a purely *Q. semecarpifolia* forest) between 2500m to 3500m altitudes were recorded (Table 1). The specimens were collected in the month of May to October 2006.

Table 1: List of 28 families with 47 genera and 106 species of lichens recorded on different substrates in the Baniyakund-Chopta.

S. No.	Lichen Taxa	Family	Growth Form	Substratum
1	*Acarospora chlorophana* (Wahlenb, in Ach.) Massal.	Acarosporaceae	Crustose	On rock
2	*Acarospora saxicola* Fink ex Hedrick	Acarosporaceae	Crustose	On rock
3	*Allocetraria stracheyi* (Bab.) Kurok. & Lai	Parmeliaceae	Foliose	On rock
4	*Aspicilia dwaliensis* Rasanen	Hymeneliaceae	Crustose	On rock
5	*Buellia leptocline*(Flotow) Massal.	Physciaceae	Crustose	On bark
6	*Buellia stigmea* Tuck.	Physciaceae	Crustose	On rock
7	*Bulbothrix bulbochaeta* (Hale.) Hale.	Parmeliaceae	Foliose	On bark

8	*Bulbothrix meizospora* (Nyl.) Hale.	Parmeliaceae	Foliose	On bark
9	*Caloplaca pelodella* (Nyl.) Hasse	Teloschistaceae	Crustose	On bark
10	*Caloplaca* sp1	Teloschistaceae	Crustose	On rock
11	*Caloplaca* sp2	Teloschistaceae	Crustose	On rock
12	*Canoparmelia aptata* (Krempedh) Elix & Hale	Parmeliaceae	Foliose	On bark
13	*Cetrariopsis wallichiana* (Taylor) Kurokawa	Parmeliaceae	Foliose	On bark
14	*Cetrelia braunsiana* (Muell. Arg.) Culb & C. Club	Parmeliaceae	Foliose	On bark
15	*Cetrelia cerarioides* (Delise ex Duby) Culb & C. Culb	Parmeliaceae	Foliose	On bark
16	*Cetrelia pseudolivetorum* (Asah) Club & C. Club	Parmeliaceae	Foliose	On bark
17	*Cetrelia sanguinea* (Schaerer) Club & C. Club	Parmeliaceae	Foliose	On bark
18	*Cetrelia sanguinea* (Schaerer) Club. & C. Club.	Parmeliaceae	Foliose	On bark
19	*Chrysothrix candelaris* (L.) Laundon	Chrysothricaceae	Crustose	On bark/rock
20	*Chrysothrix chlorina* (Ach.) Laundon	Chrysothricaceae	Crustose	On bark
21	*Cladonia corymbescens* Nyl.	Cladoniaceae	Squamules	On soil
22	*Cladonia furcata* (Huds) Schrader	Cladoniaceae	Squamules	On bark/rock with moss
23	*Cladonia* sp.	Cladoniaceae	Squamules	On rock
24	*Cladonia squamosa* (Scop) Hoffm	Cladoniaceae	Squamules	On bark
25	*Dermatocarpon vellereum* Zschacke	Dermatocarpaceae	Foliose	On rock

26	*Everniastrum cirrhatum* (E Fries) Hale ex Sipman	Parmeliaceae	Foliose	On bark
27	*Everniastrum nepalense* (Taylor) Hale ex Sipman	Parmeliaceae	Foliose	On bark
28	*Graphis aicatricosa* Nyl.	Graphidiaceae	Crustose	On bark
29	*Graphis chlorotica*	Graphidiaceae	Crustose	On bark
30	*Graphis proserpens* Vainio	Graphidiaceae	Crustose	On bark
31	*Graphis scripta* (L.) Ach.	Graphidiaceae	Crustose	On bark
32	*Graphis sikkimensis* (Nagarkar & Patw.)	Graphidiaceae	Crustose	On bark
33	*Heterodermia diademata* (Taylor) D. Awasthi	Phyasciaceae	Foliose	On bark
34	*Heterodermia hypocaesia* (Yasuda) Awasthi	Phyasciaceae	Foliose	On rock
35	*Heterodermia incana* (Stirton) D. Awasthi	Phyasciaceae	Foliose	On bark
36	*Heterodermia isidiophora* (Vainio) Awasthi	Phyasciaceae	Foliose	On bark
37	*Heterodermia japonica* (Sato.) Swinsc. & Krog.	Phyasciaceae	Foliose	On soil with moss
38	*Heterodermia leucomela* (L.) Poelt	Phyasciaceae	Foliose	On bark
39	*Heterodermia pseudospeciosa* (Kurokawa) Culb	Phyasciaceae	Foliose	On bark with moss
40	*Heterodermia speciosa* (Wulfen) Trevisan	Phyasciaceae	Foliose	On rock
41	*Hymenelia* sp.	Hymeneliaceae	Foliose	On bark
42	*Hypotrachyna awasthi*Hale & Patw.	Parmeliaceae	Foliose	On rock with moss
43	*Hypotrachyna crenata* (Kurok) Hale	Parmeliaceae	Foliose	On rock
44	*Hypotrachyna exsecta* (Taylor) Hale	Parmeliaceae	Foliose	On bark
45	*Hypotrachyna scytophylla* (Kurok.) Hale	Parmeliaceae	Foliose	On rock
46	*Ioplaca pindarensis* (Rasanen) Poelt & Hintergger	Teloschistaceae	Crustose	On rock
47	*Lecanora achroa* (Nyl.) Crombie	Lecanoraceae	Crustose	On bark

48	*Lecanora* sp	Lecnoraceae	Crustose	On rock
49	*Lecidea* sp.	Lecideaceae	Crustose	On bark
50	*Lepraria lobificans* Nyl.	Lichen imperfecti	Crustose	On bark
51	*Lepraria* sp1	Lichen imperfecti	Crustose	On bark
52	*Lepraria* sp2	Lichen imperfecti	Crustose	On bark
53	*Leprocaulon pseudoarbuscula* (Asah.) Lamb & Ward	Lichen imperfecti	Crustose	On rock
54	*Leptogium askotense* D. Awasthi	Collemataceae	Foliose	On bark
55	*Leptogium papillosum* B. de Lesd Dodge	Collemataceae	Foliose	On bark
56	*Leptogium pedicelatum* M. P. Jorg	Collemataceae	Foliose	On bark
57	*Leptogium trichophorum* (Muell.) Arg.	Collemataceae	Foliose	On bark
58	*Lobaria retigera*(Bory) Trevisan	Lobariaceae	Foliose	On bark
59	*Lobaria* sp	Lobariaceae	Foliose	On bark
60	*Myelochora aurulenta* (Tuck) Elix & Hale	Parmeliaceae	Foliose	On bark
61	*Myelochora irrugans* (Nyl.) Exil & Hale	Parmeliaceae	Foliose	On bark
62	*Myelochora xantholepsis* (Mont & Bosch) Elix & Hale	Parmeliaceae	Foliose	On bark
63	*Ochrolechia rosella* (Muell. Arg.) Vers.	Pertusariaceae	Crustose	On bark
64	*Opegrapha* sp.	Opegraphaceae	Crustose	On Leaf
65	*Parmelia squarrosa*Hale	Parmeliaceae	Foliose	On bark
66	*Parmelinella wallichiana* (Taylor) Elix & Hale	Parmeliaceae	Foliose	On soil with moss
67	*Parmotrema mesotropum* (Muell. Arg.) Hale	Parmeliaceae	Foliose	On bark
68	*Parmotrema nilgherrense* (Nyl.) Hale	Parmeliaceae	Foliose	On bark
69	*Parmotrema saccatilobum*(Taylor) Hale	Parmeliaceae	Foliose	On bark

70	*Peltigera polydactyla* (Neck) Hoffm	Peltigeraceae	Foliose	On bark/Soil with moss
71	*Peltigera rufescens* (Weiss) Humb	Peltigeraceae	Foliose	On soil with moss
72	*Pertusaria aqussiae* Fe	Pertusariaceae	Crustose	On bark
73	*Pertusaria leucosorodes* Nyl.	Pertusariaceae	Crustose	On bark
74	*Phaeophyscia hispidula* (Ach.) Moberg	Phyasciaceae	Foliose	On bark
75	*Phyllopsora albicans* Muell. Arg.	Lecideaceae	Crustose	On bark
76	*Physcia dimidiata* (Ach.) Nyl.	Physciaceae	Foliose	On bark
77	*Porpidia albocoerulescens (*Wulfen) Hertel & Knoph in Hertel	Porpidiaceae	Crustose	On rock
78	*Porpidia crustulata*(Ach.) Hertel & Knoph in Hertel	Porpidiaceae	Crustose	On rock
79	*Porpidia macrocarpa*(DC) Hertel & Knoph in Hertel	Porpidiaceae	Crustose	On rock
80	*Punctelia borreri* (Sm) Krog.	Parmeliaceae	Foliose	On bark
81	*Punctelia neutralis* (Hale) Korg.	Parmeliaceae	Foliose	On rock
82	*Punctelia subrudecta* (Nyl.) Krog.	Parmeliaceae	Foliose	On rock
83	*Pyrenula immersa* Muell. Arg.	Pyrenulaceae	Crustose	On bark
84	*Pyrenula immissa* (Stirton) Zahlbr	Pyrenulaceae	Crustose	On bark
85	*Pyxine berteriana* var *himalaica* D. Awasthi	Phyasciaceae	Foliose	On bark
86	*Pyxine subcinerea*Stirton	Physciaceae	Foliose	On bark
87	*Ramalina conduplicans* Vainio	Ramalinaceae	Fruticose	On bark
88	*Ramalina himalensis*Rasanen	Ramalinaceae	Fruticose	On rock
89	*Ramalina roesleri* (Hochst) Hue	Ramalinaceae	Fruticose	On bark
90	*Ramalina sinensis* Jatta	Ramalinaceae	Fruticose	On bark
91	*Rimelia reticulata* (Taylor) Hale & Fletcher	Parmeliaceae	Foliose	On rock
92	*Stereocaulon foliolosum* Nyl.	Stereocaulaceae	Foliose	On rock

93	*Stereocaulon pomiferum* Duvign.	Stereocaulaceae	Foliose	On rock
94	*Sticta nylanderiana*Zahlbr.	Stictaceae	Foliose	On bark
95	*Sulcaria sulcata* (Lev) Bystr. Ex Brodo & D. Hawkow	Alectoriaceae	Foliose	On bark
96	*Umbilicaria badia* Frey	Umbilicariaceae	Foliose	On rock
97	*Umbilicaria indica* Frey	Umbilicariaceae	Foliose	On rock
98	*Umbilicaria virginis* Schaerer	Umbilicariaceae	Foliose	On rock
99	*Usnea aciculifera*Vainio	Usneaceae	Fruticose	On bark
100	*Usnea eumitrioides* Mot.	Usneaceae	Fruticose	On bark
101	*Usnea indica* Mot.	Usneaceae	Fruticose	On rock
102	*Usnea longissima* Ach.	Usneaceae	Fruticose	On bark
103	*Usnea orientalis* Mot.	Usneaceae	Fruticose	On bark
104	*Usnea pectinata* (Taylor)	Usneaceae	Fruticose	On bark
105	*Usnea subfloridana* (Stirton)	Usneaceae	Fruticose	On bark
106	*Verrucaria acrotella* Ach.	Verrucariaceae	Crustose	On rock

DISCUSSION

The most common lichen species growing on different phorophytes belongs to the genera Chrysothrix, Parmelioid, Usnioid and Graphidiaceous lichens while Acarospora, Aspicilia, Umblicaria, Dermatocarpon, Porpidia, Buellia and Caloplaca mostly prefers to grow on rocks. Species of lichen genera Peltigera, Lobaria and Sticta prefers soil for their growth. The lichen flora in the study area exhibits greatest abundance in variety and luxuriance of growth. The lichens in the study area seem to prefer the bark of trees or rock as their substratum. Lichens also occur on soil, decaying wood, mosses and humus. The corticolous lichens are greatly influenced by the physical characters of the bark. Corticolous lichens may be epiphloedal or endophoedal based on their growth above or within the substratum. In epiphloedal lichens or the lichen tissue (especially the algal layer) develops above the outermost corky layer of bark, although few layers of cork are incorporated into the lower portion of the thallus. In endophloedal lichens the thallus crust lies entirely below the cork of periderm. Section of endophloedal crustose lichens together with their

bark substrate generally show that the lichen thallus remains to the corky outer periderm by one or many layers of suberised impermeable cork cells. The nature of bark (smooth or rough) and moisture retaining capacity of bark also plays vital role in determining the type of lichen species. *Quercus, Rhododendron, Acer* spp. and many other trees, as well as species of shrub and ringal act as favorable substrate for the luxuriant growth of lichens. Together with trees some shrubs of Berberis and Cotoneaster also provide a suitable substrate for growth of many lichen taxa.

The growth of lichens on rock is based on the physical and chemical characters of the rocks. The hard, permanent, and moist rock preferred by most of the lichen than the rocks which weather soon and allowing less time to the lichen to produce reproductive organs. Proximity of water to substratum also exerts great influence in determination of the type of lichen growth.

The lichen on the rock depends upon whether the rocks are acidic or basic. The exposure and moisture relationship strongly influence the lichen cover on rocks. The boulders along the stream and in open fields and fell fields are suitable habitats for lichens. In the open boulder fields the foliose lichen Heterodermia and Phaeophyscia occupies the exposed rocks and boulders while humus and soil containing pebbles at the base of boulders in moist places provide a habitat for lichen species Cladonia and Peltigera. The exposed dry boulders received sunrays throughout the day remains more or less dry and hot and only few dark black Buellia and Acarospora species able to grow.

The common epiphytic foliose and fruticose genera are Everniastrum, Parmoterma, Heterodermia, Bulbothix, Hypotrachyna, Leptogium, Parmelia, Parmellinella, Lobaria, Ramalina, Rimelia, and Usnea. These genera colonize on trunk, branches, minor branches and twigs.

The moist shady location in the study area provide suitable habitat for growth of terricolous (soil inhabiting) and muscicolous (moss inhabiting) lichen species of Peltigera and Cladonia. Vertical face of roads covered with moss and small herbaceous plant provide a moist shady habitat for growth of terricolous and muscicolous lichens. Among different lichen forms the foliose forms dominated the area by 57 species followed by crustose 34 and 11 fruticose and 4 squamules species. Among the different lichen families, the Parmeliaceae exhibit its dominance in the area represented by 15 genera (31.9%) out of the 74 genera of lichens known from the area.

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Chapter-5

MACRO-LICHENS COVER AND THEIR DISTRIBUTION PATTERN ON TWO COMMON PHOROPHYTES (*QUERCUS SEMECARPIFOLIA* AND *RHODODENDRON ARBOREUM*) IN A TEMPERATE FOREST OF RUDRAPRAYAG DISTRICT GARHWAL (UTTRARKHAND), INDIA

ABSTRACT

Macro-lichens cover and their distribution pattern on two common *Quercus semecarpifolia* and *Rhododendron arboreum* trees from the moist temperate forest (Chopta) of Garhwal Himalaya. Out of three d. b. h. classes trees (diameter at breast height), d. b. h. between 0.1-0.30m, has found maximum cover of macro-lichens at southeast aspect.

Key Words- Lichen cover, Macrlichens, Garhwal Himalaya

INTRODUCTION

Lichens are most successful symbiotic organisms in nature, dominating 8% or more of the earth's terrestrial area (Ahmadjian 1995) and are amongst the most significant indicators of air pollution and ecosystem health (Richardson 1992, Wolseley et al 1995, Upreti 1995). They are very sensitive to microclimatic changes. Therefore any natural manmade disturbances are bound to affect lichen populations (Negi, 1996). Lichens are able to grow in diverse climatic conditions and on equally diverse substrata. They are widely distributed in almost all the phytogeographical regions of the world. Requisite moisture and light, unpolluted air and undisturbed substratum often favor optimum growth and abundance of lichens (Awasthi, 2000).

To assess the micro-lichen distribution pattern and cover on different tree species, the host tree species were identified through a survey and presence or absence of occurrence of macro-lichens on different tree species in an open canopied forest (ocf) and a closed canopied forest (ccf) were recorded. A total of eight tree species viz. *Rhododendron arboreum*, *R. anthopogon*, *Quercus semecarpifolia*, *Taxus baccata*, *Ilex dipyrena*, *Abies pindrow*, *Asculus indica*, and *Acer sp* were identified in both the forest between 2500m to 3500m altitudes. Due to variation of the aspects and vegetation type on the southeast aspect (ocf site) only two species viz. *Quercus semecarpifolia* and

Rhododendron arboreum were present there. *Rhododendron arboreum* was less dominant than the *Quercus semecarpifolia*. Thus comparison of macro-lichen species distribution and cover on different parts viz. trunk, branch and twigs of these two tree species were performed.

The present paper, enumerates the cover of some macro-lichens of the Chopta area of the Garhwal Himalaya viz. *Usnea, Everniastrum, Parmotrema, Cetrariopsis* and *Ramalina.* Because these five lichen taxa are commercially exploiting in some high altitude area of Uttarakhand state.

METERIALS AND METHODS

Site

Chopta forest is situated between 2500m to 3500m altitudes along with Akashkamini valley of district Rudraprayag (Garhwal) India. A stratified random sampling method was employed. For the assessment of the macro-lichen species distribution pattern and cover on tree parts, the selected host tree species viz. *Quercus semecarpifolia* and *Rhododendron arboreum* were stratified into different parts or locations of tree parts, due to suitability of the work, on northwest aspect and south east aspect of the forest. The studied parts of the host tree are as trunk, branch, and twigs.

Sampling of host trees

The trees were categorized into three d. b. h. (diameter at breast height) classes viz. 0.1-0.30m, 0.31-0.60m and 0.61-0.90m. Five trees of each species on both the site of the forest of each d .b. h. class were selected randomly between 2500m to 3500m altitudes, and laid five quadrats (10cm²) randomly on each selected tree trunk and in each quadrat, number of individuals of small, medium and large macro-lichens were counted in each sample quadrat and noted properly. The d. b. h of the trunk was also recorded. Similarly three branches of each selected tree species randomly selected and placed randomly five quadrats (5cm²) on each branch and count and noted the number of individuals of small, medium and thallus in each quadrat sample.

The summing of individuals of each small, medium and large macro-lichen taxa in total number of quadrats studied on total sample trees trunk (five trunks) and multiplied by calculated mean size of small, medium and large size of each selected macro-lichen and the calculated value is divided by total number of quadrats studied. The calculated mean cover represented by square centimeter size of the lichen on the tree part. Formula (Kumar, 2008)-

$C = T \times A / N$

Where 'C' is the size wise cover (cm²) of a macro-lichen.

'T' is the total number of individuals of each small, medium & large size macro-lichen taxa in all quadrats studied on total number of sample trunk for each dbh class.

'A' is the calculated size of macro-lichen taxa.

'N' is the total number of quadrats studied on total sampled trunk of each dbh class.

Similarly for branch the lichen species cover (size wise) were calculated by the following formula (Kumar, 2008)-

$C = B \times A / N$

Where 'C' is the size wise cover (cm²) of macro-lichen taxa.

'B' is the total number of individuals of each small, medium & large size macro-lichen taxa in all quadrats studied on total number of branches for each dbh class tree.

'A' is the calculated mean size of that lichen taxa.

'N' is the total number of quadrats studied on total sampled branches of each d. b. h. class tree.

To estimate the lichen cover on twigs, a scale with ten centimeter marking at 1cm distance was used on five randomly selected twigs of each d. b. h. class tree, and the sum of total lichen cover on all sampled twigs of each d. b. h. class trees, was divided by total number of twigs sampled on that d. b. h. class trees (Table 1).

Table 1: Calculated mean size (cm²) of each major lichen taxa

Major lichen species	Calculated mean size of major macro-lichen thallus (cm²)		
	Small	Medium	Large
Everniastrum	1.7	3.12	6.48
Parmotrema	1.74	3.08	5.0
Usnea	1.9	3.74	6.0

Ramalina	1.56	3.02	4.88
Cetrariopsis	1.74	3.1	5.94

RESULTS

The macro-lichen cover analysis on the tree parts at two different study sites are given in table 2, 3, and 4. In both the aspects young saplings of ***Quercus semecarpifolia*** (dbh between 0.01-0.30m) provides maximum lichen cover, and ***Rhododendron arboreum*** recorded minimum cover of macro-lichens.

Table 2: Lichen cover (cm²) on trunk of two phorophytes at southeast aspect (ocf)

Phorophyte (Trunk)	Trunk dbh (m)	Available mean surface area (m²) for covering/growth of lichens	Lichen cover (cm²/10cm²)
Q. semecarpifolia	0.1-0.30	0.33	7.46
	0.31-0.60	0.9	4.13
	0.61-0.90	8.4	3.2
R. arboreum	0.1-0.30	0.17	4.24
	0.31-0.60	1.31	2.31
	0.61-0.90	5.42	1.39

Table 3: Lichen cover (cm²) on trunk of two phorophytes at northwest aspect (ccf).

Phorophyte (Trunk)	Trunk dbh (m)	Available mean surface area (m²) for covering/growth of lichens	Lichen cover (cm²/10cm²)
Q. semecarpifolia	0.1-0.30	0.35	9.46
	0.31-0.60	0.95	1.43
	0.61-0.90	8.02	2.37
R. arboreum	0.1-0.30	0.12	0.61
	0.31-0.60	0.96	0.53
	0.61-0.90	4.36	0.85

Table 4: Lichen cover (cm²) on branch of the phorophytes

Forest	Branch	Lichen taxa	Lichen cover (cm²/5cm²)	Available mean surface area of the branch for growth of lichen taxa (m²)
OCF	*Q. semecarpifolia*	*Everniastrum*	2.21	
		Parmotrema	0.69	
		Usnea	1.62	
		Ramalina	0.17	
		Cetrariopsis	0.24	
		Total cover	4.93	0.08
	R. arboreum	*Everniastrum*	0.92	
		Parmotrema	0.35	
		Usnea	0.42	
		Total cover	1.69	0.03
CCF	*Q. semecarpifolia*	*Everniastrum*	3.28	
		Parmotrema	0.34	
		Usnea	0.62	
		Ramalina	0.16	
		Cetrariopsis	0.07	
		Total cover	4.46	0.08
	R. arboreum	*Everniastrum*	0.08	
		Parmotrema	0.29	
		Total cover	0.37	0.03

DISCUSSION

The lichen cover indicates the tree growth function and also attributes for health and ecosystem function of the area. The corticolous lichens growth on tree bark is a useful indicator of

young trees. The lichen cover on different parts of phorophytes at south east aspect (open canopied site) of the forest as young *Quercus semecarpifolia* tree diameter (dbh) between 0.1-0.30m, the lichen cover was 7.46cm²/10cm² and the available mean surface area of the trunk was recorded 0.33m². The trunk diameter between 0.31-0.60m exhibit lichen cover 4.13cm²/10cm², when the available surface area of the trunk was recorded 0.901m². Similarly the trunk diameter between 0.61-0.90m when the available surface area of the trunk was 8.40 m² and 3.20cm²/10cm² lichen cover was recorded.

In the northwest aspect (ccf) of the same forest, the *Q. semecarpifolia* young tree diameter (dbh) between 0.1-0.30m has 9.46cm²/10cm² lichen cover out of 0.35m² available surface area of the trunk. The trunk diameter (dbh) 0.31-0.60m has 1.43cm²/10cm² of lichen cover in 0.95m² surface area of the trunk. Similarly the trunk diameter 0.61-0.91m has lichen cover of 2.37cm²/10cm² out of 8.02m² surface area of the trunk. Both the foliose lichen genera Everniastrum and *Parmotrema* covered about 1cm²/10cm² area of the *Q. semecarpifolia* while other lichen genera *Usnea, Ramalina* and *Cetrariopsis* exhibit lower lichen cover.

Lichen cover on branch of *Quercus semecarpifolia* was recorded as 4.93cm²/5cm² out of the available surface area of 0.08m² at southeast aspect (ocf). In the north west aspect (ccf) it was recorded 4.46cm²/5cm² out of available area of 0.08m². In both the aspect the *Everniastrum* play a significant role providing as it constitutes the highest lichen cover (3cm²/5cm²). The other lichen taxa provide a poor representation (<1cm²/5cm² area) for lichen cover on *Quercus semecarpifolia* branch (Table 4).

The *Quercus semecarpifolia* tree at, northwest aspect exhibits the maximum lichen cover represented by more than 70% while southeast aspect has only 40% of lichen cover.

In the open canopied forest the *Rhododendron arboreum* trunk shows maximum lichen cover. The *Rhododendron arboreum* tree trunk in closed canopied site has poor lichen cover (< 1cm²/10cm²) as compare to the open canopied trees (Table 2 and 3).

The *Rhododendron arboreum* trunk dbh between 0.1-0.30m has 4cm²/10cm² of lichen cover. The trunk with 0.31-0.60m dbh has 2.31cm²/10cm² of lichen cover out of the available surface area of 1.31m². The trunk of dbh 0.61-0.91m recorded 1.39cm²/10cm² lichen cover out of 5.42m²

available surface area of the trunk. It is interesting to note that the lichen cover was decreasing with increasing diameter of the *R. arboreum* trunk (Table 2 and 3).

Rhododendron arboreum branches in the open canopied forest has 0.92cm²/5cm cover of *Everniastrum* which is quite low in the closed canopied forest (0.08cm²/5cm), while the *Parmotrema* cover in both closed and open canopied forest was more or less similar. The fruticose lichen *Usnea* was not recorded only closed canopied *Rhododendron* forest (Fig. 4.12 and 4.13). The twigs and trunk of *Rhododendron arboreum* in northwest aspect bear 16% of lichen taxa than the southeast aspect, which has only 5% of lichens.

The size of lichen cover may be affected by a number of climatic variations in the study area. The aspect variation, type of vegetation, darkness and disturbances, presence or absence of light, moisture and other climatic conditions play important role in growth and colonization of lichens. It also depends on the age and bark condition of the tree. The bark of the trees in closed canopied forest; provide excellent conditions for growth of other epiphytes viz. mosses, bryophytes, ferns, orchids, and angiosperms. Thus there remains little space for lichens to colonize.

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Chapter-6

ESTIMATION OF DRY MASS OF EPIPHYTIC LICHENS IN A TEMPERATE FOREST OF GARHWAL HIMALAYA, INDIA

ABSTRACT

The dry mass of epiphytic lichens of two common *Quercus semecarpifolia* and *Rhododendron arboreum* trees from the moist temperate forest of Chopta-Tunganath region of Garhwal Himalaya District Rudraprayag has been discussed. Out of three d. b. h. classes' trees (diameter at breast height), d. b. h. 1-30cm and 30-60cm has found maximum mass of epiphytic lichens.

INTRODUCTION

According to the concept of Esseen & Renhorn (1998), high biomass of epiphytic lichens is a characteristic feature of many old- growth forest ecosystems in temperate and boreal areas. Various workers like Pike (1978), Boucher & Nash (1990), Knops et al. (1991, 1996) and Esseen et al. (1996) epiphytic lichens are abundant, they may play an important role in the nutrient cycling in forest ecosystem. In the temperate regions of the Garhwal Himalaya lichen collection is a common practice among the villagers and the trivial to collect the lichens together with tree twigs, as oak trees especially *Quercus semecarpifolia* (Kharsu oak). The precipitation peculiar to the high altitudes raise the atmospheric humidity; the frequency of clouds in summer as well as the snow amount in winter are water reservoirs favouring the development of lichen flora. As a result, this superior band of wood vegetation includes the great number of lichen species. The great richness of *Usnea* and fewer *Ramalina* genera represented by aerophile species.

The present paper, enumerates the dry mass of major epiphytic lichens was only for five major lichen taxa of the Chopta area of the Garhwal Himalaya viz. *Usnea, Everniastrum, Parmotrema, Cetrariopsis* and *Ramalina.* Because these five lichen taxa are commercially exploiting in some high altitude area of Uttarakhand state. In order to collect lichens from the trees it is not allowed because of the lichens are very slow grower plants, these are pioneer plants in all the epiphytes, if the lichens are extracted from any plant species, the other epiphytes like orchids, mosses and

angiosperms can be effected and unable to re-sprout. Kumar (2008) study showed only the ground or fallen lichen collection should be possible.

In order to improve the socio-economic standard of the people of Uttarahkand, it may also be necessary to increase and improve the botanical resources of the area. Depletion of lichen population is a matter of concern from conservation standpoint because of several reasons; being unique symbiotic organisms they contribute to biodiversity; they are ecologically important as food, shelter and nesting materials for a variety of wild animals (Mc Cune and Geiser 1997).

METERIALS AND METHODS

The Chopta region lies between and 30° 30'-30° 42' N latitude and 79°-79° 30' E longitude in the Garhwal Himalaya is dominated by *Quercus semecarpifolia* trees associated with *Rhododendron* spp, *Taxus baccata*, *Abies pindrow*, *Aser* spp. and *Cotoneaster* shrub. The dry mass estimation of major lichens from the area on *Quercus semecarpifolia* and *Rhododendron arboreum* trees made between 2500m - 3500m above mean sea level. We have identified two purely *Q. semecarpifolia* forest at southeast aspect (open canopied forest) and northwest aspect (closed canopied forest) of the study area. At presents lichen exploitation has band in the study area due to the area comes under the Kedarnath Wild Life Sanctuary area (KWLS). The study has been carried out during June to September 2006. To assessing the mass of major epiphytic lichens vegetation on three dbh classes trees, we have developed a appropriate methodology. Before collecting the epiphytic lichen mass, we have provided a reconnaissance survey to collecting the information on traditional method of lichen harvesting from some high altitude villages of district Chamoli.

A. Traditional Method of Lichen Harvesting

The method has been traditionally followed by lichen collectors of Deval and Tharali block of Chamoli district of Uttrakhand. In these areas lichens collected by the villagers or lichen collectors of Ratgawn, Bursol, Dungari, Man, Kolpuri, Mundoli, Vaan, Kuling, Baak and Ghes village. This area comes under the Badrinath forest division. These areas falls within the Garhwal Himalaya region and the forests are dominated with *Quercus semecarpifolia* (brown oak) and these areas lies between 2000m to 3000m altitudes in west Pinder range of Tharali Tehsil. Brown oak trees of the area harbors luxuriant growth of epiphytic lichens. The collectors collects these plants from the

forests and sold it in the local market at Tharali, Deval and Narayanbagar. Some villagers also sold it at Kerabagar and Vaan village of the area.

Villagers of Ratgawn region, approximately 250 collectors collects these plants from the forests in every day in its peak season of collection especially for fallen lichen collection from March to May; there is a major cause of lichen fall due to heavy snow fall in the high altitude areas of the forest. The traditional method of lichen collection is locally called 'Makku Tipan'. Lichen extracts from standing trees through climbing on tree parts (as trunk, branch and twigs) and lichen removed from bark through hands, and for large tree or long branches, a traditional method has followed and used a iron knife tied on a log and then applied it for lichens extraction from the trees. If this kind of technique has not possible, then they cuts the tree parts and after fall down the branch or twigs and extract lichens. Some time the Nepalese are also collects lichens from the forest, they stay there for a month and they harm the trees during the lichen extraction and they also cuts the branches of the trees and extract lichens for sale and wood for fuel or cooking.

B. Sampling of Epiphytic Lichen Thallus

To assessing dry mass of epiphytic lichens, we have collected fifteen (15) individuals of each major lichen taxa from the forest and calculated their dry mass (sun dry mass) for each selected lichen taxa.

C. Sampling of Phorophytes

On the basis of availability of tree species (phorophytes) in both the aspect of the forest, lichen rich habitat and to convenience of the study (as easy to climbing for lichen species counting on tree parts) at both the forest (open canopied as well as closed canopied forests), the trees of *Q. semecarpifolia* and *R. arboreum* categorized into three dbh classes as 1-30cm, 31-60cm and 61-90cm. Three replicates of each dbh class of each phorophyte have randomly selected in both the forests.

D. Counting of Major Epiphytic Lichens on Selected Phorophytes and Estimation of their Dry Mass

We have just counts the number of individuals of each major epiphytic lichen taxa on tree trunk, three randomly selected branches (including lichens on the sub branches and on twigs) of selected trees of each dbh class. The lichen dry mass calculated with the help of following formula-

i. Lichen dry mass on trunk = Total number of individuals of each major epiphytic lichen on trunk X estimated dry mass of each major lichen taxa.
ii. Lichen dry mass on a branch = Sum of individuals of each lichen taxa on all randomly selected branches of the tree X estimated dry mass of each lichen taxa / total number of randomly selected branches.
iii. Lichen dry mass on the total branches of the tree = lichen dry mass on a branch X total number of branches of the selected tree.
iv. Total dry mass of lichens on the tree (phorophyte) = lichen dry mass on tree trunk + lichen dry mass on all branches of the phorophyte.

RESULTS

The maximum dry mass of epiphytic lichen of *Usnea* species represented by 11mg followed of 6mg *Ramalina* species and 5mg of *Parmotrema* species. Two species of lichens i.e. *Everniastrum* and *Cetrariopsis* have found equal dry mass. The youngest Q. *semecarpifolia* trees dbh 1-30cm provided 329.16(±112.2) g. lichen d.w/tree, at south east aspect, and it was greater about 588.46(±454.93) g. lichen d. w. /tree *Q. semecarpifolia* at north west aspect of the forest The *Q. semecarpifolia* tree dbh 31-60cm recorded 598.56(±317.31) g. lichens d. w. /tree (south east) and 496.86(±349.87) g. lichen d. w. /tree (north west). Similarly for tree dbh 61-90 cm, the lichen dry mass was found on the phorophyte as 753.7(±53.51) g. lichen d. w. /tree at south east and only 189.13(±83.62) g. lichen d. w. at north west aspect of the forest.

Lichen mass on the second phorophye *Rhododendron arboreum* was found very poor as campared to *Q. semecarpifolia*, due to type of bark, shape and size of the tree. In case of *R. arboreum* the highest dry mass of lichens was recorded on trees dbh 61-90cm dbh was 72.76(±35.67) g. lichen d. w. /tree at north west aspect and it was lesser 21.4 (±13.21) g. lichen d. w. /tree at south east aspect of the forest.

DISCUSSIONS

The lichen mass was situated in the Chopta area on *Quercus semecarpifolia* and *Rhododendron arboreum*, species trees at southeast and northwest aspect. The major lichen taxa exhibited on individual pattern of vertical distribution. The lichen mass depends on tree cover, size

& shape of tree, age of tree, and climate of the region. The Quercus *semecarpifolia* is an excellent phorophyte to providing much lichen mass due to dome shaped canopy.

In both the cases the phorophytes *Q. semecarpifolia* and *R. arboreum*, more than 70% mass of major epiphytic lichens was contributed by the canopy twigs and remaining 30% lichen mass contributed by tree branches and trunk or bole at both the aspect of the forest.

The youngest trees of *Q. semecarpifolia* have found as good lichen mass due to the age trees and smoothness in the trunk bark and absence of growth of other epiphytes, and in case of sapling (dbh1-30cm), all the parts of the saplings (including trunk, branches and twigs) were contributed for lichen mass. In case of increasing diameter (dbh>31cm), the twigs also provided good lichen mass as compared to tree branch and trunk or bole.

The Usneaceae family is represented in about more than 60% at southeast aspect and 58.26% lichen dry mass at northwest aspect of the forest. The Parmeliaceae family also represents 26.19% and 25.54% lichen dry mass at southeast and North West aspect. In both the forests Ramaliniaceae family is represents as very poor contribution about 2% in open and 3% in closed canopied forest.

In open canopied forest (southeast aspect) and closed canopied forest (northwest forest) the fruticose lichens provided 46.4% and 26.84% dry mass of lichens, this contribution is grater than dry mass of foliose lichens as 27.94% and 27.36% dry mass of lichens.

According to Degelius (1978) the lichens began to colonize oak twigs in Europe at about five years. Stone (1989) reported that branches of *Quercus garryna* upto twenty year old show growth of many foliose and fruticose lichens. Similar to the studies it was observed that on mature *Quercus semecarpifolia, Q. floribunda,* and *Q. leucotrichophora* trees in and around the study area attainment of the climax stage was exhibited by dominance of foliose and fruticose lichens represented by *Ramalina* and *Usnea* species. Dudgeon (1923) mentioned six stages of succession on epiphytic lichens of *Quercus leucotrichophora*. The crustose lichen stage, begining with numerous little patches of crusts as pioneers on the bark of branches that were 3-4 year old, of which two species frequency wise represent about 75% of the total vegetation. Foliose and fruticose lichens appear simultaneously but become somewhat conspicuous, 3-4 years old *Usnea barbata* (=*Usnea complanata*: Mull. Arg.Mot.) was a prominent member. This stage under favorable condition takes about 9-12 years to achieve its full development. The later stage of

succession is taken over by mosses, fern and flowering plant. By this time the twig become thick branches. In the present investigation it was observed that on young tree trunk and twigs of *Quercus semecarpifolia,* Q. *floribunda, Q. leucotrichophora* and *Rhododendron arboreum,* there is dominance of crustose lichens while mature tree twigs bear luxuriant growth of foliose and fruticose lichens. Du Rietz (1945) attempted to correlate certain tree species with dominance of epiphytic lichens and termed them as **Lichen Rich-Bark** species and **Lichen Poor-Bark** species. *Quercus semecarpifolia* is **Lichen Rich-Bark** trees while a *Rhododendron arboreum tree is* **Lichen Poor-Bark** species.

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Chapter-7

SEASONAL PATTERN OF LICHEN FALL FROM TREES IN AN EVERGREEN *QUERCUS SEMECARPIFOLIA* FOREST OF GARHWAL HIMALAYA, INDIA

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ABSTRACT

The Himalaya is one of the richest sources with respect to the occurrence of lichen on oak species. These unique symbiotic organisms that contribute to biodiversity and are important as food and shelter for various wild animals are being lost because of unsystematic harvesting. We purpose that collection of fallen lichens would reduce lichen diversity loss. In the paper we have documented the seasonal pattern of lichen and twig fall, and frequency of fall of common genera in closed and open canopied forests of *Quercus semecarpifolia* (the brown oak) in a moist temperate forest of Garhwal Himalaya. The annual fall of marketable material was 6.4 kg/ha/yr in the open canopied forest. The lichen fall was maximum in the early summer seasons (April-May) at both sites. Lichen collection from the oak forests (*Quercus* species) is carried out without any consideration for sustainability. The branches are chopped and the bark scraped off using sickles and axes.

Key Words: Lichen fall, *Quercus semecarpifolia*, Garhwal Himalaya.

INTRODUCTION

According to the concept of basic adaptational strategy of plants (Grime 1977), lichens are stress-tolerant organisms. Such organisms are not expected to survive deficiency in resources (stress), as well as destruction of biomass (disturbance). In Uttarakhand and much of the other Himalayan regions people harvest lichens from forests, particularly from oak (*Quercus*) trees

without any consideration for sustainability. The lichen collectors damage trees by chopping branches for collecting lichens and firewood from trees for cooking food while camping in/around forest sites. Poverty is so acute in some sections of the society that incomes of Rs.10, 000-35,000 per annum are enough economic incentives for them.

Depletion of lichen populations is a matter of concern from conservation standpoint because of several reasons; being unique symbiotic organisms they contribute to biodiversity; they are ecologically important as food, shelter and nesting material for a variety of wild animals and birds (Mc Cune and Geiser 1997). Among the animals which use lichens as food include the rare species, Himalayan musk deer, and others such as goats, sheep, pikas, mice and bats. Some birds use lichens as nesting material (Banfield 1974, Conner 1983). Studies of the Northwest Pacific forests indicate that lichens are important component of food chain, and they play a significant role in forest nutrient cycling (Pike 1978; Maser et al. 1985).

In this article we describe the seasonal pattern of lichen fall from trees in a brown oak forest (*Quercus semecarpifolia*). No data are available on lichen fall in this part of world. We understand that collection of fallen lichens would reduce the depletion of lichen diversity and forest degradation. In order to collect lichens from the ground it is important to know the period of year when lichen falls are high. *Quercus semecarpifolia* is possibly; the most widely distributed species in high altitude areas (above 2400m) of the Himalaya, and is in a serious problem because of poor regeneration and aging population.

MATERIALS AND METHODS

One plot each of 0.22ha. (110m X20m) was identified both within open canopied stand (located on a sun facing slope, having lower moisture and tree diversity) and closed canopied stand (slope having more in moisture, more forest cover, and more tree diversity of Kharsu oak) between 2750-2850m altitudes. 30 permanent plots of 1m² were placed within each the plot. The tree density in the area was estimated by placing 10, 10X10m² random quadrats (Saxena and Singh, 1982). Canopy cover was estimated using a densiometer.

The fallen lichen taxa from each permanent plot were collected at fortnightly interval (represented on monthly basis). Fallen twigs on ground, bearing lichens were collected carefully and were placed in poly bags for further identification. The lichens were scratched of the twigs

using a sharp knife. Fresh weight of the collected material (lichens & twigs) taken using an electronic balance which was oven dried at 60ºc for 48 hours till constant weight. Seasonally collected fallen lichen and twig samples were weighted separately and packed carefully in hard card board notes bearing proper information viz. date of collection, name of collector, plot number, forest site, condition of fallen lichen samples (as lichen found with or without twigs) which have been presented at the Centre for Ecological Studies, A.T. India, Ukhimath (Uttarakhand) India.

Fortnightly information on climatic conditions of the area was documented through interaction with local persons who live there for approximately seven or eight months every year from May to December. On and around collection dates records were made about the visit of troop of langurs (*Prestbytis entellus*), events of heavy snowfall, heavy rainfall, strong wind blowing, hails, human activities (such as harvesting of fodder, lopping of branches for fuel wood, timber and agriculture implements).

RESULTS

The tree density varied between 406 trees/ha at open canopied forest (OCF) and 712 trees/ha at closed canopied forest (CCF) and the forest cover between 42% and 58% (Table 1). The annual lichen fall from trees was 110.5 (±23) mg dry mass (DM)/m² and 158.5 (±28.6) mg DM/m² in OCF and CCF. CCF also had more twig fall than OCF 484.5(±136.5) mg vs. 378 (±129) mg DM/m² (Table 2 and 3).

Among the lichens *Everniastrum* was the largest major contributor to the mass of fallen lichen both in open and closed canopied sites. *Usnea* and *Parmotrema* are other regularly falling lichen species of the area. A total of ten fallen lichen taxa were recorded in the open canopied site of the study area, but in case of closed site it was nine. *Sulcaria* species of fallen lichens was not found in closed canopied site of the forest. *Parmelia, Leptogium* and *Sticta* rarely fall in the CCF, and in case of OCF fall of *Sticta* and *Sulcaria* species are rare, the frequency of these fallen lichens was below 1%.

The lichen fall peaked in April, and this month accounted for about 30% annual lichen fall. This was followed by May and July. Collecting lichens from ground in April and May is quit convenient because herbaceous cover was at the lowest point almost negligible.

Table 1: Representation of density and forest cover in OCF and CCF

Forest site	Forest strata	Species	Density (plants ha^{-1})	Forest cover (%)
OCF	Tree	*Quercus semecarpifolia*	280	42
		Rhododendron arboreum	100	
		Acer sp	26	
		Total	406	
CCF	Tree	*Quercus semecarpifolia*	293	58
		Rhododendron arboreum	380	
		Abies pindrow	13	
		Taxus baccata	13	
		Acer sp	13	
		Total	712	

Table 2: Seasonal pattern of lichen fall and twigs dry mass estimation in open canopied forest (OCF)

Year 2006-2007	Dry mass of fallen material (mg/m^2)		No. of fallen lichen genera
	Lichens	Twigs	
May	14.5 (±2.0)	36.5 (±11.0)	8
June	10 (±1.5)	20 (±5.0)	7
July	14 (±4.0)	43.5 (±19.0)	6
August	6.5 (±1.5)	43 (±16.0)	6
September	13 (±4.0)	64 (±25.0)	6
October	5.5 (±2.0)	25 (±11.0)	9
November	6 (±1.0)	26 (±12.0)	7
December	4 (±1.0)	10 (±4.5)	8
January	4.5 (±1.0)	11 (±4.5)	8

February	*	*	*
March	*	*	*
April	32.5 (±5.0)	99(±23.0)	9
Total	110.5 (±23.0)	378 (±129.0)	

Table 3: Seasonal pattern of lichen fall and twigs dry mass estimation in closed canopied forest (CCF)

Year 2006-2007	Dry mass of fallen material (mg/m²)		No. of fallen lichen genera
	Lichens	Twigs	
May	32.5 (±7.5)	77 (±30.0)	9
June	7.5 (±1.0)	24.5 (±6.5)	6
July	21.5 (±5.5)	54 (±17.0)	6
August	10.5 (±2.0)	38.5 (±12.0)	6
September	10.5 (±2.5)	38.5 (±14.0)	6
October	1.5 (±o.1)	16.5 (±9.0)	4
November	6.5 (±2.0)	20.5 (±7.5)	6
December	4.5 (±1.0)	15 (±5.0)	5
January	8.5 (±1.5)	22.5 (±4.0)	7
February	*	*	*
March	*	*	*
April	55 (±5.5)	177.5 (±33.0)	7
Total	158.5 (±29.0)	484.5 (±137.0)	

*The lichen fall could not be counted during February and March because of the inaccessibility of sites due to heavy accumulation of snowfall.

Table 4: Frequency list of commonly fallen lichen genera in descending order in the study area

S. No.	Fallen lichen genera	
	OCF	CCF
1.	*Everniastrum*	*Everniastrum*
2.	*Parmotrema*	*Usnea*
3.	*Usnea*	*Parmotrema*
4.	*Cetrariopsis*	*Heterodermia*
5.	*Heterodermia*	*Ramalina*
6.	*Ramalina*	*Cetrariopsis*
7.	*Leptogium*	*Leptogium*
8.	*Parmelia*	*Parmelia*
9.	*Sulcaria*	*Sticta*
10.	*Sticta*	*Sulcaria*

DISCUSSION

Seasonal pattern of lichen fall

The higher tree density and canopy cover contributed to larger total lichen fall mass in the CCF. The twig fall consisted of both twigs with attached lichens and twigs without lichens. The similarity in lichen fall patterns between the two study sites indicates that lichen fall has a definite seasonal pattern, the knowledge of which can help collectors to decide on strategy to collect them. Storms and movement of monkeys seem to hasten twig fall, as following such events lichens could be seen all over the place. Seasonal pattern of twig fall was similar to that of lichen fall, indicating that lichen growth would hasten twig fall. The lichen cover might hasten twig senescence, or lichens grow well on senescing twigs. The abscission of wood is promoted by higher temperatures in the annual cycle (summer and rainy seasons) although abscission continues, though irregularly, through out the year as a mechanism of canopy clearing by self-pruning (Singh and Singh, 1992). According to the concept of Stone (1989) allogenic factors caused by outward growth of oak canopy, including changes in microclimate and thickening and sloughing of bark, appear to be far more important to most species than changes brought on by the epiphytic species.

On the basis of hypothesis of Larson (1984), Lawrey (1981), and Topham (1977) epiphytes could be competing for light, branch surface space, and water. Fruticose lichens (*Usnea* spp) and

foliose lichens (*Everniastrum* spp) were found dominant on twigs, competition in *Usnea* species appeared to be mainly intrageneric and therefore *Usnea* species should not be affected by clearing other species from around them. The primary succession on oak branches is mostly influenced by the allogenic factors of microclimate change brought by outward canopy growth. However, within the framework of allogenic factors, autogenic factors of competition and facilitation are similar to those, which cause secondary succession (Stone, 1989). Stone (1989) reported that foliose and fruticose lichens developed fully in 9-12 years. The ten most frequent genera were the same in two forest sites, but differed in their order of importance (Table 4).

Doignon (1954) reported that lichens begin to colonize oak twigs in Europe at about five years of tree age. Foliose lichens began to colonize on oak at Fontainebleau, France at about 15-20years. Generally, lichens found on leaves of very long durability are not obligate folicolous but also belong to the corticolous flora, indicating that the obligately folicolous lichens are perhaps restricted to their habitats because they are relatively poor competitors in other habitats. Slightly higher moss coverage on the south side of trunks, (Rincon, 1993) suggested that the combination of abundant moisture and more sunlight may result in greater photosynthetic production which in bryophytes translates into greater volume and biomass growth.

Some experimental studies of Graham (1971), on corticolous lichen (bark inhabiting), showed that the lichen thallus is partly responsible for the modification of its own environment, by increasing its own water holding capacity, it would be possible to grow lichens over a period of years and determine their increase in size and dry weight. A concept given by Denison (1973), he studied on air quality monitoring with lichens in Willamette valley (Oregon), there are major differences in amounts of light and moisture on different sites of a tree trunk. Moisture varies because rainwater flows down channels in the bark of the trunk, living intervening areas well up in the tree receive similar amounts of light and moisture whether they are on the north or the south site of the tree. By examining the lichens on branches we can limit differences caused by variation in light and moisture.

Light affects growth by affecting the rate of photosynthesis and ultimately the amount of assimilate available to the fungus. Most lichens are as matter of fact photophils, and any light reduction would probably come about by gradual closing of the forest canopy over many years. Hakulinen (1966) reported reduction in lichen growth caused by less light might conceivably be offset by an increase in moisture in a shaded habitat.

The market lichens are sold along with twigs, therefore we need to consider both lichens and twigs to which they are attached. Thus the annual fall of marketable material is 6.4 kg/ha/yr in the CCF and 4.9kg/ha/yr in OCF. These lichens are sold at rates of approximately half a dollar/kg in the local markets (Upreti et al 2005). The price however doubles when these lichens reach the central market areas. A trained collector can easily collect 6-8kg of lichens with twigs from the ground (collecting lichens from attached twigs slow down the collection as the entire branches are cut or the lichens are scraped off along with the bark and portion of sapwood). A collector for the major part of the year can earn a reasonable income by collecting the fallen lichens without being destructive with some knowledge of the fall and seasonal pattern.

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Chapter-8

AN ACCOUNT OF LICHENS ON FALLEN TWIGS OF THREE *QUERCUS* SPECIES IN CHOPTA FOREST OF GARHWAL HIMALAYAS, INDIA

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ABSTRACT

The association of epiphytic lichens on the fallen twig of three common *Quercus* species viz. *Quercus semecarpifolia*, *Q. floribunda* and *Quercus leucotrichophora* from the moist temperate forest of Chopta region, Rudraprayag district of Garhwal Himalayas has been discussed. *Q. semecarpifolia* exhibits the maximum growth of lichens on its twigs represented by 29 species followed by *Q. floribunda* and *Q. leucotrichophora* with 16 and 12 species respectively. The twigs of diameter classes more than 4.1 cm in *Q. semecarpifolia* and Q. *floribunda* bears the maximum individuals of lichens represented by 148 and 71, while *Q. leucotrichophora* the twigs 3.1-4.0 diameter class exhibit maximum 82 individuals. All the three oak species exhibit luxuriant growth of Parmelioid lichens on their twigs.

Key words Lichens, fallen twigs, *Quercus* spp., Chopta, Uttarakhand.

Introduction

Lichens in India are collected from the temperature regions of Himalayas and used indigenously for preparation of perfumes, dyes, and condiments. Approximately 750 metric tones (MT) of lichens are collected from Uttarakhand hills, 800 MT are imported from other regions of India, including Himachal Pradesh, Sikkim and Assam and out of which about 50-80 MT are exported (Shah, 1997). In Nepal and adjoining areas of India, 320 MT of lichens are utilized annually for different purposes (Moxham, 1986). The lichens are picked up by hand from the

lower branches, trunk and fallen twigs of trees or sometimes scrapers are also used. Upreti *et al.* (2005) listed 38 species of lichens belonging to 23 genera from the commercial samples of lichens collected from seven states of India.

The lichens grow at a rate ranging from 1.0mm or less per year in case of crustose forms up to a few centimeters a year for most rapidly growing leafy (foliose) or shrubby (fruticose or pendant) lichens. The larger lichens in the last two categories grow on an average about 5.0mm per year in length or rapidly are more conspicuous and exploited for collection. In the recent year there has been a great concern about the loss of lichen diversity in India (Upreti, 1996) and there is a need to know the patterns and processes that regulate species occurrence and behavior in natural forests. An account of the lichens associated with fallen twigs will provide an idea about the lichen species which play important role in the formation of lichen material utilized for their commercial use.

Quercus trees in temperate Himalayas form major vegetation and are the excellent host for colonization of a large number of lichen taxa together with epiphytic ferns and orchids. Out of the five species of *Quercus*, *Q. semecarpifolia* bears the maximum member of lichens species on its trunk, branches and twigs (Upreti and Chatterjee, 1999).

This paper is based on sampling designed to provide estimates of twig lichen of three *Quercus* species in temperate Himalayas, and to determine the contribution of twigs of Oak tree which are colonized by lichen and collected for commercial exploitation. The estimated lichen species individuals on more than 100 sampled twigs of three common *Quercus* species of different diameter classes have been provided in table 1, 2, and 3. The diameter classes of the sampled twigs have been categorized on the basis of availability of fallen twigs.

Materials and Methods

Study Area: Chopta is situated 35 km from Ukhimath block in Rudraprayag district of Uttarakhand, in Akashkamini valley between 1,500 m -3,500 m at 79^0-79^0 30'E and 30^0 30' – 30^0 42' N. The mountain landscape has steep to moderate slopes, spreads over an area of 500 Km^2. The Maximum monthly temperature varies from 19^0 C to 37^0 C from the higher altitude grasslands to the lower elevation, during May to October, while the minimum temperate drops as low as – 15^0C in the alpine grasslands during December to February.

More than 100 twig samples of each species of Oak were randomly collected from three altitudinal gradient during months of October-November 2006. The altitude between 1500-2000m exhibit growth of *Quercus leucotrichophora* (White Oak), followed by 2000-2500m of *Q. floribunda* (Green Oak) and above 2,500m of *Quercus semecarpifolia* (Brown Oak) respectively. The collected twigs were categorized in five diameter size classes of 0-1cm, 1.1-2.0cm, 2.1-3.0cm, 3.1-4.0cm and more than 4.1cm.

The diameters of 20 twig samples of each class were measured. Individuals of macrolichen species growing on each twig were counted.

Results and Discussion

All the three oak trees exhibit luxuriant growth of Parmelioid lichens and members of lichen family Physciaceae together with fruticose lichen of genera Ramalina and Usnea (Table 1-3).

a) *Lichens associated with twigs of Q. leucotrichophora (altitude between 1,500-2,000 m):* The twigs of *Q. leucotrichophora* bear only 12 species of lichens (Table 1). The twigs of diameter 3.1-4.0cm and more than 4.1cm bear 82 and 27 individuals of lichens. *Parmotrema wallichiana* exhibits occurrence on twigs of all five diameter classes twigs but the diameter class 3.1-4.0 cm bears the maximum individuals *P. wallichiana* followed by twig classes 0-1.0 cm, 1.1-2.0cm, 2.1-3.0 and more than 4.1cm. Parmelioid lichens dominate the *Q. leucotrichophora* twigs than Usneoid lichens.
b) *Lichens associated with twigs of Q. floribunda (altitude between 2,000 m-2,500 m):* The twigs of *Q. floribunda* bear 16 species of lichens (Table 2). The twigs of diameter more than 4.1cm exhibit occurrence 71 individuals. *E. nepalense*, dominates on all the five diameter class of twigs. But the diameter class 3.1-4.0cm and 1.1-2.0 cm bear similar number of individuals. The fruticose lichens exhibit higher association with *Q. floribunda* twigs than the foliose form.
c) *Lichens associated with twigs of Q. semecarpifolia (altitude above 2,500 m): Q. semecarpifolia* twigs bear 29 species of lichens (Table 3). The twigs of diameter class more than 4.1cm bear 148 individuals of lichens. *E. nepalense* exhibits its occurrence all the five diameter classes of twigs. The twig class 3.1-4.0cm bears the maximum individuals followed by twigs of 2.1-3.0cm and 1.1-2.0cm. The diameter class of 0-1.0cm towards the

tip of the twigs shows less number of individuals. There is a great decrease in lichen abundance with decreasing twig diameter.

The Parmelioid genera *Everniastrum cirrhatum*, *E. nepalense* and *parmotrema nilgherrense* with 18, 9 and 10 individuals respectively, dominate the twigs towards the tips while individual of other lichen exhibit their poor presence there.

The luxuriance of lichen growth on *Quercus* twigs may possibly be attributed to the retention of moisture because of their hanging position. The flow of rain water and that of the melting snow along the hanging twigs perhaps provide greater exposure to moisture. However, according to Pike *et al.* (1975), twigs being at the edge of the trees canopy receive higher levels of light than most of the remaining surfaces of the tree. Rainfall strikes foliage and twigs directly and these receive additional water which drips from higher branch system. Because of the exposure, and the low water holding capacity of the bark, twigs dry out quickly after rainfall. Twigs can however hold a considerable load of snow during and after wet snow fall.

Wolseley and Pryor (1999) studied the lichen communities on twigs of *Quercus petrarea* in Welsh woodland site and concluded that there is a correlation between environmental condition and lichen communities of twigs. Roughness, bark pH and chemistry of twigs, amount of moisture as rain tracks or humidity, degree of illumination, aspect and illumination of the surface, acidification of the atmosphere are the specific characteristics of the substratum influence the growth of lichens on twigs. The environmental conditions were more or less similar in all the stands of the study area except the aspects of the illumination at few sites. Both Parmelioid and fruticose lichens were evident on the twigs than elsewhere. The crustose lichens were abundant on apical areas of the young twigs and covered a substantial area. According to Essen et al (1996), the fruticose pendulous species (*Alectoria* and *Bryoria*) are highly sensitive to forest practices and are strongly related to age of branches while type of forest has no significant effect on foliose lichens. Similarly all the three Oaks in the study area share growth of common foliose and fruticose lichens.

McCune (1993) while studying the epiphyte biomass in three *Pseudotsuga-Tsuga* forest in western Oregon and Washington, recorded greater epiphyte biomass in old-growth stands than the younger stands. Similarly in the present study *Q. semecarpifolia* comprised of mostly the old-growth forest stands exhibited greater number of individuals. Based on the ecological roles rather than taxonomy the epiphytic lichens of the Oak trees can be grouped into Parmelioid

(*Everniastrum*, *Parmotrema*, *Cetrariopsis* and *Sticta*), Cyanolichens (*Leptogium*), Usnioid (*Usnea*, *Ramalina*) and Physcioid (*Heterodermia*) lichens.

The Physcioid genera having larger thallus (*Heterodermia diademata*) prefer to grow on the thicker twigs while members having smaller sized thallus (*H. hypocasia*, *H. incana*, *H. leucomela*) grow on thin twigs in association with crustose lichens towards the apex. *Q. semecarpifolia* stands of diameter class of more than 4.0 cm exhibit only the presence of Cyanolichens.

Most of the Parmelioid genera colonize on all the five diameter classes of twigs and number of species increases as the thickness of the twigs increases, except *E. cirrhatum* which grows on thinner branches also. Some species of Usnioid lichens prefer thin barks towards the distal region of twigs.

Q. semecarpifolia bears the maximum individuals in different diameter classes followed by *Q. floribunda* and *Q. leucotrichophora*. The probable reason for dominance of lichens on *Q. semecarpifolia* may be the higher altitude as mentioned by Pirentoses et al. (1995), the crucial factor determining the spatial heterogeneity of epiphytes lichens of *Fagus sylvatica* is the altitude and not the height on the trunk at which lichen community is established.

Q. floribunda and *Q. leucotricophora* exhibit the representation of only Parmelioid and Usnioid lichen communities. *Q. leucotrichophora* has 3 genera belonging to 3 species of Parmelioid and 7 species of Usnioid lichens while *Q. floribunda* has 3 species of Parmelioid and 12 species of Usnioid lichens.

Out of the 38 commercially used lichen species from different states of India, enumerated by Upreti *et al.* (2005), 24 species of 15 genera belong to Parmelioid lichens with maximum representation of *Everniastrum* and *Parmotrema* species followed by Usnioid (8 species of 2 genera) lichens. Lichen genera *Everniastrum*, *Parmotrema*, *Rimelia*, *Parmelaria*, *Usnea*, *Lobaria*, and *Ramalina* are exploited exhaustively for their commercial use. *Q. semecarpifolia* forests are the best collection sites for these lichens. Shah (1997) and Upreti *et al.* (2005) have documented the need for protection and conservation of lichens in India because of their intensive exploitation, but conservation has not received the desired attention. The less lichen biomass in India forest as compared to other European countries further advocate that the trade of endangered lichen species such as *Parmotrema nilgherrense*, *Everniastrum cirrhatum*, and *E. nepalense* should be banned in

Himalayas and these should be included in the CITES (Convention of International Trade in wild species of Endangered Fauna and Flora) list.

Table 1- Different diameter class twigs of Q. leucotrichophora with individual numbers of lichen species

S. No.	Lichen Taxa	Total number of individuals of lichen species on twenty twigs of each diameter(cm) class				
		0-1	1.1-2	2.1-3	3.1-4	>4.1
1	*Everniastrum nepalense* (Taylor) Hale ex Sipman	2	3	6	12	6
2	*Everniastrum cirrhatum* (Nyl) Hale	1	2	2	3	0
3	*Parmotrema nilgherrense* (Nyl) Hale	7	5	9	22	8
4	*Parmotrema wallichiana* (Taylor) Elix & Hale	6	10	4	30	7
5	*Parmotrema mesotropom* (Müll. Arg.) Hale	5	5	0	10	0
6	*Usnea pectinata* Taylor	0	0	0	1	2
7	*Usnea Indica* Mot	0	0	1	0	0
8	*Usnea longissima* Ach.	0	0	1	0	0
9	*Usnea orientalis* Mot.	0	0	0	2	2
10	*Usnea aciculifera* Vinio	0	0	1	0	0
11	*Usnea eumitriodies* Mot.	0	0	0	2	1
12	*Usnea subfloridana* Stirton	0	0	1	0	1
Total individuals of lichens found on twenty twigs of each diameter class		21	25	25	82	27

Table 2- Different diameter class twigs of Quercus floribunda with individual numbers of lichen species

S. No.	Lichen Taxa	Total number of individuals of lichen species on twenty twigs of each diameter(cm) class

		0-1	1.1-2	2.1-3	3.1-4	>4.1
1	*Everniastrum nepalense* (Taylor) Hale ex Sipman	13	17	22	27	12
2	*Everniastrum cirrhatum* (Nyl) Hale	6	8	0	4	7
3	*Usnea pectinata* Taylor	6	6	2	8	7
4	*Usnea Indica* Mot	0	8	4	1	5
5	*Usnea longissima* Ach.	3	2	0	1	3
6	*Usnea orientalis* Mot.	2	5	3	3	3
7	*Usnea aciculifera* Vinio	3	1	0	3	13
8	*Usnea eumitriodies* Mot.	4	0	0	3	9
9	*Usnea subfloridana* Stirton	1	3	0	3	5
10	*Cetrariopsis wallichiana* (Taylor) Kurokawa	0	0	1	0	0
11	*Ramalina sinensis* Jatta	2	2	0	0	3
12	*Ramalina conduplicans* Vainio	2	2	0	0	3
13	*Ramalina Himalayensis* Ras.	1	0	2	0	0
14	*Ramalina rosleri* (Hochst. ex Schaerer) Hue	3	0	2	0	0
15	*Rimelia reticulata* (Taylor) Hale & Fletcher	1	0	1	0	0
16	*Sticta nylanderiana* Zahlbr.	0	0	0	0	1
Total individuals of lichens found on twenty twigs of each diameter class		47	54	37	53	71

Table 3- Different diameter class twigs of Quercus semecarpifolia with individual numbers of lichen species

S.		Total number of individuals of

No.	Lichen Taxa	lichen species on twenty twigs of each diameter(cm) class				
		0-1	1.1-2	2.1-3	3.1-4	>4.1
1	*Everniastrum nepalense* (Taylor) Hale ex Sipman	18	30	35	46	39
2	*Everniastrum cirrhatum* (Nyl) Hale	9	9	6	0	0
3	*Parmotrema nilgherrense* (Nyl) Hale	10	10	8	3	16
4	*Parmotrema wallichiana* (Taylor) Elix & Hale	6	2	11	10	20
5	*Parmotrema mesotropom* (Müll. Arg.) Hale	2	2	0	2	6
6	*Usnea pectinata* Taylor	1	2	6	6	12
7	*Usnea sp.*	1	0	0	0	0
8	*Usnea longissima* Ach.	1	13	10	3	12
9	*Usnea orientalis* Mot.	3	7	3	7	15
10	*Usnea aciculifera* Vinio	2	2	0	0	0
11	*Usnea eumitriodies* Mot.	2	1	1	0	0
12	*Usnea subfloridana* Stirton	2	1	0	0	0
13	*Cetrariopsis wallichiana* (Taylor) Kurokawa	1	0	3	2	4
14	*Ramalina sinensis* Jatta	1	0	0	0	0
15	*Ramalina conduplicans* Vainio	2	1	0	0	0
16	*Ramalina Himalayensis* Ras.	1	0	0	0	0
17	*Ramalina rosleri* (Hochst. ex Schaerer) Hue	1	0	0	0	0
18	*Rimelia reticulata* (Taylor) Hale & Fletcher	3	0	0	0	1
19	*Heterodermia isidiophora* (Vainio) Awas.	0	1	2	1	8
20	*Heterodermia hypocaesia* (Yasuda) Awas.	0	1	0	0	0
21	*Heterodermia diademata* (Taylor) D. Awasthi	1	0	0	0	8
22	*Heterodermia incana* (Stirton) D. Awasthi	0	0	2	0	0
23	*Heterodermia leucomela* (L) Poetl	0	0	1	0	0

24	*Heterodermia psuedodpeciosa* (Kurokawa) Culb.	1	0	1	0	0
25	*Leptogium pedicelatum* M.P. Jorg.	0	0	1	0	0
26	*Leptogium trichophorum* Müll, Arg.	0	0	1	0	1
27	*Leptogium askotense* D. Awasthi	0	0	0	0	2
28	*Leptogium papillosum* (B. de Lesd.) Dodge	0	0	0	0	1
29	*Sticta nylanderiana* Zahlbr.	0	0	0	0	3
Total individuals of lichens found on twenty twigs of each diameter class		68	81	92	80	148

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Chapter-9

Quantitative analysis of fallen lichen vegetation in eleven forest sites of a *Quercus semecarpifolia* forest of Garhwal Himalaya, India

ABSTRACT: The present study was carried out on eleven forest sites dominated by *Quercus semecarpifolia* forest to assess fallen lichen (fall from trees) diversity between 2500m to 3500m elevation in Garhwal Himalaya. A total of ten fallen lichens were recorded from the study area.

Keywords: Fallen lichens, study sites, distribution pattern, Garhwal Himalaya

Introduction

The Himalayan Mountain (27´38 º N latitude and 72´98 º E longitude) is the youngest, largest, highest and most complex mountain system in the world covering east to west (Gupta, 1963). On the basis of altitudinal variation the Himalayan ranges are divided into sub-tropical, temperate and alpine zone representing a variety of forest types.

Garhwal Himalaya is extremely rich in lichen diversity, it is about 69% of the Uttarakhand and 35% of the Himalayas and more than 16% of Indian lichen diversity (Kumar, 2008), and its climate factors, temperature variations, rainfall pattern, soil support, strong fauna and flora. Kumar (2008) reported 106 species of lichens from the area and also reported ten regularly fallen lichen species. Studies of the Northwest Pacific forests indicate that lichens are important component of food chain, and they play a significant role in forest nutrient cycling (Pike 1978; Maser et al. 1985).

In this article author describe the diversity of fallen lichen genera and their distribution pattern in different forest sites of a brown oak (*Quercus semecarpifolia*) forest.

MATERIALS AND METHODS

Study area Chopta was located at altitude between 2500-3500m elevations of Garhwal Himalayas India. Altitudinally Chopta is located in temperate zone. For the detailed study of fallen lichen (fall from trees) diversity, the area was divided into eleven different sites. All the sites broadly have similar major tree species. *Quercus semecarpifolia* and *Rhododendron arboretum* trees was the major tree species present in all the eleven investigated sites. In all the sites the forest cover were recorded between 32-58% (Kumar, 2008).

The phytosociological analysis of the fallen lichen vegetation was done by sampling of 40, 2M² ground quadrats on each site. All the individuals of fallen lichen genera were recorded carefully in each sampled quadrat. The collected lichen samples were identified in the Lichen Laboratory, IBRI Lucknow. The data on fallen lichen vegetation were quantitatively analyzed for abundance, density, and frequency and A/F ratio by the following formulas given by Curtis and Mc Intosh (1950).

$$\text{Abundance} = \frac{\text{Total number of individuals}}{\text{Number of quadrat occurrence}}$$

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats occurrence X 100}}{\text{Total number of quadrats studied}}$$

Distribution of population: The ratio of abundance to frequency is a relative measure to present the distribution of fallen lichen vegetation in a community. Curtis and Cottam (1956) suggested the following for regular (less than 0.025), contagious (0.025-.05) and random (more than 0.05) distribution of the population.

RESULTS

Quantitative analysis of fallen lichen vegetation at different study sites are given in Table 1. A total of 10 fallen lichen genera were recorded from the study area. The density of fallen lichen genera was recorded to be maximum 13175 individuals of *Everniasteru* ha¹ at site 1st and 3rd and the minimum density 125 individuals of *Everniastrum* ha¹ was recorded at site 9th. Among the lichen vegetation maximum density was recorded for 26900 individuals of lichen ha¹ was recorded for site 1st, and the minimum density also recorded 6350 individuals of lichen ha¹ at site 6th (Table

1). *Everniastrum* was the most dominantly fallen lichen in all the eleven investigated sites followed by species of *Usnea*. The other common fallen lichen genera of the study area were *Parmotrema* spp, *Cetrariopsis* spp, *Heterodermia* spp, *Ramalina* spp, *Leptogium* spp, *Parmelia* spp, *Lobaria* spp and *Cladonia* spp.

There was 6.06% fallen lichens displayed regular distribution pattern in the study area as maximum lichens genera (56.06%) displayed their random distribution pattern at different sites and 37.87% genera of fallen lichens contagious distribution pattern at different sites of the study area.

Table 1: Vegetational parameters for fallen lichens at different forest sites

Forest sites	Fallen lichen taxa	Frequency (%)	Density (Ind ha^{-1})	Abundance (Ind ha^{-1})	A/F
1	*Usnea*	85	575	2.7	0.031
	Everniastrum	92.5	13175	5.7	0.061
	Parmotrema	62.5	5675	3.64	0.058
	Cetrariopsis	42.5	1375	1.29	0.03
	Heterodermia	32.5	925	1.15	0.035
2	*Usnea*	42.5	3300	3.11	0.073
	Everniastrum	67.5	6500	3.85	0.057
	Parmotrema	57.5	2875	2	0.034
	Heterodermia	17.5	675	1.57	0.089
	Cetrariopsis	15	425	1.16	0.077
3	*Usnea*	55	4300	3.13	0.056
	Everniastrum	87.5	13175	6.02	0.068
	Parmotrema	72.5	5000	2.28	0.031
	Heterodermia	0.35	1175	1.35	3.857
	Cetrariopsis	0.35	1050	1.21	3.457
4	*Usnea*	70	4000	2.28	0.032

	Everniastrum	90	8300	3.69	0.041
	Parmotrema	47.5	2050	1.73	0.036
	Cetrariopsis	37.5	1175	1.26	0.033
	Heterodermia	27.5	750	1.09	0.039
	Ramalina	25	675	1.1	0.044
5	*Usnea*	40	1425	1.43	0.035
	Everniastrum	72.5	6125	3.37	0.046
	Parmotrema	67.5	3125	1.85	0.027
	Ramalina	17.5	425	1	0.057
	Heterodermia	10	650	1	0.1
	Cetrariopsis	12.5	300	1	0.08
	Leptogium	12.5	375	1.2	0.096
	Parmelia	10	2500	1	0.1
6	*Usnea*	22.5	1500	2.66	0.118
	Everniastrum	32.5	2750	3.38	0.104
	Parmotrema	22.5	925	1.66	0.073
	Ramalina	12.5	425	1.4	0.112
	Cetrariopsis	7.5	375	2	0.266
	Heterodermia	12.5	375	1.2	0.096
7	*Usnea*	50	5925	4.75	0.095
	Ramalina	55	1375	1.46	0.026
	Parmotrema	32.5	1625	2	0.061
	Everniastrum	70	7000	4	0.057
	Heterodermia	32.5	1050	1.3	0.04
	Cetrariopsis	22.5	1300	2.33	0.103
8	*Usnea*	50	5625	4.5	0.09

	Everniastrum	85	11750	5.52	0.064
	Parmotrema	35	4050	4.64	0.132
	Ramalina	22.5	1175	2.11	0.093
	Cetrariopsis	10	500	2	0.2
9	*Usnea*	42.5	2125	2	0.047
	Everniastrum	52.5	5925	4.52	0.086
	Parmotrema	40	2000	2	0.05
	Heterodermia	10	500	2	0.2
	Cetrariopsis	5	125	1	0.2
	Ramalina	7.5	250	1.33	0.177
10	*Usnea*	67.5	3050	1.81	0.026
	Everniastrum	82.5	8300	4.03	0.048
	Parmotrema	82.5	4500	2.18	0.026
	Heterodermia	17.5	625	1.42	0.081
	Cetrariopsis	22.5	675	1.22	0.054
	Ramalina	22.5	750	1.33	0.059
	Lobaria	10	300	1.25	0.125
	Leptogium	15	625	1.66	0.11
11	*Usnea*	47.5	2925	2.47	0.052
	Everniastrum	65	5875	3.61	0.055
	Parmotrema	70	5425	3.1	0.044
	Heterodermia	32.5	1175	1.46	0.044
	Cladonia	7.5	250	1.33	0.177
	Ramalina	25	750	1.2	0.048

DISCUSSION

Lichen fall is a relatively more continuous process in the temperate oak forest of the Garhwal Himalaya. In the Central Himalayan forests, water stress and extremes of temperature are probably not the dominant causal factors of wood fall. The abscission of wood is promoted by higher temperatures in the annual cycle (summer and rainy seasons) although abscission continues, though irregularly, through out the year as a mechanism of canopy-clearing by self-pruning (Singh and Singh, 1992). According to the concept of Stone (1989) allogenic factors caused by outward growth of oak canopy, including changes in microclimate and thickening and sloughing of bark, appear to be far more important to most species than changes brought on by the epiphytic species. However, within the framework of the allogenic tree canopy factors, the same sorts of interspecific interactions take place as more found in autogenic type of succession.

The fallen density depends on the forest cover and tree density, site 5^{th} & 10^{th} represented by 8 fallen lichen genera followed of 6 at site 4^{th}, 6^{th}, 7^{th}, 9^{th} & 11^{th}, and 5 genera at 1^{st}, 2^{nd}, 3^{rd} & 8^{th}. Lichen genera *Parmelia, Leptogium* and *Stcta* of the study area were found rare.

According to Kumar (2008) the lichen fall in a particular area may be affected by a number of climatic factors and activities of the inhabitants of the area. The common factors responsible for lichen fall in the study area were type of fauna (jumping of Languor's from one tree to other), birds, heavy snow fall, hails, heavy rainfall, human activities and wind condition, direction.

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Chapter-10

LICHEN RESOURCE USE PATTERN AND ITS SOCIO-ECONOMIC STATUS IN TEMPERATE REGION OF GARHWAL HIMALAYA, INDIA

ABSTRACT: The resource use pattern of some macrolichens and their socioeconomic status in temperate region of Garhwal Himalayas has been discussed. Out of five blocks, stakeholders of Narayanbagar and Dewal block are found highly dependent on lichen (macrolichens) based activity to conduct their livelihood.

Key Words- Macrolichen biomass, *Quercus semecarpifolia*, Garhwal Himalaya

INTRODUCTION

According to the concept of Upreti et al (2005) the lichens have been household items of Indians since ancient times. In India, lichens collected from the temperate regions of the Himalayas are used indigenously and are explored. The Uttarakhand hills and Himanchal Pradesh are the main areas of the lichen collection in India. The lichens are very slow growing plants. Because of their unique thallus composition, which is made of fungus and alga, they can not be cultivated in large scale like other plants. Thus, lichens growing in nature provide a basic raw material required for various uses of lichens. The lichens weigh very little when dry, thus a vast bulk of these plants is required.

Mountain and hillside areas hold a rich variety of ecological systems. Because of their vertical dimension, mountain creates gradient of temperature, precipitation, and insulation. In Uttarakhand nine of the thirteen districts comprise the expansion of lesser Himalaya. But with the pace of rapid modernization and increasing anthropogenic pressure on vegetation in general and on forest in particular coupled with natural disasters, the Himalayan vegetation is rapidly deteriorating in its richness as well as diversity. However, in recent past there has been a deep concern and realization for the conservation of the fragile Himalayan ecosystem.

Lichen exploitation is a common practice among the villagers and the rivals in moist temperate regions of the Garhwal Himalaya to collect the lichens together with tree twigs as oak and other trees bears luxuriant growth of lichens. Kumar (2008) reported Parmelioid lichens belonging to family Parmeliaceae are commercially trading lichens from Garhwal Himalaya i.e. *Everniastrum, Parmotrema, Cetrariopsis, Bulbothrix, Hypotrachyna and Rimelia* collected by rivals together with two fruticose genera, *Ramalina* and *Usne.*

Lichens in India are collected from the temperature regions of Himalayas and used indigenously for preparation of perfumes, dyes, and condiments (Kumar and Upreti, 2008). Approximately 750 metric tons of lichens are collected from Uttarakhand hills, 800 metric tons are imported from other regions of India, including Himachal Pradesh, Sikkim and Assam and out of which about 50-80 tons are exported (Shah, 1997).

Upreti (1995) assessed the different factors responsible for loss of lichen diversity in India. Important factors include the change in the ecological conditions, forest cover, and loss of habitat and increase of the urban and industrial areas. The various activities of man in hilly regions of India such as 'Jhoom' cultivation, agriculture, mineral extraction, tourism, hydroelectric and road building projects are other factors leading to the rapid deterioration of lichen rich habitats. Overexploitation and selective removal of economically important lichens by local people have now become the major threat to the lichen flora of India.

Lichens are sold at rates of approximately half a dollar/kg in the local markets (Upreti et al 2005). The price however doubles when these lichens reach the central market areas. A trained collector can easily collect 6-8kg of lichens with twigs from the ground (collecting lichens from attached twigs slow down the collection as the entire branches are cut or the lichens are scraped off along with the bark and portion of sapwood). A collector for the major part of the year can earn a reasonable income by collecting the fallen lichens without being destructive with some knowledge of the fall and seasonal pattern.

A number of lichen patches in the forests 'hot spots' were identified together with the study viz. Bramtal, Jhaltal, Suptal, Bhekaltal, Didina forest, Kuling forest, Ghesh-Balan, Badeni forest, and Gairsain forest patches are in Chamoli district. Similarly Chopta-Tunganath, Khod-Bakseer, Badhanital, Devariyatal, Madhmaheshwar peak, and Tirjuginarayan forest patches were the major hot spots in Rudraprayag district. These all identified forest patches are similar in lichen diversity

as well as for lichen biomass resource availability. These all forest patches (lichen hot spots) are purely dominated by the *Quercus semecarpifolia* (brown oak) trees and some time associated with *Rhododendron arboreum* (Burans) trees and associated shrubs *Barberis* spp and *Cotoneaster spp* occurs in these regions.

METERIALS AND METHODS

District Rudraprayag and Chamoli Garhwal of Uttarakhand state are the remotest areas in terms of lifestyle and also rich in botanical resources like lichen resource. A total of five blocks has been covered in two districts Rudraprayag and Chamoli. Ukhimath and Jakholi blocks in Rudraprayag and Dewal, Tharali and Narayanbagar in Chamoli district have been studied. From each selected block of Chamoli district, selected three village randomly villages on the basis of the temperate region, availability of lichen resource, lichen exploitation by local collectors and the areas were open for lichen collection. But the district Rudraprayag was totally band for lichen collection since ten years; from this district only two blocks (Ukhimath and Jakholi) were selected. The three selected blocks of district Chamoli were similar in lichen diversity and resource use pattern, but different in its collection and trading system.

A. Reconnaissance Survey: The reconnaissance survey was conducted for knowing the traditional method of lichen collection and involvement of lichen stakeholders of different rivals of the area. The traditional method of lichen collection is locally called ‘Makku Tipan’. The method has been traditionally followed by lichen collectors of some lichen exploiting areas of Deval and Tharali block of Chamoli district of Uttrakhand state. In Chamoli district, lichens collected by the villagers or lichen collectors of Ratgawn, Bursol, Dungari, Man, Kolpuri, Mundoli, Vaan, Kuling and Ghes villages of the Tharali and Deval block. These areas come under the Badrinath forest division. These areas falls within the Garhwal Himalaya region and the forests are dominated with *Quercus semecarpifolia* (brown oak) and these areas lies between 2000m to 3000m altitudes in west Pinder range of Tharali Tehsil. Brown oak trees of the area harbors luxuriant growth of epiphytic lichens.

The traditional collectors of the villages are collects these plants and sale in local market at Tharali, Deval and Narayanbagar. Some small villagers sold it at Kerabagar and Vaan village of the area.

During the field visit author have interviewed with some lichen collectors and local contractors to asses the information on traditional method of lichen collection, extraction, resource use pattern and socioeconomic status of lichens (macrolichens) in the area.

B. Questionnaire Design: An ideal questionnaire was prepared after complete search of available literature on the lichen ecology and its economic role in our vital needs. The questionnaire was designed with keeping in mind of some tasks related to socio-economic and ecological impacts of lichens, which are always ignored by various workers.

C. Questionnaire Sampling and Selection of the Respondent: The survey was carried out during May-June 2007. The questionnaire was used to gather information on resource use pattern and assessment of earn money from lichen sector at different level of stakeholders. The respondents from the area were selected randomly on the basis of their involvement in the lichen sector as traditional collector, store keepers, packers loaders, horse trackers (transpiring lichens from forest to collection point/store house), local traders etc. were the respondents of the ideal questionnaire.

D. Process Questionnaire Filling: All questionnaires were filled throughout a long discussion along with the respondent.

E. Data Analysis: The data has been analyzed by using the SPSS software.

RESULTS

Households of Narayanbagar block depends highly on macrolichen based activity to conduct their livelihood represented by 93.65% followed of 63.32% households of Dewal and 18.38% of Tharali block of Chamoli district. Households of Rudraprayag district (Ukhimath & Jakholi block) was found less dependent on lichen sector (Table 1). In both the districts lichen sector found highest contribution to generate income as compare to other sources (Table 2). In both the districts lichen transporters and traders get maximum benefit from lichen sector as compared to other sources like agriculture, labor and shop etc. (Table 3). Earned money of the stakeholders from lichens sector was mostly used to provide foods like rice, wheat, pulses and vegetables etc. and it was less used in other daily needs (Table 4). The lichens collected/extracted from different substratum by the collectors maximum (51.53%) from tree bark followed by 43% and 4% from ground (fallen lichens) and rock substratum and only 1.37% extracted from soil (Table 5).

In the district Chamoli a lichen collector was collected average 254.5 kg lichens per year and its estimated income was Rupees 7668.08 per year @ 30.13 Rs. /kilogram. Similarly, it was in district Rudraprayag the average annual lichen collection was 78 kg and its estimated annual income was only Rupees 2393.82 @ Rupees 30.69/kilogram. Table 5 showed in Chamoli district, April-May (summer season) provided the maximum lichen material (313.4-267.15 kg/month/collector) followed of lowest (12.8kg/month/collector) in rainy season. In the district Rudraprayag, winter season (November to February) showed the maximum collection of lichens and throughout the year it was provided 414 kilogram /collector and provided Rupees 12705.66/ collector/year (Table 6).

Table1. Percentage of households engaged in lichen activity

District	Block	Number of households engaged in lichen activity (% of the total households)
Chamoli	Deval	62.32
	Tharali	18.38
	Narayanbagar	93.65
Rudraprayag	Jakholi	3.4375
	Ukhimath	14.375

Table 2. Contribution of lichens in income generation of lichen stakeholders

Sources of income	Contribution of lichens in income generation (%)	
	Chamoli	Rudraprayag
Service	1.08	0.90
Agriculture	33.82	31.59
Agriculture labor	1.56	1.30
Other labor	5.93	11.66
Lichen collection	56.31	53.02
Shopkeeping	1.29	1.53

Table 3. Shearing benefit from lichen sector at different level of stakeholders

Different level of Stockholders of lichens	Shearing benefit from lichens (%)	
	Chamoli	Rudraprayag
Collector	29.14	30.96
Tracker	15.36	0.00
Transporter & Traders	46.13	58.59
Storekeeper at village	0.00	0.03
Grader & shorter at village	0.84	2.17
Loader (Nepalis at local market)	8.54	8.16
Packer	0.00	0.09

Table 4. Percentage wise use of earned money (from lichens) in different basic requirements of the stakeholder

Basic requirements of the stakeholders	Percentage wise (%) use of earned money from lichens	
	Chamoli	Rudraprayag
Food	44.00	75.29
Medicines	10.93	6.47
House construction	6.86	4.71
Schooling of children's	1.00	1.18
Agriculture	1.40	0.00
Clothing	18.72	7.06
Assets creation	8.37	5.29
Marriage celebrations	7.21	0.00
Purchasing grams (feed) for horse	1.51	0.00

Table 5. Percentage wise extraction or collection of lichens from different substratum

Substratum	Lichen extraction or collection (%)
From trees	51.53
From rock	4
Fallen lichen collection	43
From soil	1.37

Table 6. Month wise collection of lichens by collectors in Chamoli and Rudraprayag districts

Months	Collection of lichen material kg/month/collector	
	Chamoli	Rudraprayag
Jan	190.4	97
Feb	78.36	51
March	62.53	34
April	313.4	23
May	267.15	0
June	74.41	8
July	15.82	0
Aug	12.8	5
Sep	33.54	24
Oct	66.96	52
Nov	75.6	74
Dec	42.1	47
Total	1233.07	414

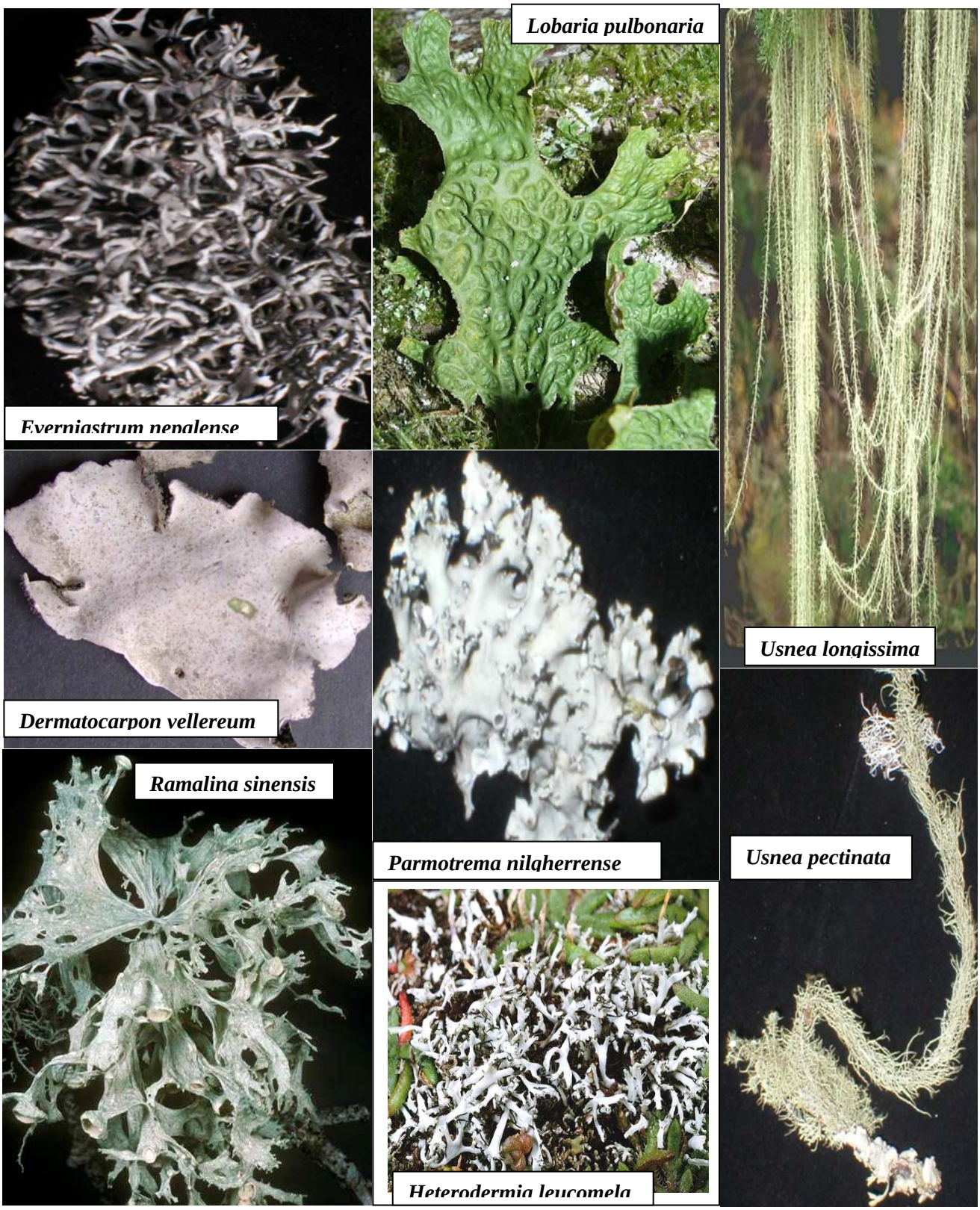

Fig. Photographs of some potential lichen species of Garhwal Himalaya

DISCUSSION

Well resource use pattern of lichens was situated in diatrict Chamoli Garhwal and the collectors were mostly depends on lichen sector. It was the interesting feature of the study, the involvement of outsiders like Nepali's labours are completely restricted in lichen harvesting activity, which were involved only in few cases as loading of lichens and some time grading and sorting of the lichen species. But through the economic point of view, the outsiders are interfering in the income of lichen stockholders at the time of sorting and grading, loading-unloading and transporting from forest to collection point. The lichen traders (local traders) were the highest beneficiaries in lichen sector because they were well aware about this sector.

Lichens are house hold items of some local users and used for Garam Masala for providing flavoring taste through lichens etc. The earned money through lichens about 44% has been used in food by the stakeholders of district Chamoli, and in past the earned money of about 75.29% was used in food by the stakeholders of district Rudraprayag, therefore, at presently the activity is directly effects on food requirements of the stakeholders of district Rudraprayag due to the lichen harvesting activity was totally banned by the forest department. Some other needs like clothing, schooling of children's, medicinal treatments, house constructions, and assets creation of lichen stakeholders were directly effected by the process of opening and closing rules of forest department for lichen harvesting from the forests.

Kumar (2008) hypothesis showed only fallen lichen (fall from trees) collection can be allowed to provide livelihood for some stakeholders of high altitude or temperate regions of Uttarakhand, it can be possible about five kilograms per hectare per year from a pure Kharsu Oak forest.

If the grading and sorting process of the lichens would be conducted at villages so it can be increased the income of the collector (primary collector). The lichen sector in the state Uttarakhand has required a proper channel of its tender, collection and trading/marketing system from its collectors to traders (Village to Mandi).

If the lichen based livelihood activity would be started so the migration of some peoples of the area to the plains can be reduced, because they can get the job opportunity in lichens sector.

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LICHEN-MOSS HARVESTING PRACTICES AND THEIR MARKETING STRATIGY IN UTTARAKHAND, INDIA

ABSTRACT: The present article is based on the concept of socioeconomic status of lichens (Kumar, 2009) and a compiled report of Appropriate Technology India, Ukhimath (Garhwal). Out of three auction sites of the State Ramnagar auction/ mandi (market) is the biggest market of lichen & moss followed by Tanakpur and Rishikesh. Traders of the mandi level are getting maximum profit from lichen & moss sector.

***Key Words*:** Lichen, Marketing, Uttarakhand State.

INTRODUCTION

Lichens are the unique group of plants that consists of two unrelated organism, a fungus and an alga, growing together in a close symbiotic association. The study of lichen remains quite neglected throughout the world, through they together with mosses from dominant organism in ecosystem covering 10% of the earth terrestrial habitats, particularly higher elevations (Nash & Egan, 1988). Kumar & Upreti (2008) and Kumar (2009) lichen exploitation is a common practice among the villagers and the rivals in moist temperate regions of the Western Himalaya to collect the lichens together with tree twigs as oak and other trees bears luxuriant growth of lichens. Upreti et al (2005) mentioned the members of the families Parmeliaceae and Physciaceae are the ones most exploited commercially and are recommended by inclusion in the CITES list. However, Kumar (2008) reported Parmelioid lichens are commercially trading lichens from Garhwal Himalaya i.e. *Everniastrum, Parmotrema, Cetrariopsis, Bulbothrix, Hypotrachyna and Rimelia* collected by rivals together with two fruticose genera, *Ramalina* and *Usne.* Within Uttarakhand State of India where the present study was carried out 75 species of Parmelioid lichens reported, of which 27% each are known in Mussooorie hills and Saryu river valley near Pindari Glacier area, 17.5% are in Chaubatia-Ranikhet followed by 12.1% and 10.8% in Nain Singh top en route to Milam Glacier and Chopta-Tunganath peak (Divakar & Upreti, 2005).

Approximately 750 metric tons of lichens are collected from Uttarakhand hills, 800 metric tons are imported from other regions of India, including Himachal Pradesh, Sikkim and Assam and out of which about 50-80 tons are exported (Shah, 1997).

Total three bigger markets of lichen-moss of the State viz. Ramnagar, Tanakpur and Rishikesh were visited during 2005. Accept Rishikesh, other two markets are approximately similar in trade and turnover system of lichen and moss. In subsistence and rural economies, the role of contribution of lichen-moss is as crucial as source of food, fodder and nesting material etc. it helps to generate additional employment and income. Since lichens and mosses grow in the hilly areas, it is important source of livelihood for the people living in the area. Local people extract lichen-moss and sell it to the middlemen (local contractors) as they do not have the resources to reach the market or the auction sites, where they can fetch remunerative prices for their produce. Lichens are sold at rates of approximately half a dollar/kg (Upreti et al 2005, Kumar, 2009) and mosses are 0.11 dollar/kg in the local markets. The price however becomes triple for lichens and double for mosses when these materials reach in the auction sites. A trained collector can easily collect 6-8 kg of lichens with twigs (Kumar, 2009).

Description of the government and semi government corporation involved in the marketing of lichen and moss in the State:

Zila Bhesajh Sangh Sahkari Samiti (ZBSSS): It is a registered public institution central society under corporative samiti Act 1965. ZBSSS is in operation since 1983 in almost all the district of the Uttarakhand state. President who is the head of the samiti is selected in every five years. There are many societies formed in the villages by ZBSSS. The directors among themselves elect the president. Secretary of the ZBSSS is supposed to be the government employee. The main objectives of the ZBSSS are to provide training on extraction of medicinal plants in the hilly area through scientific method, employment to the cooperative society members, and establishment of ZBSSS based small enterprises, improve the economic condition of the farmers by providing training on cultivation of those plant species which are becoming extinct. ZBSSS is also helps in preventing the exploitation of local village collectors from different middlemen and contractors and making them available remunerative price for their produce. The percentage of profit of the ZBSSS earned through commission is sheared among its members. About 10% of the profit is sheared.

Van Vikas Nigam (VVN): VVN is semi Government Corporation with divisional sales manager (DSM) directly from corporation, regional manger equivalent to conservator of forest from forest

department. Previously the forest department (FD) used to directly give tenders to the contractors for the extraction of timber as well as other forest produces, as a result of which was massive exploitation of forest produce by local contractors. In order to regulate the trade of minor forest produce, FD involved VVN. Initially this Nigam was established with their prime objective of storage, production and trade of timber. Since 2004 VVN diversified its activity and earned into the field of ecotourism and medicinal plants also from the time was declared as an herbal state, the government asked the FD to take active role in the production, sustainable harvesting, conservation and marketing of forest produce. The FD with the help of VVN has also started commercial activities regarding medicinal and aromatic plants. Apart from these two agencies, Kumaun Mandal Vikas Nigam (KMVN) and Garhwal Mandal Vikas Nigam (GMVN) are performing the similar role as of ZBSSS.

MATERIALS AND METHODS

Study area: Uttarakhand, the 27th State of the Republic of India, was formed on 9th Nov. 2000 and, carved in out of the hilly tracts of Uttara Pradesh. It lies between 28º53'24" East and 31º27'50" North latitude and between 77º34'27" and 81º02'22" longitude. It has international boundaries with Tibet in the North and Nepal in the East. Himanchal Pradesh and Hariyana lie to its west and Uttar Pradesh to its south. The state with predominance of mountains and hills is spread over 13 districts with an area of 51,082 sq. kms or about 5.5% of such terrain of India (NRIF, 2004). It has a forest cover of 64.80%. The major forest types found in the state are sub-tropical, temperate and alpine forests. The total agriculture land in the state is 14% of its geographical area. Vast topographical, climate and seasonal variation makes the state rich in floral as well as faunal diversity.

Climate changes from subtropical in the southern foothill with average temperatures of about 30ºC and winter temperature of about 18ºC. Warm temperate conditions in the middle Himalayan valleys, with average summer temperature of 25ºC and cool winters. A cold alpine climate is observed at higher elevation where summers are cool and winters are severe. At elevation about 4880m the climate is very cold with freezing temperatures and the area is permanently snow covered. There are rains in July-September due to south west monsoon and occasional snow fall in winter months (November-February), due to western disturbances at higher elevations.

A survey was conducted in different district of Uttarakhand during year 2005. Market surveys were conducted to identify the marketing channels, price spread, and prospective markets in the important places. A detailed study of lichen & moss conducted by rural population of necessary for establishing the trade and ensuring proper margin to the collectors. The major auction markets (called mandis) and traders in these areas were interviewed in order to know the quantum of trade of lichen & moss in Uttarakhand.

Sampling frame: Information was collected from collectors, contractors (middlemen), small and big traders, commission agents from three trading centers (Ramnagar, Tanakpur and Rishikesh).

Method of sampling:

Criteria for selection of forest division: Badrinath and Kedarnath forest divisions were selected for the study in Garhwal region where the lichen & moss takes place in large scale. In BFD blocks selected for the study were Narayanbagar, Tharali and Dewal. These three blocks were studied as the primary collectors from the adjoining villages sell their produce to the local contractors from this division. The major villages of BFD involved in the extraction of lichens are Vaan, Dungari, Man, Kolpuri, Kuling Ghes-Balan, Himni, Mundoli, Ratgawn, Bursol etc.

Selection of auction sites: Before October, 2004 there was no regulation in the trade of lichen & moss. Entire trade was done privately without involvement of any Government agencies. Only the local contractors had to be approach the ZBSSS, from there they used to get approval for the forest department for "Ravanna" and then they could sell there produce anywhere in India in the open market. But after October, 2004 in order to provide remunerative price to the primary collectors, Govt. took steps involving semi government corporation, VVN in this trade. In Uttarakhand, three auction sites are involved in the auctioning of lichen and moss viz. Ramnagar, Tankpur and Rishikesh. These auction sites were studied in order to estimate the quantum of lichen and moss from Uttarakhand.

Selection of contractors at block level: about four contractors from Tharali, five from Narayanbagar and two from Dewal block of district Chamoli Garhwal were interviewed in order to estimate the quantum of lichen & moss collected and priced received by the primary collectors for their produce.

Technique for data collection: Both primary and secondary data was collected for the study. Secondary data was collected in order to obtain the information and gets the idea regarding the availability of lichen & moss quantity trade from each of the auction sites, information sources for getting the relevant information regarding the study were as follows: Forest department (KFD & BFD), VVN, Bhesajh Sangh etc. Similarly, the primary data was collected from the local contractors, traders and commission agents. These techniques involved in the collection of data were personal interviewed and discussion through semi-structure interview. To explore the exiting value addition process, interviews with the people at each level were conducted at primary collectors level, traders level and on site visit.

RESULTS

The lichen and moss collection season is of six months in a year and one trader collects the produce from about 15-20 primary collectors. Table 1 shows on an average quantity of lichen is about 301 qtl per trader per season and the total quantity of lichen loaded from three blocks comes out to be 4515 qtl per season. Tharali block has found maximum contribution about 1750 qtl followed by Narayanbagar 1715 qtl and Dewal 1050 qtl lichen per season.

Seasonal availability of lichen-moss (L & M): The extraction of L & M takes place mainly from October to March. After 31st of March extraction of produce is completely banned as fire season commence. From July to September the produce can not be extracted because of monsoon season. The availability of lichen depends on monsoon as it is supposed to be the most effective season for its growth.

Market information at primary collector level: Primary collectors of BFD extract the lichen and moss from the allotted range and sell them to the contractors at Tharali, Narayanbagar and Dewal. They sell the produce to the contractors at these places after drying. All produce collected are sold and they do not keep it for personal use. The primary collector collects about 4-5 kg of lichen material per day but Kumar (2009) reported 3.39 kg lichen/day/collector in its collection period during October to March. The laborer collects lichen material 15-20 kg per day. The lichen is collected directly from the trees as well as from the ground that is fallen lichen.

The laborer collect the maximum amount of lichens about 5 quintals per month as they are hired especially for this job, but the villagers (primary collectors) collect it as a part time job apart from their agricultural and other household activities.

Different mode of marketing of L & M: In order to study the marketing channel for L & M, it is important to know the past and the present mode of marketing of this produce as well as the role of different institutions and organizations involves in the promotion of the trade. Prior to the year 2005-06, the L & M and other medicinal plants were not regulated. It was on the basis of contractor system. The only registered society that helped in the promotion of trade was Zila Bhesagh Sangh Sahkari Samiti (ZBSSS), which was responsible for regulating the trade only at extraction level. It had nothing to do with marketing of the produce.

After October 2004, Forest Department (FD) took active role by involving two semi government corporations namely Van Vikas Nigam (VVN) and Kumaun Mandal Vikas Nigam (KMVN) for Kumaun and Garhwal Mandal Vikas Nigam (GMVN) for Garhwal region. VVN now plays important role in auction of L & M.

Marketing channels for L & M: Out of three prevailing marketing channels for L & M, first two are more in practice. The main purpose of involving the ZBSSS and VVN in this trade is to regulate the extraction of the produce so that it is not overexploited and to provide remunerative price to the primary collectors (villagers) prevent their exploitation from contractors and middlemen.

Channel first: In this channel the forest department gives contract to two agencies for collection of L & M namely ZBSSS and VVN. Forest department is also involving KMVN for Kumaun and GMVN for Garhwal. The local traders whosoever is interested in the extraction of lichen and moss approach the ZBSSS for their area for contract. These contractors deposit a sum of Rs. 10,000.00 as registration fee in the form of security. This fee is refundable after 31st March when extraction of produce from the allotted ranges (areas) gets over. The FD opens only few ranges for the extraction of the produce. This goes on the rotational basis i.e. if range 1 was opened last year, the range 2 will be opened this year and range 3 the consequent year.

The local traders collect lichen and moss from two sources viz. primary collectors and laborers appointed by them. The permit is provided to the villagers for the collection of L & M. The villagers collect the produce on daily basis and after drying sell the produce to the local contractors. These contractors have retail shops in the village itself. When sufficient quantity of L & M is collected by the local traders, they tabulate the quantity of L & M in terms of sack bags, number of trucks in the sack bags are loaded and other information about quantity etc. in the form of 'Talika' (tabular form) to the ZBSSS. The ZBSSS cross checks the information and forwards it to the forest department. The DFO forwards it to the range office, where they charge their royalty (Rs.

210.00/qtl., which was previously Rs. 160.00/qtl), which includes sale tax and income tax. After all these formalities of the FD issues transit pass locally called as 'Ravanna' to local traders. Ravanna tells the route to be followed by the contractor to the auction places (mandi). This Ravanna is valid till seven days from date of issue. The produce then reaches the VVN depot. VVN is responsible for the auctioning of the produce. This is a public auction and any person involved in buying for the produce can participate in this. After auction, the produces is loaded in truck and transported to its destination places for example Kannauj (a town of Uttar Pradesh). The commission charged of different commission agents from the trades given in table 2 and estimated expenses & profit per truck is given in table 3.

Second channel: It is also know as Van Panchayat Channel. In this method, the villagers with the permission from the Panchayat can extract the L & M from the Van Panchayat/ (called community) forest. The VP has to seek permission from the ZBSSS but the FD does not charge royalty. This fee is issued by the Panchayat for village development works. ZBSSS only takes the commission of selling price of the lot. After this the ZBSSS transports the produce of VVN deport for auction. The process is similar as in channel first.

Third channel: This channel is known as 'Bandhak' in local language or pledge. This is rarely practiced. According to this method, 75% of the amount of the goods sale is given to the traders and rest 25% is retained by the ZBSSS after deduction of its commission of 10% returns the rest 15% to the traders after completion of sale of the entire produce.

Auction process at the VVN depots: In Uttarakhand, auction of L & M takes place at three places, namely Ramnagar, Tankpur and Rishikesh. The auction is conducted at the VVN depots at these places. The date of auction is fixed and is different for each of these places. This is a public auction and any person can participate in it and can buy the produce by calling the price. Table 4 shows the produce from different places comes to these depots for auction.

Fixing of price at auction: The rates of lichen and moss are fixed on per kilogram basis. The standard rate is fixed by local traders and is approved by VVN officials. This standard rate is fixed keeping in view the entire expenses on transportation, cost price and profit. After this standard price is fixed, the private traders participate in auction process and call their price. The highest bigger gets the produce and within seven days, the price is paid to the local contractors.

Quantity analysis of lichen and moss traded at different auction sites: Table 5 shows the quantity of the lichen and moss at VVN depots in an auction. It is depicted that majority of the produce traded

is lichen. It is evident that, out of all the three auction depots Ramnagar is the biggest mandi (market) and the number of participants is very high (Table 5).

Two auctions are held in each month, and it can be estimated that if in Ramnagar, in the last auction 500qtl of lichen and 76 qtl of moss was traded so in the a month total trade in approximate terms was of 1000 qtl of the lichen and 150 qtl of moss. The number of months auction takes place in one season is 8 (i.e., total number of an auctions in a year are 16). Approximate trade in terms of quantity in one season from Ramnagar mandi is around 8000 qtl lichen and 1200qtl for moss. The auction system in Ramnagar mandi was initiated from October 2004.

In Tanakpur, auction system was initiated from January 2005. The sales in the auction were not regular, if in one auction three was sale the other one showed nil sales. Total quantity of lichen traded from January to April was about 600 quintals and moss traded from the time of initiation of auction is about 7 quintals.

In Rishikesh, auction began from December 2004, and the total trade in terms of quantity in lichen up to April was 939 quintals and moss was 18 quintals.

Price analysis at primary collector level: The villagers (primary collectors) sell the produce weekly or twice in a week at the retail shops of the local contractors in the villages. They get about Rs. 25-35 per kg for lichens and Rs. 5-6 per kg for moss being extracted. The price of the produce fluctuates depending upon its quality and as well as availability. About three different qualities or grades of lichens are about Rs. 35-40 per kg for primary collectors.

Grade 1st supposed to be the best quality and is known as Phoolmaal in local language (*Everniastrum* species of lichen). It does not have any bark or moss attached to it. Their price is about Rs. 35-40 per kg for the primary collectors.

Grade 2nd contains the mixed percentage of grade 1st, mosses and bark of trees. The price of this grade is about Rs. 20-35 per kg for the primary collectors.

Similarly, Grade 3rd is known as 'Patthar Chura' growing over the rock surface (saxicolous lichens). The price fetched by the primary collectors for this grade is about Rs. 25 per kg.

Table 1: Quantum of lichen material traded at contractor level from BFD in one season (October to March)

Local market of district Chamoli Garhwal	No. of traders	Qty./ Trader (in Qtls.) (Number of trucks X quantity per truck)	Total quantity (in Qtls.) (Number of traders X quantity per trader)
Narayanbagar	07	7X35= 245	07X245= 1715
Tharali	05	10X35=350	05X350=1750
Dewal	03	10X35=350	03X350=1050
		Total	**4517**

Table 2: Percentage of commission

Name of organization	Commission charges
Van Vikas Nigam (VVN)	1% of selling price
Bhesajh Sangh	10% of selling price

Table 3: Calculation of profit to the traders

Capacity of a truck	Price of one truck lichen (@ Rs 3500.00/Qtl	Expenses/ Royalty/ Commission	Selling Price @ Rs. 7500/Qtl	Net Profit (Selling cost- Total expenses) - purchase cost
1	2	3	4	5
40 Qtl	Rs. 140000.00	FD= Rs. 210X40Qtl=Rs. 8400.00 VVN= 1% of column 4= Rs. 3000.00 BS= 10% of column 4= Rs. 30000.00 Net commission= 41400.00 Transpotation cost= Rs. 4000.00 Total Expenses (Total commission + Transportation Cost) = Rs. 41400.00+4000.00 = Rs. 45400.00	Rs. 300000.00	300000.00-45400.00 = Rs. 254600.00- Rs. 140000.00= Rs. 114600.00

Table 4: The produce from different places comes to the depots for auction

VVN Depots	Sources of produce to the depots
Ramnagar	Nainital, Badrinath (Chamoli), Bageshwar and Almora
Tanakpur	Pithoragarh and Champawat
Rishikesh	Kedarnath forest division (Rudraprayag)

Table 5: Status of lichen & moss traded at different auction sites of the state on weekly basis

Auction sites	Number of participants	Forest produces	Quantity (Qtls.)	Price Rs/Kg	Average price Rs./Qtl.	Total cost of the produce (Rs.)
Ramnagar	35	Lichen	502.8	50-83	6650.00	3343620.00
		Moss	76.57	24.10-30	2705.00	207121.85
Tanakpur	18	Lichen	228.00	42-70.60	5630.00	1621440.00
		Moss	1.6	18-21.50	1975.00	3160.00
Rishikesh	15	Lichen	70.00	60	6000.00	420000.00
		Moss	No moss	-	-	-

DISCUSSION

Atkinson (1982) mentioned that the lichens from the Uttar Pradesh (now Uttarakhand) hills are traded in the plains of the country for medicinal uses as tonics, febrifuges and antipyretics. The big trading centers are located in Ramnagar, Tanakpur and Rishikesh. The Badrinath Forest Division (BFD) of the Uttarakhand state is situated extensively as majority of the trade outflow to the mandis or auction sites. The primary occupation of the peoples is agriculture, but owing to the subsistence nature of hill agriculture, they are partially dependent on surrounding forest resources for their livelihood. The primary collectors are ignorant of the market price and due to less income, are not able to participate in the auction. In the last two months quantity of lichen traded from Rishikesh was decreasing and traders are more and more participating in Ramnagar and Tanakpur depots. At the trader's level, the value addition is done by the grading of lichens. The process of grading involves separating the different qualities of lichens and marketing them by giving different graders. The traders with manufacturers are also involved in the production of end products.

In the two auctions moss was not traded from Tanakpur and Rishikesh depots. In Ramnagar auction the traders from Kannauj also participated but they were not allowed to purchase the produce to local traders bid very high price. It was done so that the manufactures from Kannauj or other places brought the produce from the local traders of Ramnagar so that they could get their own share profit. In Ramnagar auction, traders from Nainital, Bhimtal, Nandprayag, Chamoli participated in auction. The other produce like Tejpatta, Coriander, Baelgiri contributes very little

from Tanakpur and Rishkesh mandi. The major role of the VVN was the collection of lichen & moss and conducting a public auction.

Conservation Strategy: Kumar (2009) suggested a collector for the major part of the year can earn a reasonable income by collecting the fallen lichens without being destructive with some knowledge of the lichen fall and seasonal pattern. In case of lichen and moss sector, the ZBSSS provides training to the collectors on scientific harvesting technique. The bark of the respective trees should not be pulled out while its extraction. Upreti (1995) mentioned the ethnobotanical, commercial utilization of lichens and decline of forest cover as the leading factors to loss of lichen diversity in India. Singh and Sinha (1997) mentioned agriculture, urbanization, construction of road, building on hills, mineral extraction, hydroelectrical projects, shifting cultivation are responsible for depletion of many lichen rich habitats.

In this article the author have to describe the status of harvesting, collection and marketing strategy of lichens in the state. The excessive field information has been collected from several lichen collectors of Chamoli district Garhwal. A perusal of available literature (see references) has indicated that a study on lichen harvesting and marketing is not available. Therefore present article will certainly help to asses the demand of lichen and moss at different levels, so that major bottle-necks faced by the villagers in trading of lichen and moss can be removed.

This information will be the first attempt to answer these basic queries and help in collection, grading, trading, conservation and management of lichens. Define the current and future option available for alternate livelihood from the lichens. It will be help to guide immediate and long term management, policy and decision making strategies

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